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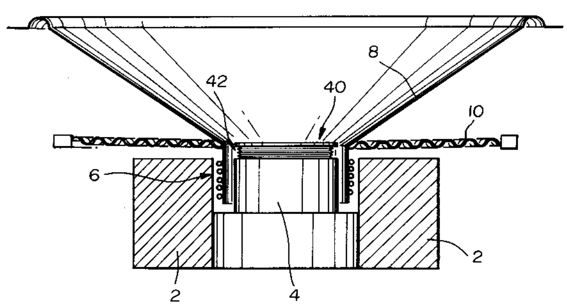
(54) A loudspeaker.

(57) The present invention relates to a loudspeaker which consists by plural diaphragms, and has wide frequency range. It is an object of the invention to provide a coaxial speaker in which a diaphragm for higher frequencies is of simple construction, light in weight, and has a good compliance at low level reproduction. In order to accomplish the above object, the present invention discloses a loudspeaker comprising a first diaphragm which is driven by a driving signal supplied into a voicecoil which is connected with said first diaphragm, and a ferromagnetic second diaphragm which is supported resiliently.

FIG.1



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Background of the Invention

The present invention relates to a loudspeaker which consists of plural diaphragms and has wide frequency range.

Background Art

Coaxial loudspeaker systems which consist of one loudspeaker referred to as a "tweeter" for higher frequencies and another loudspeaker referred to as a "woofer" for lower frequencies, are used in high fidelity audio systems. One example of the above coaxial loudspeaker system is one in which a tweeter is arranged within a voicecoil of a woofer. The above coaxial loudspeaker can reproduce a natural acoustic sound field because the tweeter and the woofer, which are arranged coaxially, can act like a single source of acoustic sound.

The above coaxial loudspeaker system has many limitations in design, because it is necessary to arrange the magnet, the voicecoil, and the diaphragm of the tweeter inside of the limited space of the woofer. In the above construction of the coaxial loudspeaker, the voicecoil of the tweeter must function under the influence of the magnetic field which originates from the woofer, because the magnetic circuit of the woofer is much stronger than the magnetic circuit of the tweeter.

Figs. 12 to 14 show the structure of a new type of coaxial loudspeaker, which avoids the above influence of the woofer on the tweeter.

Numeral 2 indicates a magnet; the numeral 4 indicates a central magnetic core; numeral 6 indicates a voicecoil; and numeral 8 indicates a diaphragm for a woofer. Numeral 10 indicates a resilient suspension which suspends the diaphragm 8 of the woofer; diaphragm 12 for a tweeter is made of conductive materials e.g. metal, and are arranged inside of the voicecoil 6 as shown in Figs. 13 and 14; diaphragm 12 for a tweeter consists of a half shell part 14 and a cylindrical part 16; diaphragm 12 is suspended by an axis 18, which is fixed on the central magnetic core 4 with a suspending piece 20. A reflecting piece 22, which compensates for the acoustic waves emitted from the diaphragm 12, is fixed at the top of the axis 18.

The cylindrical part 16 acts as a coil, because the cylindrical part 16 has a round shape in cross sectional view so as to form a single turned coil. The cylindrical part 16 can generate electrical current in the magnetic field which is generated by the voicecoil 6. Therefore, the voicecoil 6 acts as a first coil of a transformer together with the cylindrical part 16 which acts as a second coil of the transformer.

Below the upper limit of the woofer's oscillating frequency rang the diaphragm 8 for the woofer is easily driven by the current in the voicecoil 6. In such a frequency range, the current through the voicecoil 6 is not sufficient to drive the tweeter's diaphragm 12 because the impedance of the voicecoil 6 is high below the upper limit of the woofer's oscillating frequency range. Above the upper limit of the woofer's frequency range, the tweeter's diaphragm 12 is easily driven by the woofer's voicecoil 6 easily, because the impedance of the woofer's voicecoil 6 is lower than the impedance at the lower frequency range.

The coaxial loudspeaker system can reproduce acoustic sound within a wide frequency range because the diaphragm 6 can be driven easily only in the lower frequency range and because the diaphragm 12 can be driven easily only in the higher frequency range without a frequency dividing network which divides the driving current for the loudspeakers.

The above coaxial loudspeaker system has the following problems.

