Sept. 27, 1966 W. S. DUNNING 3,275,100

LOUDSPEAKER ASSEMBLY HAVING LOUDSPEAKER WHOLLY SUPPORTED BY VIBRATORY DIAPHRAGM

Filed June 16, 1965 4 Sheets-Sheet 1

Fig. 1.

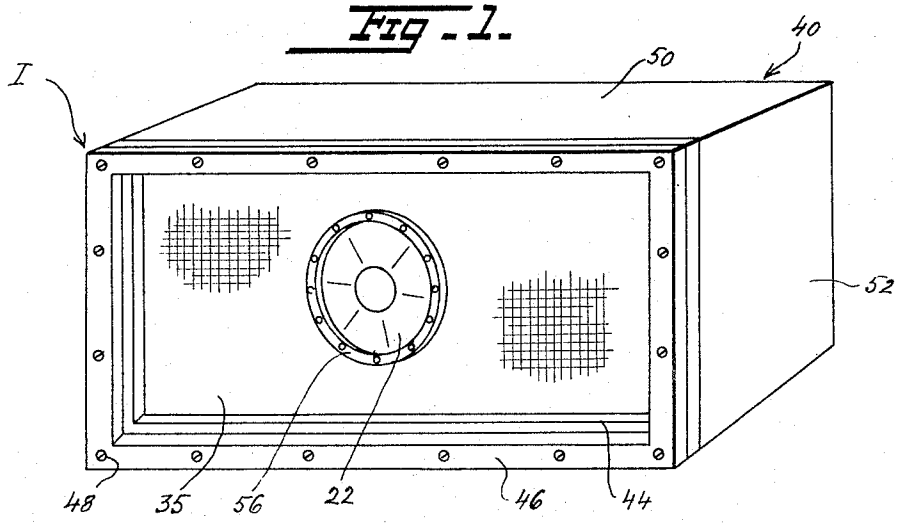
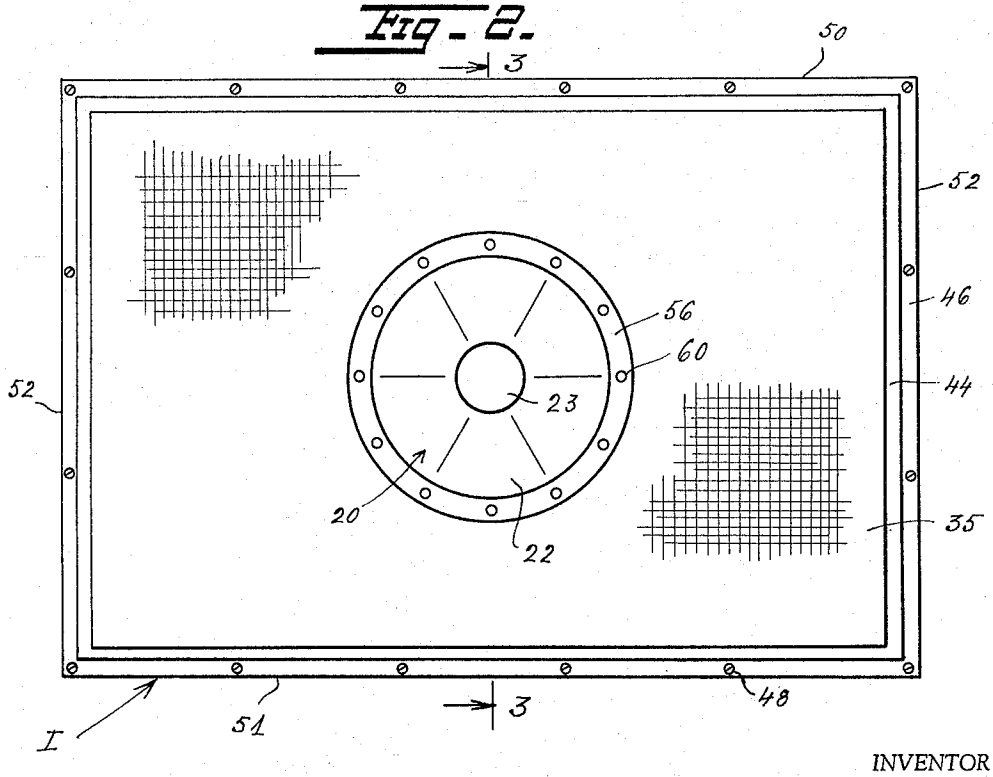


Fig. 2.



