

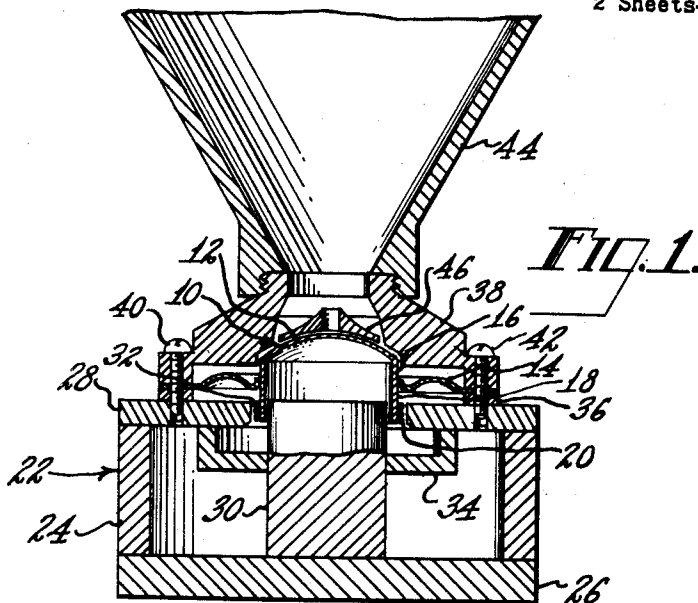
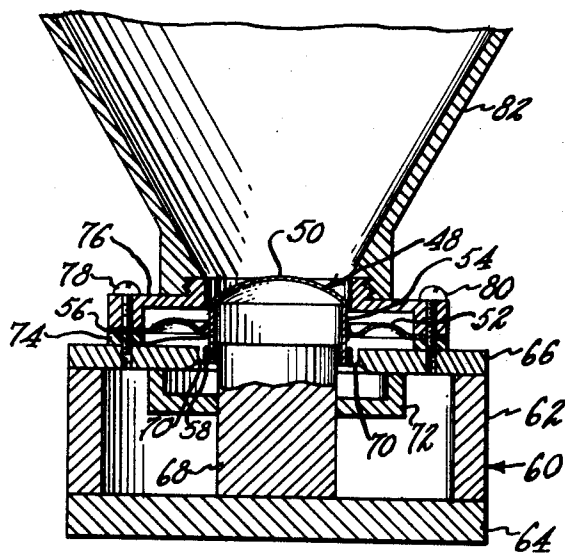
June 21, 1960