1. As shown in Figs. 12 and 13, the diaphragm 12 for the tweeter has a particular form because the diaphragm 12 must act as both a vibrating plate and a coil.
2. The diaphragm 12 has many limitations in design because the diaphragm 12 has the above particular form and must be made of conductive materials which are different from conventional forms and materials of diaphragms.
3. The diaphragm 12 is too heavy to be driven easily by the magnetic force of single turning coil because the diaphragm 12 is made of conductive metals which are heavier than the materials which are used for the diaphragms of conventional loudspeakers. Therefore, it is difficult to obtain a sensitive compliance in the moving of the diaphragm 12 under a low level reproduction.
4. The diaphragm 12 must be made smaller than the voicecoil 6 of the woofer so as to be enclosed inside the voicecoil 6.

SUMMARY OF THE INVENTION

It is an object of the present invention to make a coaxial speaker system in which a diaphragm for higher frequencies is simple in construction, light in weight, and has a good compliance in low level reproduction.

In order to accomplish the above object, the present invention discloses a loudspeaker system comprising a first diaphragm which is driven by a driving signal which is supplied into a voicecoil which is connected with said first diaphragm, and a ferromagnetic second diaphragm which is supported relatively movable with respect to the first diaphragm.

Accordingly, the loudspeaker system reproduces a natural acoustic sound field as in conventional coaxial loudspeaker systems. The first diaphragm can be driven easily by the driving current at lower frequencies according to its own mechanical oscillating mode. At the above frequency, the current through the voicecoil of the first diaphragm is not sufficient to drive the second diaphragm. The impedance of the voicecoil decreases and the current through the voicecoil increases enough to drive the second diaphragm above the upper limit of the oscillating mode of the first diaphragm. According to the increasing of the current, the second diaphragm begins to osculate in the magnetic field which originates from the voicecoil. Therefore, the first diaphragm can reproduce lower frequency acoustic sound and the second diaphragm can reproduce higher frequency acoustic sound without a frequency dividing circuit which divides the driving current for loudspeakers.

The second diaphragm can be made easily and cheaply because it can act as a tweeter through its own ferromagnetism and elastic deformation. It is easy to produce the second diaphragm, which is light in weight, because the design form and the selection of the materials for the diaphragm is flexible. Therefore, the second diaphragm obtains a sensitive compliance to the driving signal.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig.1 is a longitudinal sectional view of the loudspeaker system of the first embodiment.

Fig. 2 is a longitudinal sectional view of the diaphragm of the first embodiment.

Fig. 3 is a longitudinal sectional view of the diaphragm of the second embodiment.

Fig. 4 is an angled view of the diaphragm of the third embodiment.

Fig. 5 is a longitudinal sectional view of the loudspeaker system of the fourth embodiment.

Fig. 6 is a longitudinal sectional view of the diaphragm of the fifth embodiment.

Fig. 7 is an angled view of the diaphragm of the sixth embodiment.

Fig. 8 is a longitudinal sectional view of the diaphragm of the sixth embodiment.

Fig. 9 is an angled view of the diaphragm of the seventh embodiment.

Fig. 10 is an angled view of the diaphragm of the eighth embodiment.

Fig. 11 is a longitudinal sectional view of the ninth embodiment.

Fig. 12 is a longitudinal view of an example of a conventional loudspeaker system.

Fig. 13 is an angled view of a diaphragm of the loudspeaker system shown in Fig. 12.

Fig. 14 is a longitudinal sectional view of the diaphragm shown in Fig. 13.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figs. 1 and 2 show a first embodiment of the invention. In these figures, the numeral 40 indicates a diaphragm which acts as a tweeter. The diaphragm 40 is connected to one end of a suspending piece 42, the other end of which is connected to a central magnetic core 8. The diaphragm 40 is made of ferromagnetic materials, e.g., steel, formed as a thin sheet. The diaphragm 40 is magnetized as shown in Fig. 2. One side of the diaphragm 40, which faces the top of the central magnetic core 4 which is magnetized as a north pole, is magnetized to reversed polarity with respect to the central magnetic core 4. Therefore, the other side of the diaphragm 40 is magnetized as a north pole.

