

Aug. 19, 1941.

G. M. GIANNINI ET AL

2,252,846

ACOUSTIC DEVICE

Filed Sept. 30, 1938

4 Sheets-Sheet 1

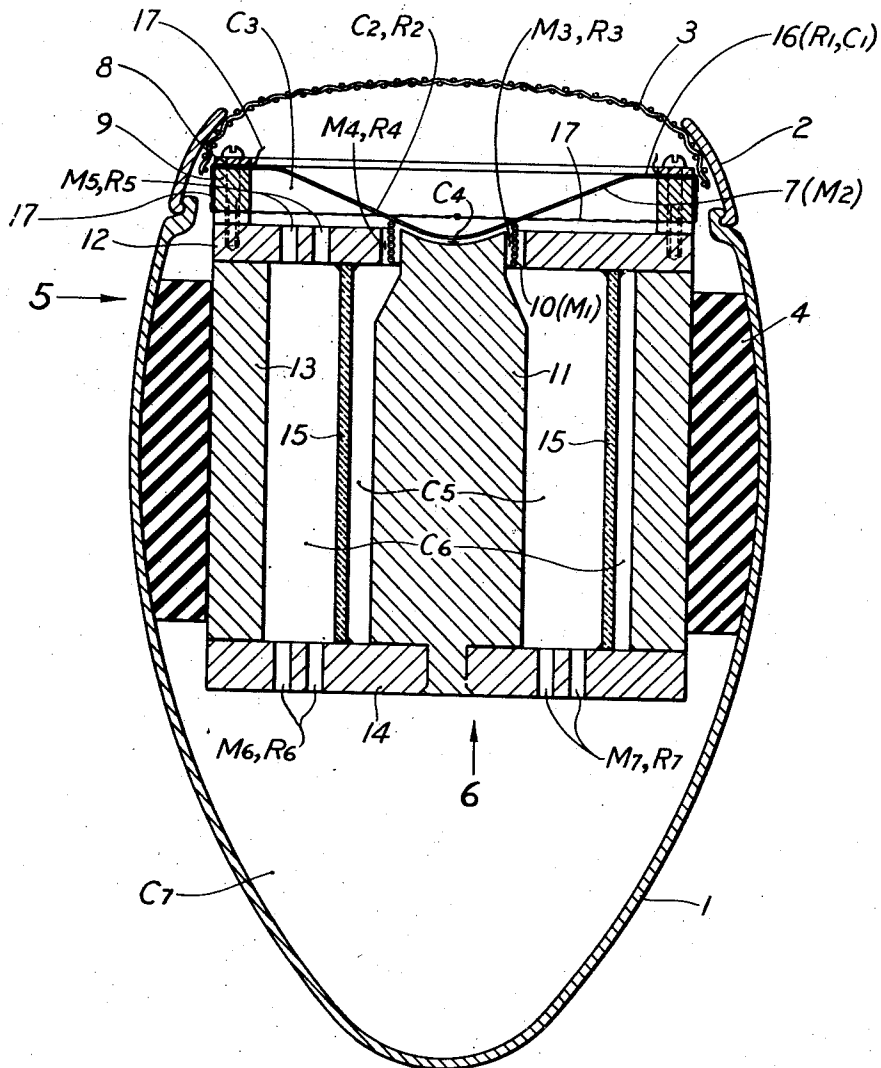


FIG. 1

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4 Sheets-Sheet 2

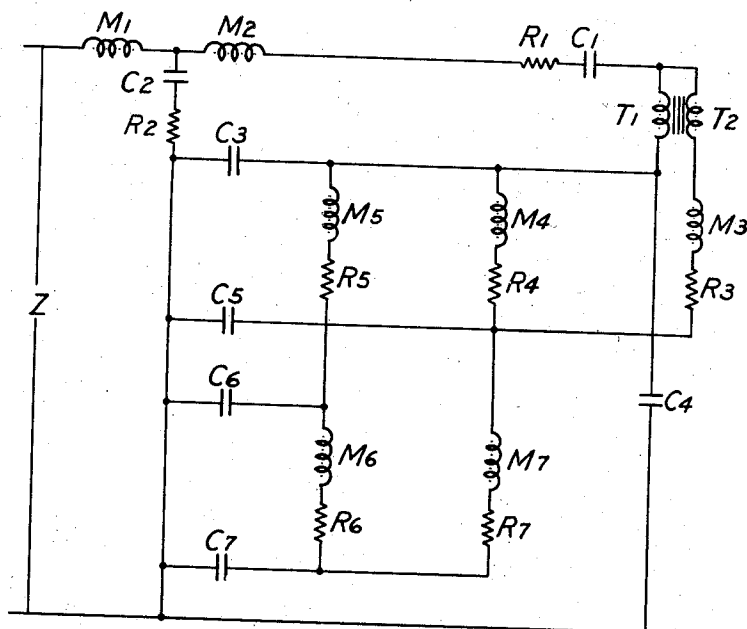


