

[54] **LOUD SPEAKER SYSTEM**
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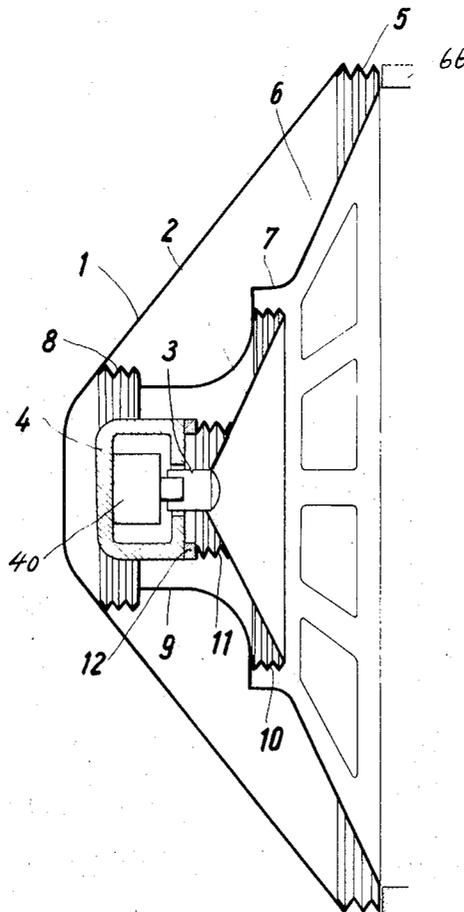
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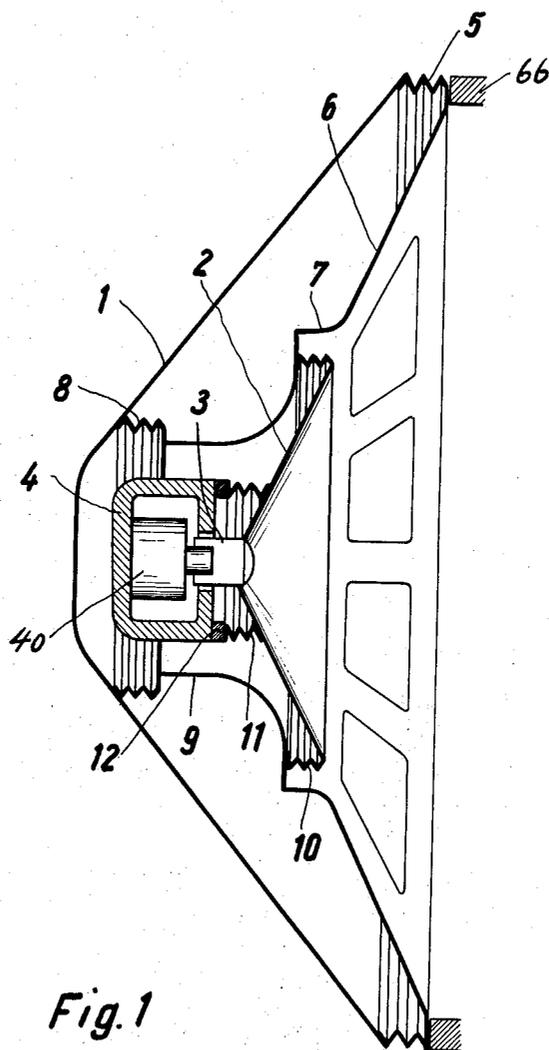
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[57] **ABSTRACT**

This invention relates to a loudspeaker system comprising a directly energized high frequency diaphragm and at least one low frequency diaphragm acoustically coupled to the high frequency diaphragm through a substantially enclosed air space having a predetermined volume and surface area whereby the frequency of vibrations transmitted there through may be controlled.