The materials which are suitable for the diaphragm 40 are not limited to metals. Many kinds of ferromagnetic materials are suitable for the diaphragm 40. A plastic sheet or film, e.g., polyester, which is coated by a ferromagnetic layer, is also suitable for the diaphragm 40.

The suspending piece 42 is formed like a bellows having many corrugations for flexibility. The suspending piece 42 can support diaphragm 40 resiliently. A block, which is made of foamed rubber or plastic is also suitable for used in a resilient suspension. The diaphragm 40 is suspended by the suspending piece 42 independently of the diaphragm 8.

In the loudspeaker system of the above construction, the voicecoil is magnetized by the driving signal and the diaphragm 8 for the woofer is driven by the magnetically induced current between the voicecoil 6 and the magnet 2. The diaphragm 8 for the woofer, having a minimum diameter of 5-10 centimeters and a maximum diameter of 20-40 centimeters, can be driven easily by a driving current of a frequency of less than a few thousands Hz, because there is a limit in the reproduction frequency range for the diaphragm 8 of the woofer according to its own mechanical oscillating mode. The diaphragm 8 for the woofer can be driven easily below the upper limit of the reproduction frequency range. At the above frequency, the current through the voicecoil 6 is not sufficient to drive the diaphragm 40 of the tweeter; this is because the impedance of the voicecoil 6 is high below the upper limit of the above frequency range. The impedance of the voicecoil 6 decreases and the current through the voicecoil 6 increases enough to drive the diaphragm 40 of the tweeter, above the upper limit of the oscillating mode. According to the increasing of the current, the diaphragm 40 begins to oscillate in the magnetic field, which originates from the voicecoil 6. Therefore, in the loudspeaker system of this embodiment, the diaphragm 8 of the woofer can reproduce lower frequency acoustic sounds and the diaphragm 40 of the tweeter can reproduce higher frequency acoustic sound without a frequency dividing circuit which divides driving current for loudspeakers.

Fig. 3 shows a second embodiment of the invention. In this embodiment, a diaphragm 40 is not actively magnetized but is instead passively magnetized by a central magnetic pole 4. One side of the diaphragm 40 which faces to the central magnetic pole 4 is magnetized into a south pole by the central magnetic pole 4 which has been magnetized into a north pole.

The above magnetized diaphragm 40 is driven by a magnetic field which originates by a voicecoil 3 as a manner similar to that of the first embodiment.

Fig. 4 shows a third embodiment of the present invention. In this embodiment, a plurality of slits 46 are provided in a ferromagnetic diaphragm 44. The slits 46 are arranged to cut off eddy currents which are produced in the diaphragm 44 by a voicecoil (not shown in Fig. 4) when the diaphragm is electrically conductive. A circular circuit, which would be formed in the diaphragm 44 in the magnetic field of the voicecoil, is interrupted by the slits 46, and therefore eddy currents cannot be generated in the diaphragm 44. The efficiency of woofer in which the diaphragm 44 is thus arranged is not degraded by the eddy currents.

Fig. 5 ahows a fourth embodiment. A diaphragm 48 which is formed in a convex shape so as to emit acoustic sound over a wide area, is arranged coaxially inside of a diaphragm 8 of a woofer.

Fig. 6 illustrates a fifth embodiment. A diaphragm 50, which is formed in a concave shape so as to emit acoustic sound over a predetermined limited area, is arranged inside of a diaphragm 8 of a woofer coaxially.

Fig. 7 and Fig.8 illustrate a sixth embodiment. A diaphragm 52 has a coaxial hole 54 in which a third diaphragm 56 is arranged. The diaphragm 56 can be driven as a super tweeter to reproduce acoustic sound above a frequency range of the diaphragm 52 which acts as a tweeter.

The diaphragm 52 for a tweeter is connected with one end of a suspending piece 58, another end of which is connected with a central magnetic core 4. The diaphragm 56 for a super tweeter is connected with one end of a suspending piece 60, another end of which is connected with a central magnetic core 4. Each suspending piece 58 and 60, each of which are formed like a bellows which has many corrugations for flexibility, are arranged coaxially. It is possible to design the diaphragms 52 and 56 to alternate frequency ranges in which these diaphragms 52 and 56 can be driven easily, by changing the form, the materials, the weight of the diaphragms 52 and 56, or by suspending pieces 58 and 60. According to the above construction, a three way loudspeaker system of simple construction may be obtained without a frequency dividing circuit which divides the driving currents for a loudspeaker. A construction to suspend the diaphragm 56 is not limited in those shown Figs. 7 and 8. The diaphragm 56 can also be suspended by the diaphragm 52.