FIG. 2

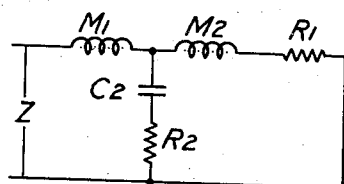


FIG. 7

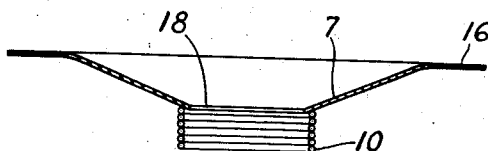


FIG. 8

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4 Sheets-Sheet 3

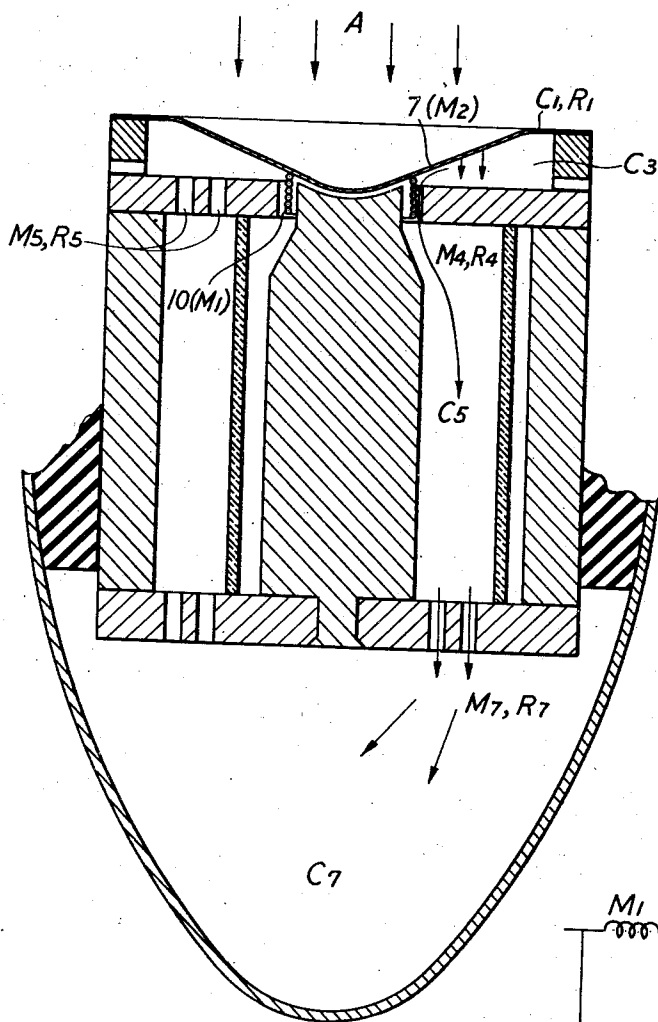
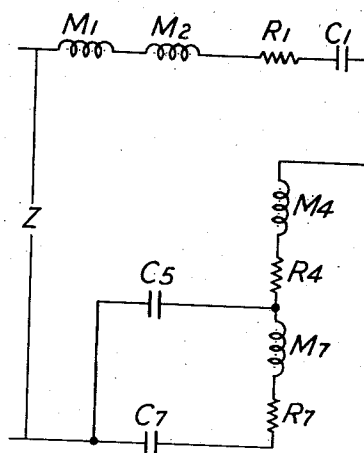