7 Claims, 6 Drawing Figures





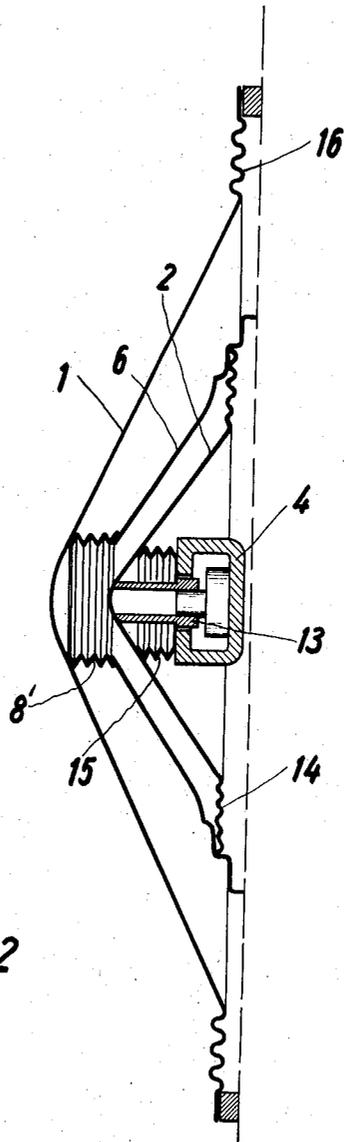


Fig. 2

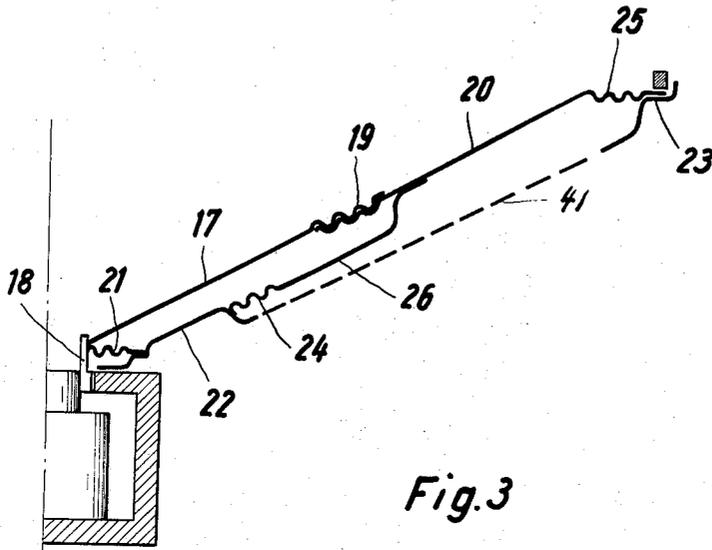


Fig. 3

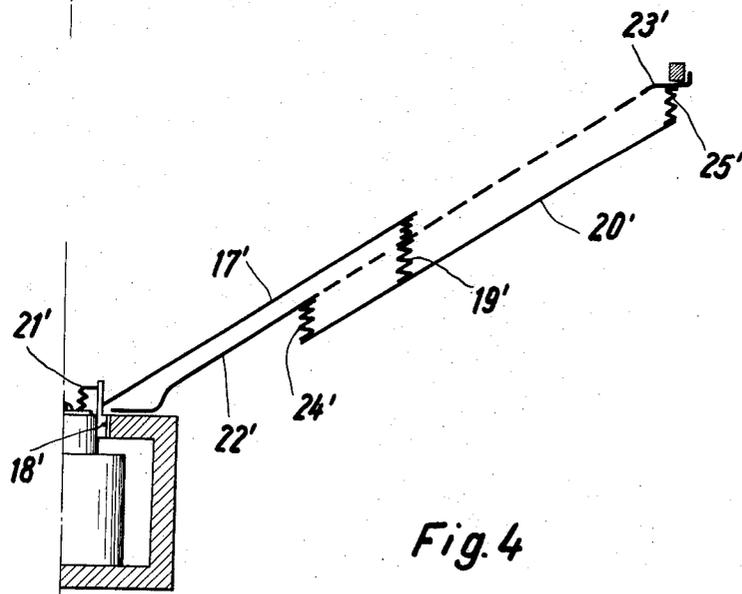
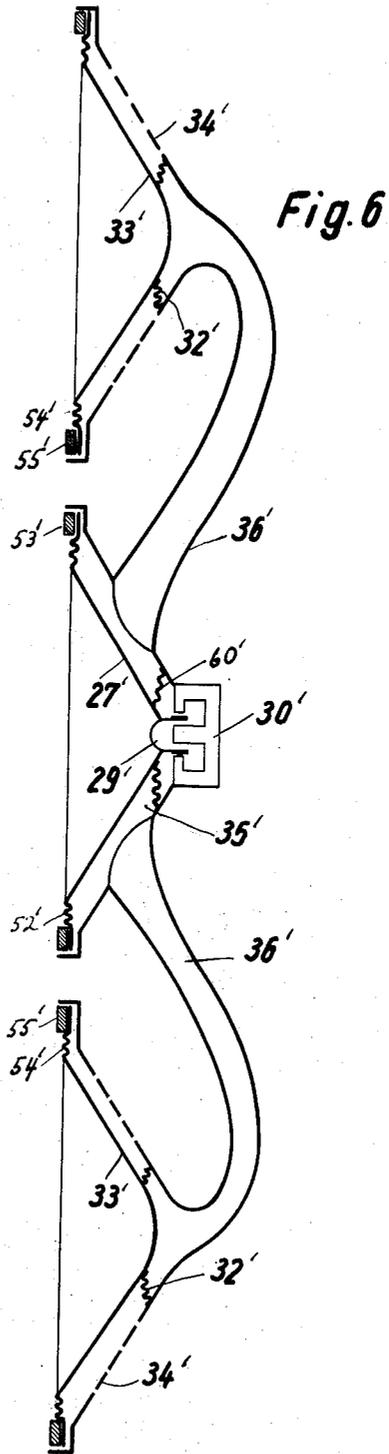
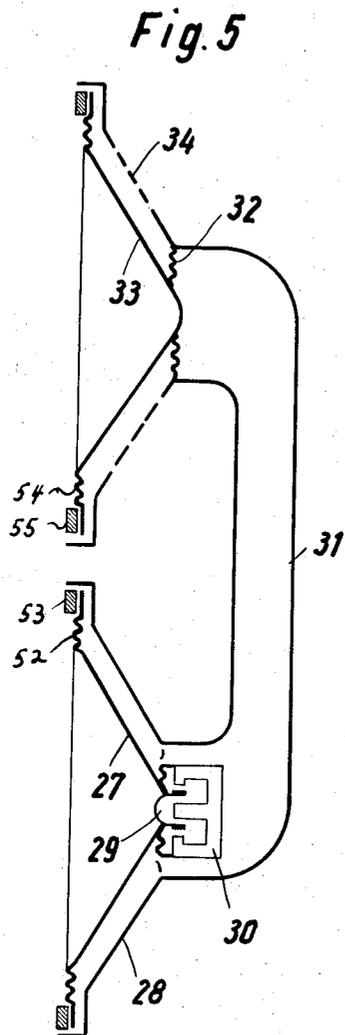


Fig. 4



LOUD SPEAKER SYSTEM

DESCRIPTION OF THE PRIOR ART

As is well known, the radiation of high and low frequencies makes different demands on the loudspeaker system. A small, light-weight diaphragm is suitable for radiating high frequencies, whereas large diaphragms are necessary for radiating low frequencies.

It is part of standard practice for one and the same magnet system to be used for energising, with the aid of the same speech coil, both a low-frequency diaphragm and a high-frequency diaphragm in the form of a small cone held in place by an adhesive. The disadvantage of that arrangement, however, is that the amplitudes of vibration of the high and low frequency diaphragms are the same and that the overall frequency response of the speaker is unsatisfactory. Another method already tried is to fit, in the vicinity of a diaphragm driven by the operating pulse system, a second diaphragm having a different radiation surface area, which is also caused to vibrate. Even these arrangements have failed to fulfil all requirements as to the quality of sound reproduction.

It is further recognized that it is desirable, for good sound reproduction over the entire audio-frequency range, for the low-frequency diaphragm to vibrate at high amplitude, if the necessary speaker performance is to be achieved over the low-frequency range, whereas a lower amplitude of vibration suffices for the high-frequency diaphragm.

Hence it was deemed desirable to provide a loudspeaker system that requires only one energising assembly but in which the low frequency diaphragm vibrates at a higher amplitude than the high-frequency diaphragm. As used herein, the term "high frequency" applies to all frequencies above the bass and might therefore equally well be termed "medium-high frequency."