A. L. WITCHEY
HORN-TYPE TRANSDUCER

2,942,071

Filed Oct. 1, 1954

2 Sheets-Sheet 1



INVENTOR.
ALBERT L. WITCHEY
BY *Marish Rabin*
ATTORNEY

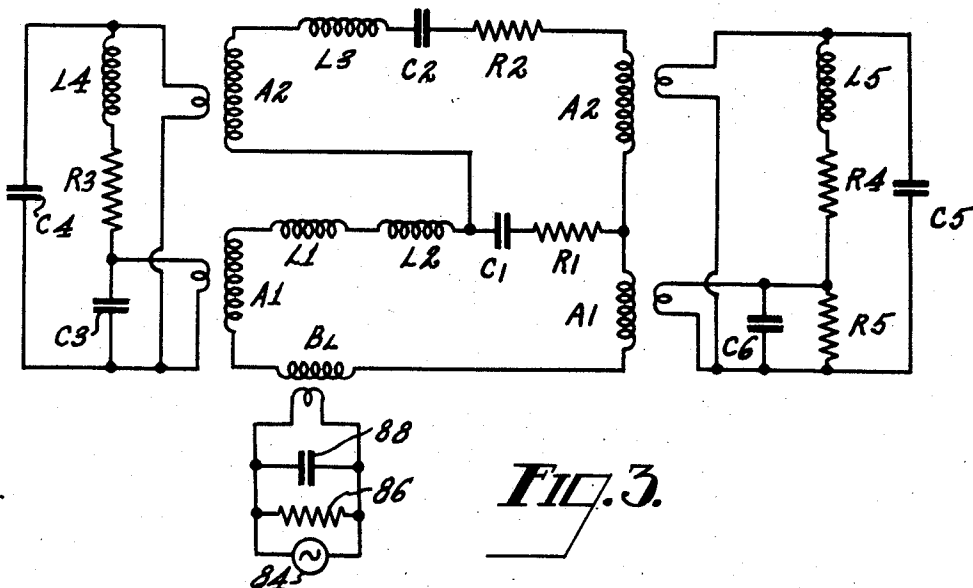
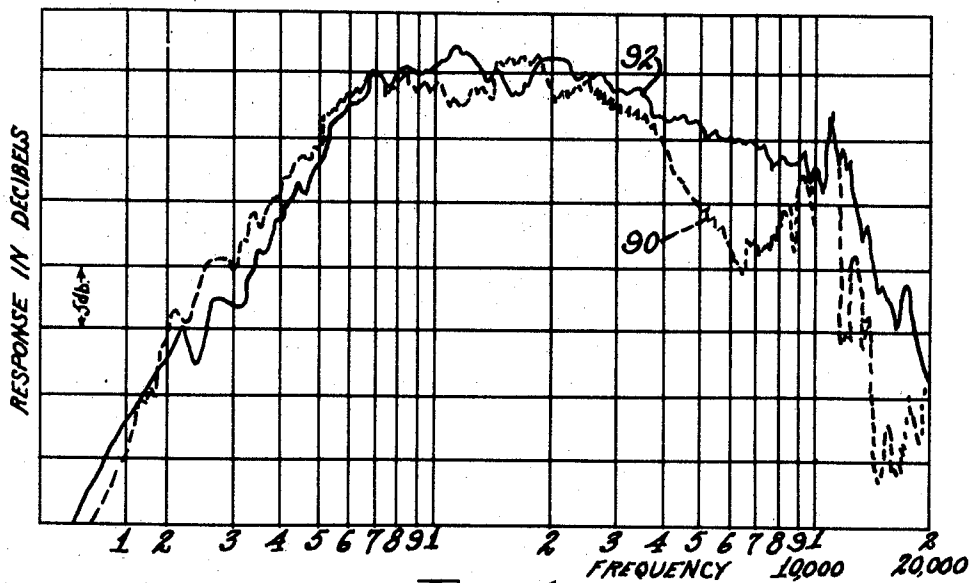
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ALBERT L. WITCHEY
BY *Marish Rabkin*
ATTORNEY

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HORN-TYPE TRANSDUCER

Albert L. Witchey, Pennsauken, N.J., assignor to Radio Corporation of America, a corporation of Delaware

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9 Claims. (Cl. 179-115.5)

This invention relates to transducers, and particularly to an improved diaphragm for improving the overall frequency response of a transducer.

In many types of transducers, a vibratile element, such as a diaphragm, is employed. These diaphragms usually include an edge portion and a central portion. Very often the acoustical coupling between the edge and central portions of the diaphragm reduces the frequency response of the transducer at high audio frequencies. A type of transducer in which the high frequency response is reduced involves horn-type mechanisms, although, of course, this problem is not restricted to such types.

When horn mechanisms are used for indoor applications, the radiation is generally taken off the voice coil side of the diaphragm. One advantage of such an arrangement is that it provides acoustic isolation between the diaphragm edge suspension and the central dome portion. This isolation is provided by the high acoustic impedance path formed on either side of the voice coil and the pole pieces in the magnetic structure associated with the diaphragm. Since this acoustic impedance is essentially inductive, the isolation is negligible at low audio frequencies and high at high audio frequencies. This isolation effectively reduces the large lateral dimension of the diaphragm directly coupled to the horn throat, thereby keeping the required number of openings at the throat to a minimum. Another advantage of this acoustic isolation is that it serves to decouple the non-piston-like clamp suspension edge of the diaphragm from its stiffened central portion.