FIG. 3

FIG. 4



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4 Sheets-Sheet 4

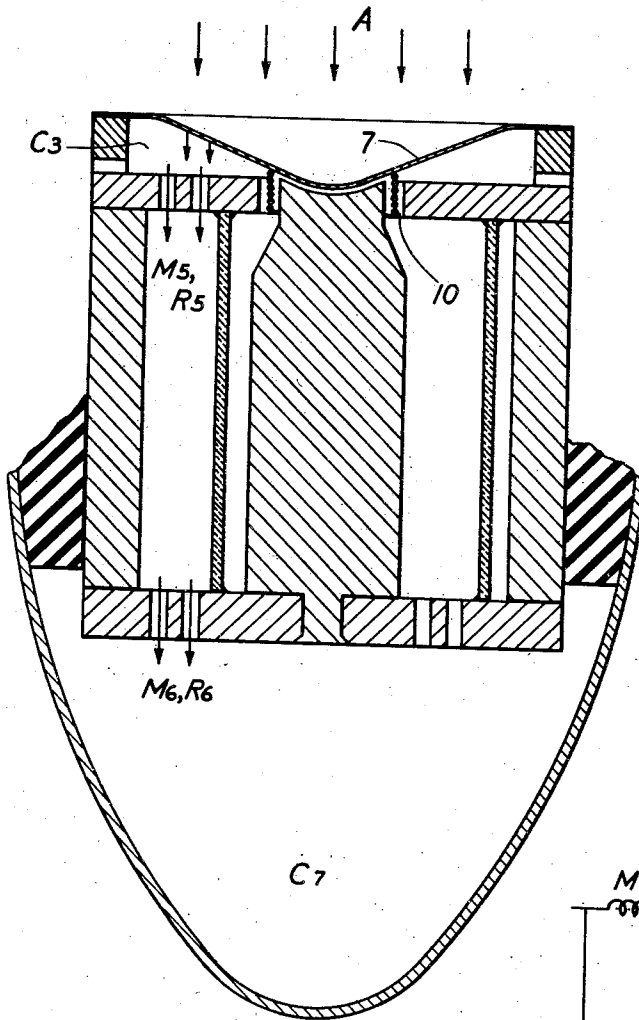
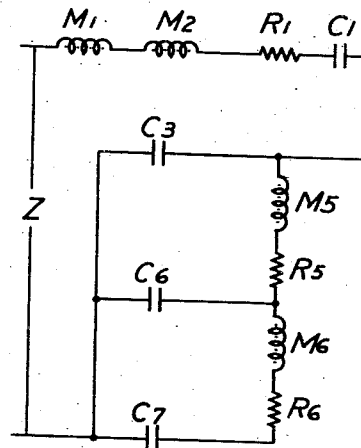


FIG. 5

FIG. 6



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UNITED STATES PATENT OFFICE

2,252,846

ACOUSTIC DEVICE

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Application September 30, 1938, Serial No. 232,658

5 Claims. (Cl. 179-180)

This invention relates to acoustic devices, and, more particularly, to electrodynamic translating devices of the type used as both microphone and loudspeaker in connection with switching devices whereby it is used alternately as microphone and loudspeaker.

An object of the invention is to improve the frequency response of a dynamic microphone, and to make a more sensitive dynamic microphone than has been made heretofore.

Another object is to construct a microphone of this class which is completely sealed against dust and moisture.

Another object is to improve the radiating qualities of a small electrodynamic device so as to make it useful as a loudspeaker without a baffle or cabinet.

Another object is to provide a shock-proof assembly in order to take advantage of new high coercive force magnets which are somewhat brittle.

A preferred embodiment of this invention comprises a transducer having a housing containing a voice coil and diaphragm assembly, a resilient mounting therefor, a magnetic structure having a longitudinally disposed core so arranged as to cause a constant magnetic flux to emanate from said core and permeate said voice coil, and various acoustic enclosures coupled to said diaphragm. In general, these consist of a small chamber behind and adjacent to the diaphragm, a pair of chambers within the magnetic structure with vents to the first-mentioned chamber, and a fourth chamber within the casing behind the magnetic structure, this being vented to each chamber within the magnetic structure.

The primary factors which combine to give good sensitivity as a microphone and good low-frequency radiation as a loudspeaker are the large number of acoustic resonances induced throughout the frequency range by the various acoustic chambers, the great flexibility with which the diaphragm and voice coil assembly are suspended and the specific acoustic labyrinth by which the effective mass of the diaphragm is augmented at low frequencies by air flowing past the voice coil into the inner air chamber surrounding the voice coil within the magnetic structure.