SUMMARY OF THE INVENTION

The present invention comprises an energising system, suitably a speech coil activated by a magnetic assembly of conventional nature, a high frequency diaphragm having at least one predetermined surface preferably having two sides, said diaphragm being acoustically activated by said energising system, at least one low frequency diaphragm having at least one predetermined surface, and means for physically connecting a portion of the predetermined surface of said high frequency diaphragm to a portion of the predetermined surface of said low frequency diaphragm.

The connecting means are so arranged that the thus defined portions of said predetermined surface areas are located at predetermined sectors of the surface of said diaphragms.

The said portions of said predetermined surfaces of said low frequency and said high frequency diaphragm taken together with said connecting means provided substantially enclosed volume of air having a predetermined volume and a predetermined total surface area.

The diaphragms may optionally be conical, suitably frustoconical in section. The surface means of said diaphragm comprise a central area which may be defined as that portion thereof through which the axis of rotation of the cone passes, and the side areas may be defined as those portions of the surface area of the cone

through which the axis of rotation of the cone would not pass.

The arrangement of the diaphragms and their acoustical coupling to each other are described in detail in the various modification herein below.

There are various possible ways exemplified below, each with its attendant special advantages, of assembling the diaphragm coupling system and forming the enclosed air space. Thus in one particularly compact arrangement illustrated in FIG. 1, the magnet system may be fitted within the fully enclosed air space. An even shallower construction can be achieved by arranging the magnet system on that side of the high-frequency diaphragm which faces away from the enclosed air space.

In these arrangements, the enclosed air space lies adjacent to the central portion of the conical low-frequency diaphragm.

It may also be advantageous, however, to arrange for the enclosed air space to lie adjacent to a ring-shaped portion formed by the sides of the frusto-conical low-frequency diaphragms. In that case, the low-frequency diaphragm and the high-frequency diaphragm should be designed as cones lying one inside the other, preferably of equal slope, on a common axis.

To enable the diaphragm to carry out purely piston-like or to-and-fro movement in the axial direction, it is desirable that part of the surface bounding the totally enclosed air space should be made in the form of a flexible member, said flexible member may be bellows or rippled members of the usual type.

The invention is not limited to the use of diaphragms positioned coaxially one within the other; they can also be coupled together by the enclosed air space when the diaphragms for the high and low frequencies lie side by side, the enclosed air space then taking the form of a tube or duct.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross sectional elevational view of one embodiment of a loudspeaker system of the present invention.

FIG. 2 is a cross sectional elevational view of a second embodiment of a loudspeaker system of the present invention.

FIG. 3 is a cross sectional elevational view showing one half of the cross section of a third embodiment of the present invention.

FIG. 4 is a cross sectional elevational view of one half of the cross section of a further modification of the third embodiment of the present invention.

FIG. 5 is a cross sectional elevational view of a fourth embodiment of a loudspeaker system of the present invention.

FIG. 6 is a cross sectional elevational view of a fifth embodiment of a loudspeaker system of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The embodiment of the loudspeaker system shown in FIG. 1 comprises a low frequency diaphragm, 1, and a high frequency diaphragm, 2, both having conical cross section. The energising system is attached to the high frequency diaphragm. In this embodiment the energising system comprises a magnet assembly 4, a speaker coil 40 situated in the air gap of said magnet assembly

4 and energised by the same, and a coupling means 3, one end of which is attached to coil 40 and the other end of which is attached to diaphragm 2. The outer edge of low frequency diaphragm 1 is connected to a chassis 6, by a connecting means, suitably a flexible connecting means such as a bellows 5. The chassis 6 is suitably in the form of an openwork truncated cone and incorporates a ring, 7. Attached to the central part of the conical low-frequency diaphragm 1 is a connecting means, suitably a flexible connecting means, such as a bellows 8 which surrounds the magnet assembly, the other end of said connecting means 8 is connected to a rigid funnel-shaped part, 9, of the chassis 6. The ring 7 is attached at one end thereof to a connecting means, suitably a flexible connecting means such as a bellows 10. The other end of said connecting means being joined to the outer edge of the high frequency diaphragm 2 this arrangement results in the production of a totally enclosed air space. The various connecting means in combination with funnel 9 define its specific portions of the predetermined surfaces of diaphragms 1 and 2. The surface areas of said enclosed air space may be more particularly defined as being bounded by the following surfaces: the high frequency diaphragm 2, the bellows 10, the funnel-shaped part 9, the bellows 8 and the central portion of the low-frequency diaphragm 1. Within this space lies the magnet assembly 4, which is joined to the part 9 by braces or arms.