Fig. 9 illustrates a seventh embodiment. Four diaphragms 61, each of which is formed as a quarter circle, are arranged on a suspending piece 62. The suspending piece 62 is made of foam plastic or rubber and is formed as an cylindrical column. The diaphragms 61 are arranged so as not to be in contact with one another so as to cut off any eddy currents.

According to the above construction, it is possible to ensure that the occurense of eddy currents thorough a diaphragm formed by the quarter circle diaphragms 61 is avoided.

Fig. 10 and Fig. 11 illustrate a eighth embodiment. Two diaphragms 64, each of which is formed as a semicircle, are arranged on a suspending piece 62. The diaphragms 64 are arranged so as not to contact each other so as to cut off any eddy currents. A diaphragm 56 is arranged in the hole 54 which is formed for the diaphragms 64.

According to the above construction, it is possible to ensure that the occurrence of eddy currents thorough a diaphragm which is formed by the semicircle diaphragm 64 is avoided.

Where technical features mentioned in any claim are followed by reference signs, those reference signs have been included for the sole purpose of increasing the intelligibility of the claims and accordingly, such reference signs do not have any limiting effect on the scope of each element identified by way of example by such reference signs.

Claims

1. A loudspeaker, comprising:
a first diaphragm (8) driven by a driving signal supplied to a voicecoil (6) connected to said first diaphragm(8); and
a second diaphragm (40, 44, 48, 50, 52) supported resiliently;
wherein said second diaphragm (40, 44, 48, 50, 52) hving ferromagnetic properties.

2. A loudspeaker in accordance with claim 1, wherein said second diaphragm (40, 44, 48, 50, 52) having ferromagnetic properties.

3. A loudspeaker in accordance with claim 1, wherein said second diaphragm (40, 44, 48, 50, 52) comprising a piece for oscillating which is coated by a ferromagnetic layer.

4. A loudspeaker in accordance with one of claims 2 and 3,
wherein said first diaphragm (40, 44, 48, 50, 52) is arranged coaxially with the first diaphragm (8).

5. A loudspeaker in accordance with one of claims 2 and 3,
wherein said second diaphragm (40, 44, 48, 50, 52) is planar.

6. A loudspeaker in accordance with one of claims 1, 2, 3, 4 and 5,
wherein said second diaphragm (40, 44, 48, 50, 52) comprising at least 2 sections.

7. A loudspeaker in accordance with one of claims 1, 2, 3, 4 and 5, wherein said second diaphragm (40, 44, 48, 50, 52) has a slit (40) to disrupt the formation of currents induced in said second diaphragm (40, 44, 48, 50, 52) by the magnetic field of said voicecoil (6).

8. A loudspeaker in accordance with one of claims 1, 2, 3, 4, 5, 6 and 7, wherein said second diaphragm (40, 44, 48, 50, 5) forms a space (54) into which a third ferromagnetic diaphragm (56) is arranged.

9. A loudspeaker in accordance with one of claims 2 and 3 wherein, said second diaphragm (40, 44, 48, 50, 52) is formed as a sheet.

10. A loudspeaker in accordance with one of claims 2 and 3 wherein, said second diaphragm (40, 44, 48, 50, 52) is formed as a film.