The specific manner in which this is made to occur will be explained in connection with the drawings, in which

Fig. 1 is a sectional view of an acoustical device constituting a preferred embodiment of this invention.

Fig. 2 is a diagram of an electrical circuit in which the various elements and their arrangements are mathematically analogous to the microphone of Fig. 1.

Fig. 3 is a schematic sectional view of the same microphone as Fig. 1 showing the principal acoustic flow paths which occur at very low frequencies.

Fig. 4 is a simplification of Fig. 2 in which all elements not important at low frequencies have been omitted.

Fig. 5 is a schematic sectional view similar to Fig. 3 but showing the principal acoustic flow paths which occur at a high frequency.

Fig. 6 is a simplification of Fig. 2 in which all elements not important at high frequency have been omitted.

Fig. 7 is another simplification of Fig. 2 in which all elements not specifically important at very high frequencies have been omitted.

Fig. 8 is an alternative diaphragm construction.

The transducer shown in Fig. 1 is in general comprised of a housing 1, a snap-on front rim 2 for said housing, a front screen 3, a resilient bushing member 4, and an inner unit designated as assembly 5. This assembly is comprised of the magnetic assembly 6 and additional parts including the diaphragm 7 and clamping rings 8 and 9. The voice coil 10 is affixed to the diaphragm 7 as indicated, and is mainly disposed in the air gap formed between the pole core 11 and the flat plate 12. The magnet 13 is of annular shape and is clamped between the pole plate 12 and the opposing pole plate 14 in any convenient manner, many of which are well known in the art.

The chamber bounded on the outside by the magnet 13 is divided into two annular chambers C_5 and C_6 by the cylindrical partition member 15 which is sealed at its ends to the pole plates 12 and 14. The outer chamber C_6 is vented to the chamber C_3 adjoining the diaphragm 7 by a plurality of apertures in plate 12, the aggregate inertance and resistance of which are designated by M_5 and R_5 , respectively. The outer chamber C_6 is also vented through the plate 14 by orifices having an aggregate inertance and resistance M_6 , R_6 , respectively. The inner chamber C_5 is vented through the plate 14 by orifices having an aggregate inertance and resistance of M_7 , R_7 , respectively.

The compliance in mechanical units of the various chambers is C_3 , C_5 , C_6 and C_7 , the figures

referring to the various chambers as indicated in Fig. 1.

The diaphragm assembly is comprised of the diaphragm 7 having a generally conoidal shape, rounded in the middle to avoid the necessity for deeply undercutting the pole core 11. The diaphragm 7 is affixed around its outer periphery to the flat ring 16, of varnished silk, which is rigidly affixed at its outer periphery between the clamping rings 8 and 9. Two threads 17 are passed through close-fitting holes in the diaphragm 7 and fastened in holes in ring 9, said threads being cemented into the diaphragm where they pass through it. In this manner a positive centering control for the voice coil 10 is assured without the introduction of appreciable stiffness into the system.

The performance of this device may be explained to persons skilled in the art of electric circuit analysis by reference to the circuit mathematically equivalent to the acoustic-mechanical structure.

An efficiency has been attained in this device far in excess of any previously-developed device of this class, by dividing the audible frequency band into a number of bands and making specific provision in the structure for lowering the acoustic and mechanical impedance in each band until the desired performance was attained.

The complete equivalent electrical circuit is shown in Fig. 2. The electrical elements are labelled with the same letters and subscripts as their mechanical or acoustic equivalents. The elements not heretofore described are as follows: C_2R_2 represent the compliance and resistance within the structure of the diaphragm 7 in the annular region thereof juxtaposed to the voice coil 10. C_4 is the compliance (very small) of the chamber bounded by the middle of the diaphragm 7 and the end of the pole core 11. T_1 — T_2 represent an electrical transformer (included only for the purpose of maintaining a strict analogy) which is intended to take into account the fact that the volume of air flow through the inner side of the voice coil 10 (a slit having inductance M_3 and resistance R_3) is much less than that through the outer side thereof because the diaphragm area within the voice coil is much less than that outside of said voice coil. The turn ratio $T_1:T_2$ is therefore in the proportion of inner area and outer area.