A further flexible connecting means, suitably a bellows, 11, has one end thereof attached to the central portion of the high-frequency diaphragm and the other end thereof to a ring, 12, located on the magnet assembly, 4, which is provided for centring the high-frequency diaphragm. The central portion of high-frequency diaphragm cone 2 is closed.

In the second embodiment shown in FIG. 2 the magnet assembly 4 is arranged not inside the enclosed air space but outside it being situated within the cone of space defined the high-frequency diaphragm 2. In this case the speech coil is attached to one end of a cylindrical carrier, 13, the other end of which is attached to the central portion of high frequency diaphragm 2. The outer edge of the diaphragm 2 has attached thereto a rippled member 14, the other end of which is joined to chassis 6. A flexible connecting member such as a bellows 15 has one end attached to magnet assembly 4 and the other end thereof to the central portion of diaphragm 2. The outer edge of the low frequency diaphragm 1 is attached to a rippled member 16, the other end of which is attached the chassis 66. Similarly a connecting member suitably a flexible connecting member such as bellows 8' is, as in the first embodiment connected at one end thereof to the central portion of low frequency diaphragm 1 but at the other end thereof directly to the predetermined surface of high frequency diaphragm 2. Thus connecting member 8' itself defines specific portions of the predetermined surfaces of diaphragm 1 and 2 which constitute portions of the surface area of said enclosed air space which may be more particularly defined as being bounded by the high frequency diaphragm 2, the chassis 6, bellows 8, and the central portion of the low-frequency diaphragm 1.

In the embodiment of FIG. 3, the diaphragms are arranged in such a manner that together they produce one conical diaphragm. The high-frequency diaphragm 17 is attached at one end thereof to the energising coil member 18 and at the other end thereof to one end of

a rippled member 19, the other end of said member 19 being contacted to the low frequency diaphragm 20. Another rippled member 21 is connected at one end to coil 21 and diaphragm 17 and at its other end to an anchorage, 22, which extends conically outwards, substantially parallel to the high frequency diaphragm 17. Optionally, this anchorage 22 may be extended by an arm member 41 to edge member 23. The low frequency diaphragm 20 is attached to connecting means 26 having a rippled portion, 24, said rippled portion 24 of member 26 is attached to the edge of the inner part, of the anchorage 22, said member 26 is acoustically considered as part of diaphragm 20. The other end of diaphragm 20 is connected to one end of rippled member 25 the other end of which is connected to edge member 23. The enclosed air space in this case is bounded by the high frequency diaphragm 17 with its vibratory rippled portions 19 and 21, the anchorage, 22, the rippled portion 24 of the low-frequency diaphragm and the inner circular portion 26 of the latter. Here again, the area of the high-frequency diaphragm 17 adjacent to the air space is larger than that of the surface 26 of the low-frequency diaphragm adjacent to the air space.

In the modification of the third embodiment illustrated in FIG. 4, bellows 24' and 19' replace rippled members 24 and 19 permit better piston-like vibration of the diaphragms. In other respects, the arrangement resembles that of FIG. 3. The speech coil carrier 18' is attached to one end of the high-frequency diaphragm 17'. 22' is joined to the edge member 23' by arms 41' extending radially outwards and connected at one end to anchorage 22' and at the other to edge member 23'. A bellows, 24', is connected at one end to low-frequency diaphragm 20' and at the other, to anchorage 22'. The other end of low frequency diaphragm 20' joined by another bellows, 19', which in turn is connected to low frequency diaphragm 17 to close off the air space, while connection of the other end of low frequency diaphragm 20 to the outer edge member 23' is established with the aid of another bellows, 25' connected to members 23' and low frequency diaphragm 20'.