FIG.1

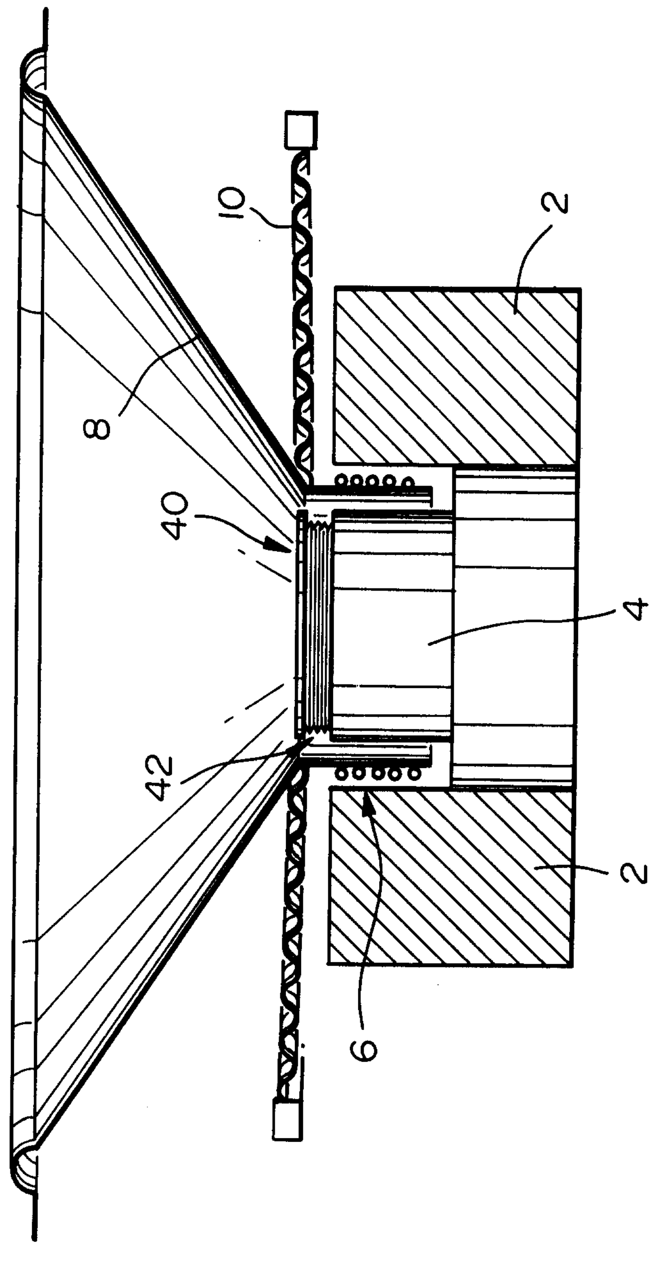

FIG.2

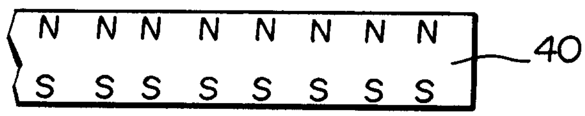

FIG.3

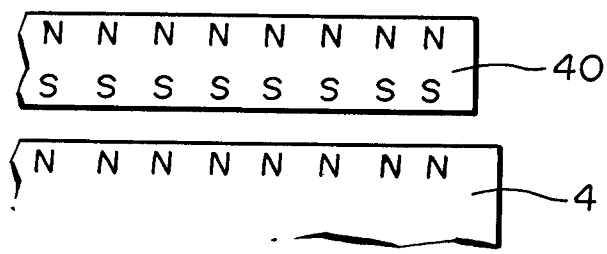

FIG.4

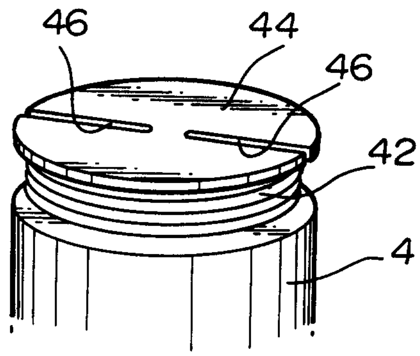

FIG.5