Since the complete equivalent circuit of Fig. 2 is very complicated, simplified circuits have been worked out in combination with charts of the acoustic system, simplified with a view towards showing the manner in which various acoustic resonances tend to accentuate the response of the device. Figs. 3 and 4 may be considered together for the purpose of explaining the action of the device at extremely low frequencies, say 60 cycles per second. Acoustic waves A impinging upon the diaphragm 7 cause motion of said diaphragm, compressing the air in chamber C_3 and forcing some air through the slit around the voice coil 10 which has inductance M_4 and resistance R_4 . This air then passes into chamber C_5 , then through the orifices M_7 R_7 into chamber C_7 . The slit M_4 has very small cross-section and consequently the inductance M_4 is high. This inductance M_4 adds effectively to the masses M_1 and M_2 of the voice coil and diaphragm respectively, and since inductance M_7 is made low, the effective compliance of chamber C_5 is directly additive to that of chamber C_7 , which is large. Due to the high effective mass

of the system and the lowered compliance, a low natural resonance frequency results, with high sensitivity of action, and with no connection between the rear of the diaphragm and the outer atmosphere. The equivalent circuit of Fig. 4 may be used for calculations by inserting suitable numerical values for the various elements. It may be mentioned in connection with the discussion of air flow that relatively little air passes through the vents M_5R_5 at low frequencies because they are padded with a predetermined amount of acoustic resistance material such as cotton, wool or silk yarn or felt.

In a similar manner the operation of the system at a fairly high frequency, say 3,000 cycles, may be explained by reference to Figs. 5 and 6. Sound waves A impinging upon the diaphragm 7 cause compression of air in chamber C_3 . Due to the high inductance of the air around the voice coil 10, no air can pulsate past it at high frequencies and it chooses the lower inductance path through the vents M_5R_5 into chamber C_5 , then through the vents M_6R_6 into chamber C_7 . Since each vent is padded the acoustic resistance is high and the entire acoustic system constitutes an acoustic damping system, by which a certain degree of resonance is built up between the voice coil and diaphragm masses and the compliance of chamber C_3 ; then this resonance is nicely damped by the coupling to C_3 of the remaining acoustic orifices and chambers. This results in a system which is extremely sensitive within the frequency range considered.

This sensitivity is due not merely to the two resonances specifically described in connection with Figs. 3 and 5, but to a number of other resonances occurring in the frequency range between these two resonances. For instance, the transition between the frequencies at which air can and cannot pass through the voice coil slit is gradual, and various resonances occur between the masses of the voice coil, diaphragm and the slit inductance on one hand and the compliances of chambers C_3 , C_5 , C_6 and C_7 on the other hand.

The mass of the diaphragm 7 varies with frequency, becoming progressively less as the frequency is raised. This is a well-known characteristic of conoidal diaphragms. It is taken advantage of in this device to introduce an additional resistance at the upper end of the frequency spectrum utilized, say around 4000 cycles. This is indicated in the equivalent of Fig. 7, C_2 and R_2 having been hereinbefore described as the compliance and resistance properties of the diaphragm in the annular region adjacent to the voice coil 10. The resonance between M_1 , C_2 and M_2 is valuable in maintaining the response at a high level for an additional frequency band.

When the device is used as a loudspeaker, the previous discussion remains valid except that instead of "response" it has "radiation" of substantially the same proportional degree of efficiency.

When a given acoustic translating device is used as both microphone and loudspeaker, it will not necessarily have the same frequency response in each application. In the case of this particular device, flat over-all response of the combination of one unit used as a microphone, connected to another unit used as a reproducer, is obtained under the condition that the unit should have a frequency response as a microphone which should be progressively more sensitive at low frequencies; while the same device used as a loudspeaker would sound progressively

louder as the frequency is increased, up to its cutoff frequency.

In an alternative construction, the diaphragm 7 may have its central portion 18 cut out as shown in Fig. 8. This makes it unnecessary to machine out the end of the pole core 11 to clear the tip of the diaphragm as was indicated in Fig. 1.

Other modifications of this device will occur to those skilled in the art.