The fourth embodiment of the loudspeaker system of the present invention is illustrated in FIG. 5. The system comprises a high frequency diaphragm 27, an air tight dome 29, attached to the central portion of diaphragm 27 an energising system 30, acoustically coupled to said air tight dome 29, an annular edge member 53, having attached thereto a rippled member 32, the other end of said member 54 being attached to outer edge of diaphragm 27, an air tight dish 28 of frustoconical cross section having the outer edge thereof attached to edge member 53. The inner circumference of which physically contacts a portion of the predetermined surface of diaphragm 27. Interconnecting duct member 31, is attached at one end thereof to the inner edge of dish 28, the other end of inter-connecting duct member 31 on the inside edge thereof is attached rippled annular member 32. Low frequency diaphragm 33 has attached to the outer edges thereof rippled annular member 54 the inner circumference of which contacts the outer circumference of diaphragm 33. The outer edge of member 54 contacts annular edge member 55. Loudspeaker dish 34, which has preferably, a frustoconical cross section, is attached at the outer edge thereof to edge member 55 and at the central portion

thereof, which, suitably, is the frustrum of a cone, to the annular circumference of rippled annular member 32 and inter-connecting duct member 31.

The fifth embodiment of the loudspeaker system of the present invention is illustrated in FIG. 6. In this embodiment there are provided a high frequency diaphragm 27 and two low frequency diaphragms 33 said low frequency diaphragms 33 may, if desired, have different resilient frequencies in the low frequency range.

The system comprises a high frequency diaphragm 27', an air tight dome 29', attached to the central portion of diaphragm 27', an energising system 30' acoustically coupled to said air tight dome 29, and an annular rippled member 60' the inner circumference of which is connected to said high frequency diaphragm 27' and a supportive dish member, 35', suitably of frustrum conical section. Said dish member 35' having the central portion thereof attached to magnetic assembly 30' and being connected a short distance towards the edge of the dish spaced from magnetic assembly 30' with the outer circumference with rippled annular member 60. The system further comprises annular edge member 53' said edge member 53' being connected to the outer edge of dish 35'. This system further comprises annular rippled member 52' the outer edge thereof being connected to edge member 53' and the inner circumference there to the outer edge of high frequency diaphragm 27'. In a similar manner low frequency diaphragms 33' are connected to annular rippled members 54' at the inner circumference thereof and said rippled members 54' are connected at the outer circumference thereof to outer edge members 55' which are connected to the outer edge of frusto conical dish members 34'. The inner edges of dish members 34' that is to say the edges located at the central or narrower portion of the frustrum are connected to the outer edges of annular rippled members 32' the inner edges of said rippled members 32' are connected to the central portions of low frequency diaphragm 33'. Duct members 36' are connected at one end thereof to dish members 35' and at the other end thereof to the inner edges of the dish member 34' at the point where said dish members 34' are connected to the outer circumference to annular rippled members 33.

It may be of advantage for the enclosed air space to communicate with the outside atmosphere through a very small aperture, for equalisation of variations in the atmospheric pressure. This aperture should be made so small, however, as to have no adverse effect on the way; in which vibrations are transmitted.

In the loudspeaker system of the present invention a high frequency diaphragm is energised by an energising system suitably a speech coil and is acoustically coupled to a low frequency diaphragm by an air space closed on all sides, in such a way that the area of that part of the low frequency diaphragm which lies adjacent to the enclosed air space and forms a portion of the surface of the enclosure is smaller than that part of the high frequency diaphragm which lies adjacent to the enclosed air space and similarly forms a portion of the surface of the enclosed. With this form of coupling, the transmission of movement is such that even a small movement of the high frequency diaphragm corresponds to a relatively greater movement of the low frequency diaphragm; the amplitude of movement of the high frequency diaphragm, that is to say, in relation

to that of the low frequency diaphragm, stands in a ratio of, for example, 1:3 to 1:5 or more.

This effect may be exemplified by reference to the modification of FIG. 1, the same explanations, however, are valid for the other embodiments.

When the high-frequency diaphragm 2 is energised and caused to vibrate by the speech coil, it is able, through being suspended by the bellows 10 and 11, to vibrate axially to and fro. Because of the compression of the enclosed air space behind the diaphragm, the low-frequency diaphragm will likewise carry out vibrations, these being transmitted across the air space to the central portion of the low-frequency diaphragm. The latter is able to vibrate axially to and from because motion in the axial direction can be imparted to it by reason of the bellows 5 and 8. The area of that part of the high-frequency diaphragm which bounds the air space is several times for example four times greater than that of the part of the low frequency diaphragm which lies adjacent to the said space. This results in a transmission ratio of 4:1 for example, between the surface areas, which produces a ratio of 1:4 in the amplitude of movement, related to the travel of the high and low frequency diaphragms respectively.