For outdoor applications of horn-type mechanisms, the radiation is usually taken off the diaphragm side away from the voice coil. This arrangement is employed to protect the voice coil from adverse weather conditions. However, the advantages resulting from the acoustic isolation between the diaphragm edge suspension and the central dome portion, heretofore mentioned in connection with indoor type mechanisms, are ordinarily not present.

Directional type microphones often involve complicated structures involving proper balancing of the elements used. A horn used in conjunction with an ordinary pressure microphone would find much utility since the manufacturing of such microphones would be relatively inexpensive.

It is an object of this invention to provide an improved horn-type transducer.

It is a further object of this invention to provide an improved horn-type transducer having substantially uniform frequency response over a wide frequency range.

It is a further object of this invention to provide an improved directional loudspeaker.

It is still a further object of this invention to provide an improved directional microphone.

In accordance with the present invention, a transducer includes a vibratile element having a suspension ring, a central dome and a neck. The neck connects the suspension ring with the central dome and extends in one

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direction. A high acoustic impedance path between the suspension ring and the central dome of the diaphragm is attained in accordance with the present invention by means associated with the neck of the diaphragm.

Other objects and advantages of the present invention will become apparent and suggest themselves to those skilled in the art to which the invention relates from a reading of the following specification in conjunction with the drawings, in which:

Figure 1 is a sectional view of a horn-type loudspeaker embodying the present invention;

Figure 2 is a sectional view of a horn-type microphone embodying the present invention;

Figure 3 shows an equivalent circuit for the horn-type loudspeaker shown in Figure 1; and

Figure 4 shows a curve representing the frequency response of a loudspeaker embodying the present invention in comparison with a loudspeaker of the usual type.

Referring to Figure 1, a diaphragm 10 includes a central dome 12, a suspension ring 14 and an extended portion or neck 16. The neck connects the suspension ring with the central dome and extends in the direction of radiation, as indicated. A voice coil form 18, having a voice coil 20 attached thereto, extends in a direction opposite to the direction of the neck. The voice coil form may be suitably attached to the diaphragm or may be integral therewith.

A magnetic structure 22 includes a ring magnet 24, a bottom plate 26 and a top plate 28. The top plate 28 provides the outer pole piece for the magnetic structure. A cylindrical member 30 is centrally disposed within the magnetic structure and provides the inner pole piece for the magnetic structure. The inner and outer pole pieces are spaced to provide an annular air gap 32. A centering ring 34, which may be made of brass or other nonmagnetic material, is provided to maintain proper spacing between the pole pieces forming the air gap.

Means for mounting the diaphragm 10 to the magnetic structure 22 include a spacing ring 36 between the top plate 28 and the diaphragm 10. A horn coupling member 38 rests upon the outer periphery of the diaphragm. The assembly including the horn coupling member, the diaphragm and the spacing ring are suitably secured to the top plate 28 by means of screws 40 and 42, or other holding means.

The horn coupling member 38 threadedly engages a horn 44. A throat piece 46 is provided in front of the central dome of the diaphragm toward the ambient to improve the frequency response of the loudspeaker. The space in front of the diaphragm is considered the load into which the mechanical vibrations of the diaphragm works.

The horn coupling member has a portion of its inward surface associated with the neck of the diaphragm to provide a narrow air path therebetween. This narrow air path provides an acoustic impedance which is essentially inductive. The inductance provides an acoustic isolation between the suspension ring 14 and the central dome 12 at high audio frequencies. Thus, the independent vibrations of the suspension ring at high audio frequencies will not be coupled to the central dome portion. At low audio frequencies, the acoustic impedance is small, thereby providing direct coupling between the suspension ring and the central dome portion. However, the vibration of the suspension ring at low audio frequencies is not an important factor in most horn-type transducers.