INVENTOR

William S. Dunning

BY Polachek & Saulsbury

ATTORNEYS.

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Fig. 3.

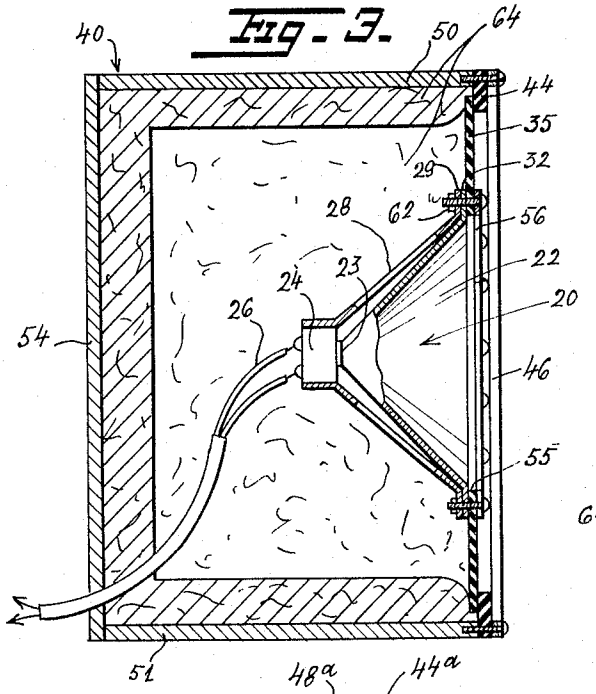


Fig. 4.

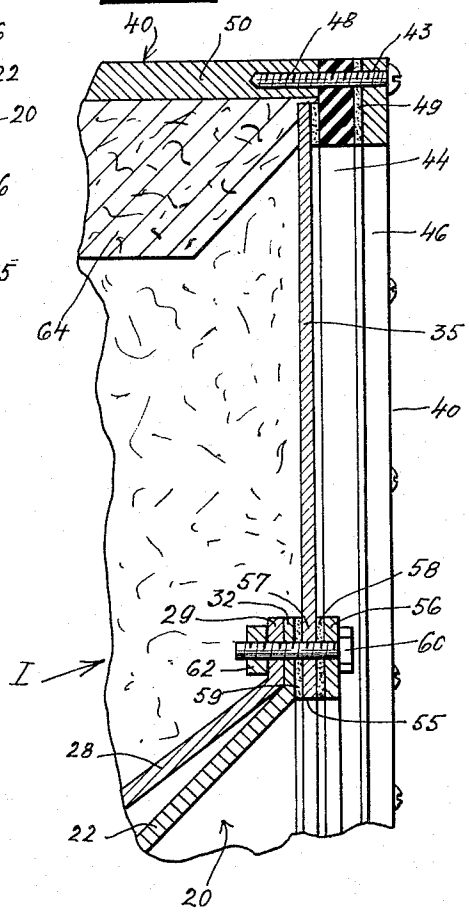
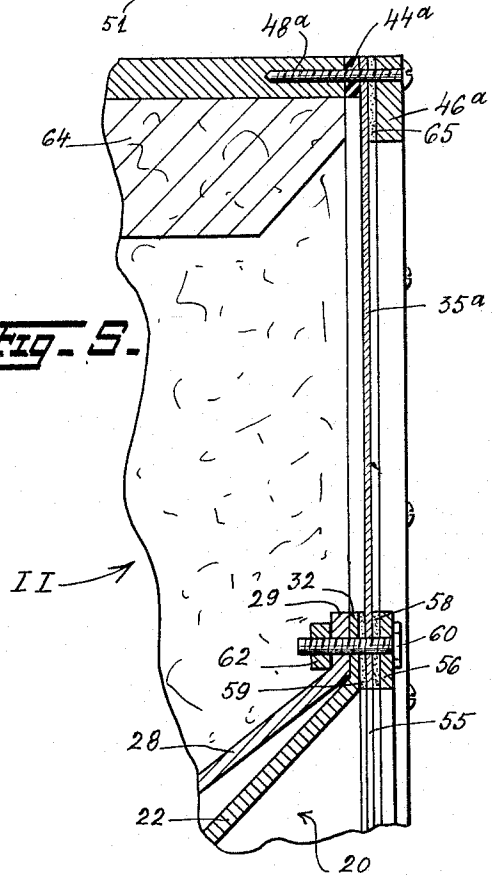


Fig. 5.