When the high-frequency diaphragm 2 carries out very rapid movements in the upper frequency range, these will no longer be transmitted to the low frequency diaphragm, because of the elasticity of the air within the enclosed air space. Slower vibrations, however, will bring about vibration of the low-frequency diaphragm. By suitable dimensioning of the air space in proportion to the diaphragm surface areas, the threshold frequency beyond which the low-frequency diaphragm is not set vibrating can be pre-determined as desired.

Coupling the two diaphragms together by means of the enclosed air space, moreover, enables the energisation of the low frequency diaphragm to be limited to a prescribed frequency range lying below an appropriately chosen limit frequency, for example, since, according to the volume of the air space in relation to the energising surface area, upper frequencies above the limit frequency will not be transmitted. It is thus possible, by suitably dimensioning the enclosed air space, to choose the threshold up to which the frequencies are transmitted from the high-frequency to the low frequency diaphragm.

The relationship between the maximum transmitted frequency and the surface area as well as the enclosed volume of air can be deducted from the book "acoustiek" published by DE MUIDERKRING, Bussum, Netherlands, pages 13 to 16.

As used herein the term "low frequency" means about 15 to about 250 suitably 15 to about 80 Hz and the term "High frequency" means frequencies of the medium — high range, for example about 80 to about 15,000 suitably 200 to about 15,000 Hz.

I claim:

1. A loudspeaker system comprising
 - an energising system,
 - a high frequency diaphragm having at least one pre-determined surface,
 - means for coupling said energising system to said high frequency diaphragm,
 - a low frequency diaphragm having at least one pre-determined surface,
 - Air-tight resilient means for physically connecting said predetermined surface of said high frequency

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diaphragm at the outer edge thereof with a portion of said predetermined surface of said low frequency diaphragm whereby a volume of air is totally enclosed between said high frequency diaphragm, said portion of said low frequency diaphragm and said physical connecting means, said predetermined surface of said high frequency diaphragm as defined thereon by said connecting means is greater in area than said portion of said surface of said low frequency diaphragm defined by said connecting means whereby a small movement of the high frequency diaphragm is transformed into a large movement of the low frequency diaphragm by the enclosed volume of air.

2. A loudspeaker system according to claim 1 wherein the energising system comprises a magnet system

located in a position adjacent to a surface of said high frequency diaphragm other than the said predetermined surface whereof a portion is connected with said means for physically connecting said high frequency diaphragm to said low frequency diaphragm.

3. A loudspeaker system according to claim 1 wherein said low frequency diaphragm has a conical cross section and

said means for physically connecting a portion of the predetermined surface of said high frequency diaphragm to said low frequency diaphragm is located upon said low frequency diaphragm so as to define upon the predetermined surface thereof an area encompassing the central portion of said low fre-

quency diaphragm wherein the axis of rotation of the cone defining the conical section of said low frequency diaphragm is also the axis of rotation of the area of surface thus defined.

4. A loudspeaker system in accordance with claim 1 wherein the said high frequency diaphragm and said low frequency diaphragm are of frusto conical cross section and said means for physically connecting a portion of the predetermined surface of said high frequency diaphragm with a portion of the predetermined surface of said low frequency diaphragm is so located that the portions of said predetermined surfaces thus defined are located so that the axis of rotation of said portions is other than the axis of rotation of the frusto conical section.

5. A loudspeaker system according to claim 4 wherein the axis of rotation of said low frequency diaphragm is substantially common with the axis of rotation of said high frequency diaphragm and

said high frequency diaphragm and said low frequency diaphragm lie in the same hemisphere of arc having a common axis of rotation with said conical section.

6. A loudspeaker system according to claim 5 wherein the angle of arc subtended by the high frequency diaphragm to said common axis of rotation is the same as that subtended by said low frequency to said axis of rotation.

7. A loudspeaker system according to claim 1 wherein said means physically connecting said high frequency to said low frequency diaphragm are rippled members.

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