What is claimed is:

1. In an electro-acoustic translating device, in combination, a voice coil and diaphragm assembly, resilient mounting means therefor, a magnetic structure having a longitudinally disposed core so arranged as to cause a constant magnetic flux to emanate from said core and permeate said voice coil, means for enclosing the side of said diaphragm disposed toward said magnetic structure, means for dividing the air volume within said magnetic structure into a plurality of chambers one of which surrounds and extends the full length of said core and the other of which surrounds the full length of said first chamber, an additional acoustic enclosure abutting on said magnetic structure, and a plurality of acoustic vents in one end of said magnetic structure connecting each of said plurality of chambers with said additional inclosure, whereby a plurality of acoustic inertances and compliances are constituted and made to reenforce the action of said diaphragm over a wide frequency band.

2. In an electro-acoustic translating device, in combination, a voice coil and diaphragm assembly, resilient mounting means therefor, a magnetic structure having a longitudinally disposed core so arranged as to cause a constant magnetic flux to emanate from said core and permeate said voice coil, means for enclosing the side of said diaphragm disposed towards said magnetic structure, means for dividing the air volume within said magnetic structure into a plurality of chambers one of which surrounds and extends the full length of said core and the other of which surrounds the full length of said first chamber, a housing, an additional acoustic enclosure abutting on said magnetic structure and bounded by said magnetic structure and said housing, and a plurality of acoustic vents in one end of said magnetic structure connecting each of said plurality of chambers with said additional inclosure, whereby a plurality of acoustic inertances and compliances are constituted and made to reenforce the action of said diaphragm over a wide frequency band.

3. In an electro-acoustic translating device, in combination, a voice coil and diaphragm assembly, resilient mounting means therefor, a magnetic structure having a longitudinally disposed core so arranged as to cause a constant magnetic flux to emanate from said core and permeate said voice coil, means for enclosing the side of said diaphragm disposed towards said magnetic structure to form a first acoustic chamber, an annular partition member surrounding the full length of said core and disposed in spaced relationship therefrom for dividing the air volume within said

magnetic structure into a plurality of chambers one of which surrounds and extends the full length of said core and the other of which surrounds the full length of the chamber surrounding the core, and a plurality of acoustic vents in one end of said magnetic structure connecting said first chamber and one of said plurality of chambers within said magnetic structure, and an air gap for said voice coil constituting an acoustic vent between said first chamber and another of said plurality of chambers within said magnetic structure, whereby a plurality of acoustic inertances and compliances are constituted and made to reenforce the action of said diaphragm over a wide frequency band.

4. In an electro-acoustic translating device, in combination, a voice coil and diaphragm assembly, resilient mounting means therefor, a magnetic structure having a longitudinally disposed core so arranged as to cause a constant magnetic flux to emanate from said core and permeate said voice coil, means for enclosing the side of said diaphragm disposed towards said magnetic structure to form a first acoustic chamber, an annular partition member surrounding the full length of said core and disposed in spaced relationship therefrom for dividing the air volume within said magnetic structure into a plurality of chambers one of which surrounds and extends the full length of said core and the other of which surrounds the full length of the chamber surrounding the core, said partition member being eccentrically disposed with respect to said core, and a plurality of acoustic vents in one end of said magnetic structure connecting said first chamber and one of said plurality of chambers within said magnetic structure, and an air gap for said voice coil constituting an acoustical vent between said first chamber and the chamber surrounding said core, whereby a plurality of acoustic inertances and compliances are constituted and made to reenforce the action of said diaphragm over a wide frequency band.

5. In a sound translating device, a voice coil and diaphragm assembly, a magnetic structure therefor, means for enclosing said magnetic structure and the side of said diaphragm assembly including said voice coil, a first acoustic chamber formed thereby between the pole face of said magnetic structure and said diaphragm, a second acoustic chamber formed thereby between the rear of said magnetic structure and said enclosing means, a third and fourth acoustic chamber within said magnetic structure, a plurality of acoustic vents in both ends of said magnetic structure acoustically connecting said third chamber with said first and second chambers to enhance the action of said diaphragm at high frequencies, an air gap for said voice coil in the pole face of said magnetic structure, a plurality of acoustic vents in the rear of said magnetic structure, said air gap and said vents acoustically connecting said fourth chamber with said first and second chambers to enhance the action of said diaphragm at low frequencies.

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