It is therefore seen that the high audio frequency response of a loudspeaker embodying the present invention is improved. This improvement in frequency response is illustrated in Figure 4 and will be described further in connection therewith. The improved diaphragm illustrated therein may be used in other types of transducers,

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other than the one described, when it is desired to decouple the central portion from the edge portion of a diaphragm.

Referring to Figure 2 of the drawing, there is illustrated a microphone embodying the present invention which includes a diaphragm 48. This diaphragm is similar in many respects to the one illustrated in Figure 1 and includes a central dome 50, a suspension ring 52 and an extended neck 54. A voice coil form 56, having a voice coil 58 attached thereto, is attached to the diaphragm and extends in a direction opposite to the directions of the neck 54.

A magnetic structure 60 includes a ring magnet 62, a bottom plate 64 and a top plate 66. The top plate 66 provides the outer pole piece for the magnetic structure. A cylindrical member 68 is centrally disposed within the magnetic structure and provides the inner pole piece. The pole pieces 66 and 68 are spaced to provide an air gap 70 therebetween. A brass centering ring 72 is provided to insure proper spacing between the pole pieces.

As was the case in the loudspeaker illustrated in Figure 1, the diaphragm is suitably attached to the magnetic structure 60. A spacing ring 74 is provided between the diaphragm 48 and the top pole piece 66 and a horn coupling member 76 rests upon the diaphragm in place. The assembly including the horn coupling member, the diaphragm and the spacing ring is suitably attached to the top plate 66 of the magnetic structure by means of screws 78 and 80. A horn 82 threadably engages the horn coupling member. No throat pieces are employed in this microphone. This device further differs from the device shown in Figure 1 in that the front of the entire central dome of the diaphragm is coupled to the ambient. Of course, in practice the microphone is generally made much smaller than the loudspeaker, although both embodiments shown in the drawings are shown as being the same size for purposes of clarity.

It is seen that a portion of the horn coupling member 76 is associated with the neck portion 54 of the diaphragm to provide a narrow air path therebetween. This air path may be considered inductive and therefore provides a high impedance to high audio frequencies. The high impedance prevents the vibrations of the suspension ring from being coupled to the central dome of the diaphragm thereby improving the frequency response of the microphone at high audio frequencies.

Referring particularly to Figure 3, there is shown an equivalent electrical circuit for the loudspeaker illustrated in Figure 1. A source of electrical energy 84 is connected across a resistor 86 and a capacitor 88, representing the electrical elements of the voice coil. The internal impedance of the generator is not shown. This electrical energy is introduced into the loudspeaker and translated into mechanical energy.

The electrical energy applied to the mechanical structure to be converted into mechanical energy is represented by B_T . The value of this electrical energy depends upon various factors including the input voltage of the electrical signal, the strength of the magnetic field within which the voice coil is disposed, the number of turns of the winding in the voice coil and the relative thickness of the voice coil.

A_1 represents the area behind the central dome 12 of the diaphragm 10. The differences in the "A's" or areas, in the circuit shown correspond to the turns ratio of the transformers shown. L_1 represents the mechanical inductance of the voice coil 20. L_2 represents the mechanical inductance of the central dome 12 of the diaphragm 10. C_1 represents the mechanical compliance between the central dome 12 and the suspension ring 14 of the diaphragm 10. R_1 represents mechanical resistance between the central dome 12 and the suspension ring 14.

In parallel with C_1 and R_1 is a series circuit including A_2 , which represents the projected area of the suspen-

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sion ring 14. L_3 , C_2 and R_2 represent the mechanical inductance, compliance and resistance, respectively, of the suspension ring 14.

The area represented by A_2 is coupled across a network including L_4 and R_3 , representing the inductance and resistance, respectively, of the air paths between the voice coil 20 and the inner and outer pole pieces 28 and 30. In series with L_4 and R_3 is a compliance C_3 , which represents the volume in back of the central dome 12 of the diaphragm 10. Shunting L_4 , R_3 and C_3 is a compliance C_4 representing the volume between the suspension ring 14 and the outer pole piece 28. It is noted that the area A_1 is also directly coupled across C_3 .