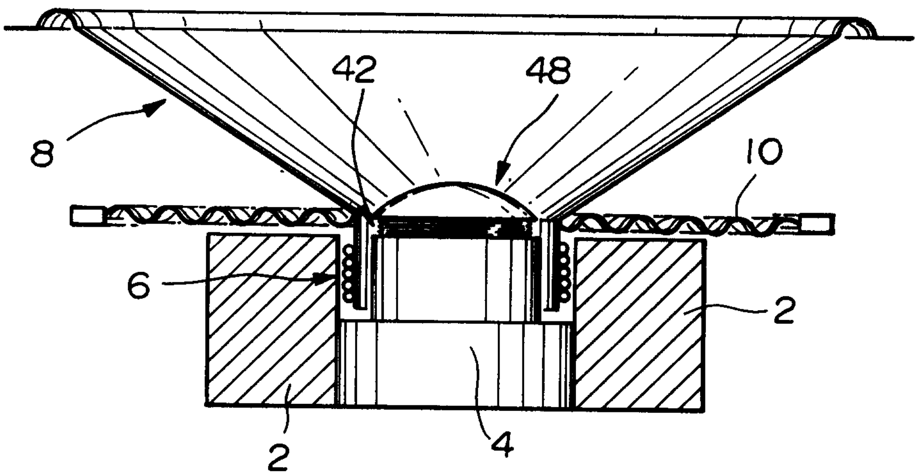

FIG.6

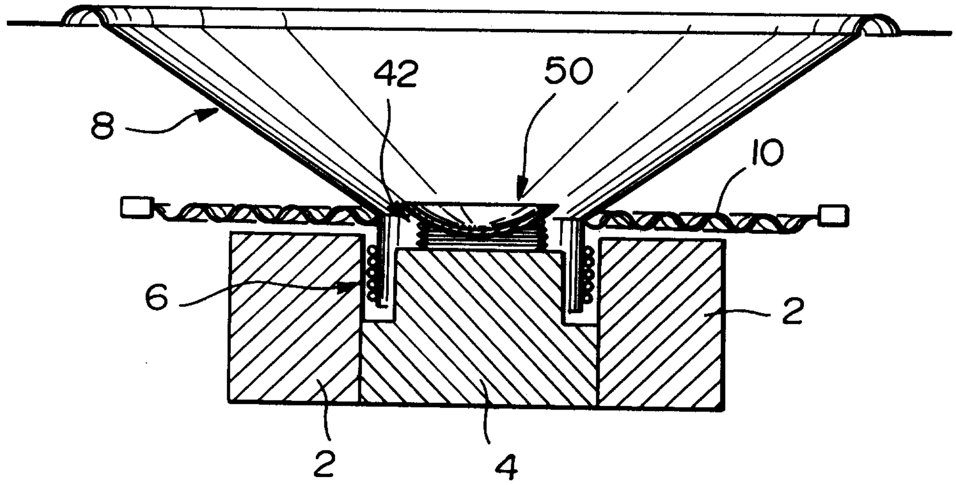

FIG.7

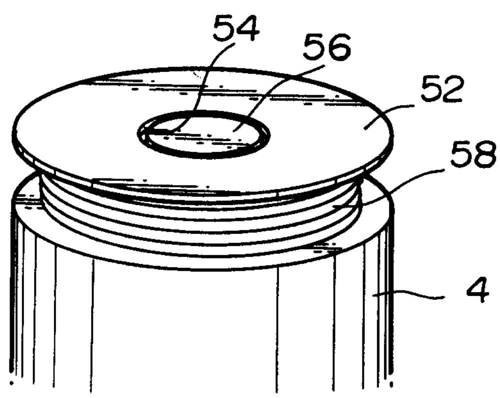

FIG.8

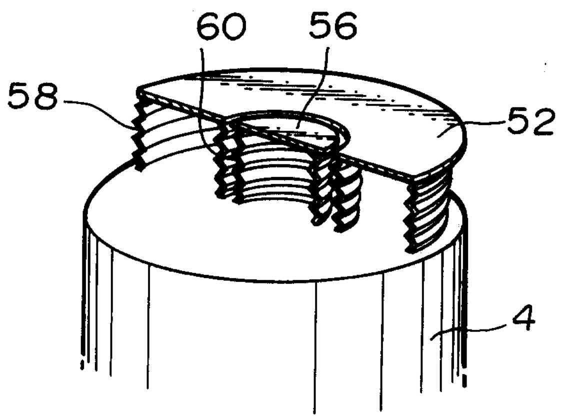

FIG.9

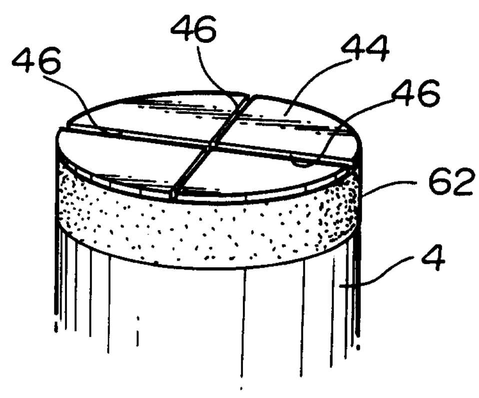