The area represented by A_2 is also coupled across a network comprising L_5 , R_4 and R_5 . L_5 represents the mechanical inductance between the central dome 12 of the diaphragm 10 and the horn coupling member 38. R_4 represents the mechanical resistance in the air path between the central dome 12 of the diaphragm 10 and the horn coupling member 38. R_5 represents the load for the horn, which is the ambient or air space in front of the diaphragm. It is the power delivered across R_5 which determines the efficiency with which the horn mechanism operates. L_5 , R_4 and R_5 are shunted by a compliance C_5 , which represents the volume between the suspension ring 14 and the horn coupling member 38. The compliance between the central dome 12 of the diaphragm 10 and the throat piece 46 is represented by C_6 , which is in parallel with R_5 .

In considering the circuit illustrated, it is noted that at low audio frequencies L_5 offers a relatively low impedance. In this case most of the signal voltage will be applied across the load R_5 . At high audio frequencies, L_5 has a relatively high impedance. Thus, very little of the voltage coupled from the diaphragm suspension ring 14 will be coupled to the central dome 12 to be applied across the load, represented by R_5 . It is seen that the neck portion 16 of the diaphragm 10 associated with other means, such as the horn coupling member 38, provides a convenient means of decoupling the vibrations of the suspension ring 14 from the central dome 12 of the diaphragm 10 at high audio frequencies.

Referring particularly to Figure 4, there is shown the output in decibels plotted against the frequencies to be reproduced by a conventional loudspeaker and a loudspeaker embodying the present invention. A response curve 90 represents the output of a conventional horn-type loudspeaker not employing the type of diaphragm having a neck as embodied in the present invention. A curve 92 represents the response curve of a loudspeaker embodying the present invention. It is noted that substantially uniform frequency response is attained in the loudspeaker utilizing the present invention, especially at high audio frequencies. The response of the conventional loudspeaker shows a definite dip in response at high audio frequencies.

Although the present invention has been described in connection with horn-type mechanisms, it is understood that various other types of transducers may utilize the novel diaphragm disclosed.

What is claimed is:

1. A transducer comprising a vibratile element having an edge portion, a central portion and a portion connecting said edge portion with said central portion and disposed in the direction of vibration of said element, and means associated with said connecting portion to define therewith a path adjacent said connecting portion having an acoustic impedance higher than the acoustic impedance of the area in said transducer adjacent said edge portion or said central portion.

2. A transducer comprising a vibratile element having an edge portion, a central portion and a portion connecting said edge portion with said central portion and disposed in the direction of vibration of said element, said

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connecting portion having inner and outer surfaces, and means associated with said outer surface of said connecting portion to define therewith an air path adjacent said outer surface providing a higher acoustic impedance than the acoustic impedance of the area adjacent said edge portion or said central portion.

3. The combination in a transducer adapted to radiate sound signals into the ambient which comprises a vibratile element having a surface facing said ambient, an edge portion and an extended portion, said extended portion having inner and outer surfaces, said extended portion directly connecting said edge portion with said central portion and being disposed in the direction of vibration of said element, and means associated with said outer surface of said extended portion to define therewith an air path adjacent said outer surface of said connecting portion to provide a higher acoustic impedance than the acoustic impedance of the area adjacent said edge portion or said central portion of said vibratile element.

4. In a horn-type transducer, the combination comprising a movable diaphragm, said diaphragm including a suspension ring, a central dome and a neck, said neck connecting said suspension ring with said central dome and extending in the direction of movement of said diaphragm, a voice coil form attached to said diaphragm extending from said neck portion in an opposite direction thereto, a voice coil disposed on said voice coil form, a magnetic structure, said magnetic structure having inner and outer pole pieces forming an air gap therebetween, means for mounting said diaphragm to said magnetic structure with said voice coil being disposed within said air gap, and means associated with said neck of said diaphragm to provide a narrow air path between said suspension ring and said central dome of said diaphragm adjacent said neck than adjacent said suspension ring and central dome.