FIG.10

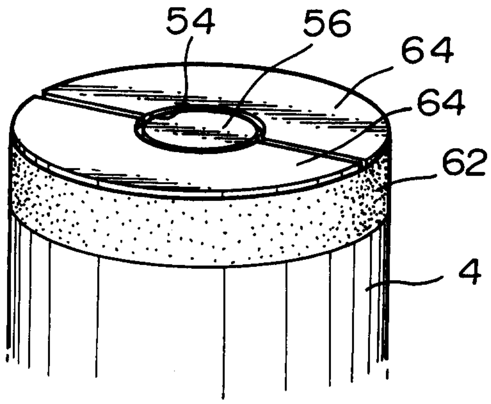

FIG.11

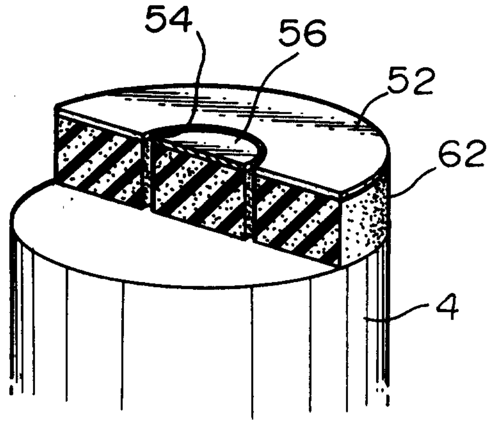

FIG.12

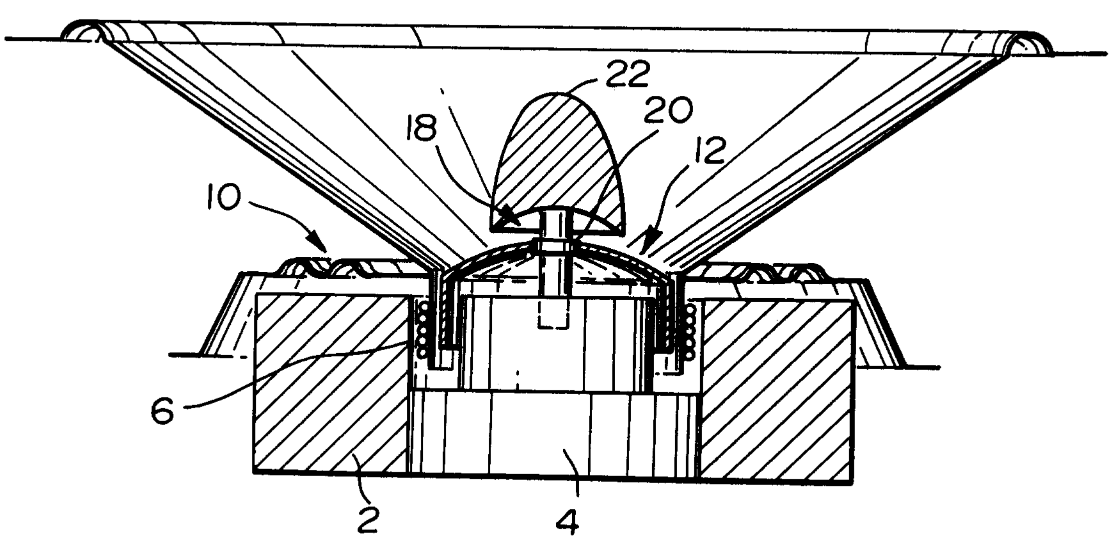

FIG.13

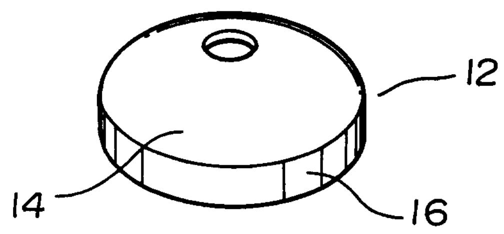

FIG.14