5. In a horn-type transducer, the combination comprising a vibratile element, said vibratile element including a compliant ring, a stiff central portion and an annular portion connecting said compliant ring with said stiff central portion and extending only in the direction of vibration of said element, a voice coil, means for attaching said voice coil to said element extending in a direction away from said central portion, a magnetic structure, said magnetic structure having inner and outer pole pieces forming an air gap therebetween, means for mounting said vibratile element to said magnetic structure with said voice coil being disposed within said air gap, and a frame member associated with said magnetic structure, said frame member having an annular inner surface in closely spaced relation with said annular connecting portion of said vibratile element to provide a path between said compliant ring and said central portion of said vibratile element adjacent said annular connecting portion having a higher acoustic impedance at high audio frequencies than the area adjacent said central portion or said ring.

6. In a horn-type transducer, the combination comprising a vibratile element, said element including a suspension ring, a central dome and a cylindrical neck disposed in the direction of vibration of said element, a magnetic structure including an air gap, a voice coil associated with said vibratile element and adapted to be moved in said air gap, means for mounting said vibratile element to said magnetic structure with said voice coil disposed within said air gap, said voice coil extending in a direction opposite to said neck, and means associated with said neck to provide a narrower air path, adjacent said neck between said suspension and said central dome than adjacent thereto.

7. In a horn-type loudspeaker, the combination comprising a movable diaphragm, said diaphragm including an outer ring, a central dome portion and a neck portion, said neck portion connecting said suspension ring

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with said central dome portion and extending only in the direction of movement of said diaphragm, a voice coil form attached to said diaphragm extending in a direction opposite to said direction of said neck, a voice coil disposed on said voice coil form, a magnetic structure, said magnetic structure having inner and outer pole pieces forming an air gap therebetween, means for mounting said diaphragm to said magnetic structure with said voice coil disposed within said air gap, a horn coupling member, said horn coupling member having a portion presenting a surface spaced closer to said neck of said diaphragm than to said ring and said central dome to provide a narrow air path therebetween, and said air path presenting a higher acoustic impedance path between said suspension ring and said central dome of said diaphragm for high audio frequencies than the area adjacent said ring and said dome.

8. In a horn-type microphone, the combination comprising a vibratory element, said element including a compliant outer portion and a stiff central portion, a substantially cylindrical collar member connecting said outer portion with said stiff central portion of said element, said collar member extending in the direction of vibratory movement of said element, a voice coil form attached to said diaphragm extending in a direction opposite to said direction of said collar member, a voice coil disposed on said voice coil form, a magnetic structure having inner and outer pole pieces forming an air gap therebetween, means for mounting said diaphragm to said magnetic structure with said voice coil being disposed within said air gap, and a member associated with said collar presenting a cylindrical surface to provide therewith a narrow cylindrical air path between said outer and central portion of said vibratory element.

9. In a horn-type transducer, the combination comprising a vibratile element having two surfaces, one of said surfaces being exposed to the ambient, said vibratile element having a compliant outer ring, a stiff central dome and a substantially cylindrical collar member connecting said outer ring with said central dome, said collar member extending in a direction from said outer ring towards the ambient, a voice coil form extending in a direction opposite to said collar member, a voice coil disposed on said voice coil form, a magnetic structure, said magnetic structure having inner and outer pole pieces forming an air gap therebetween, means for mounting said diaphragm to said magnetic structure with said voice coil disposed within said air gap, and a member having a cylindrical inner surface associated with said collar member to provide a narrow cylindrical air path between said outer ring and said central dome on the side of said vibratile element exposed to the ambient whereby said air path provides a high impedance for high audio frequencies.

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