INVENTOR

William S. Dunning

BY Polachek & Saulsbury

ATTORNEYS.

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Fig. 6.

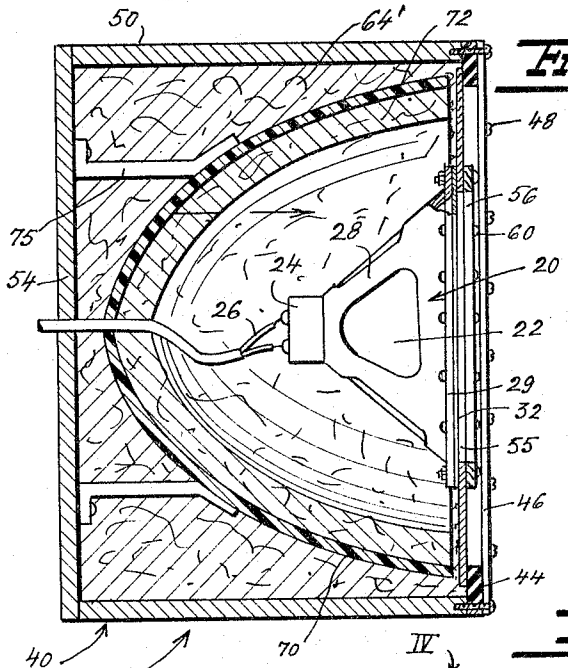


Fig. 9.

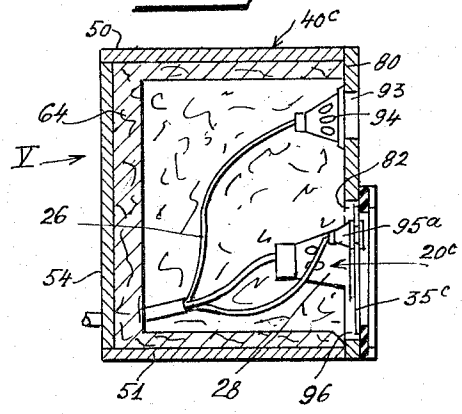


Fig. 7.

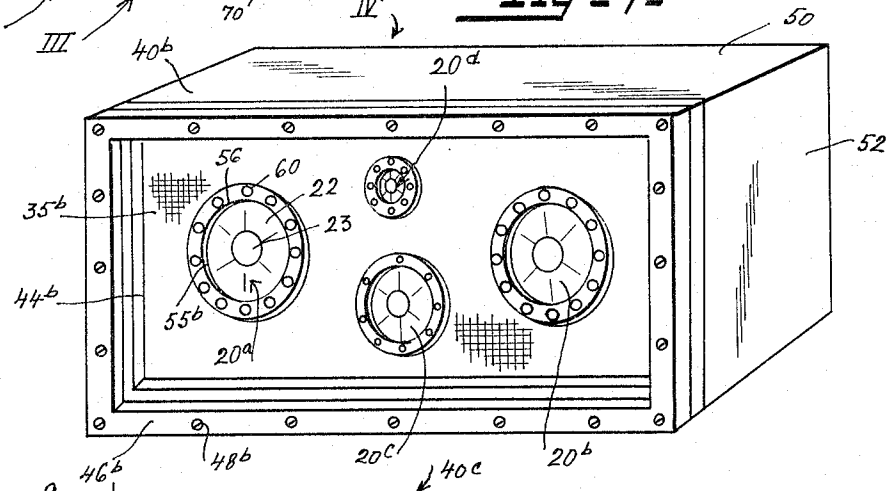
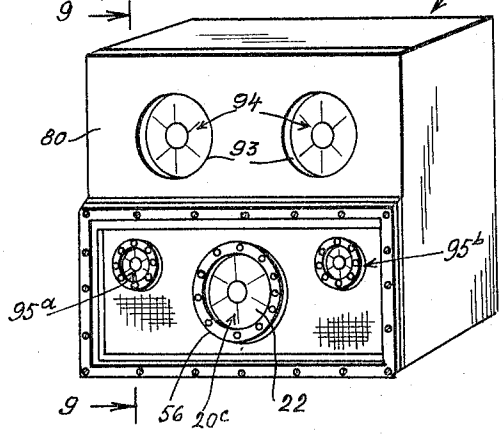


Fig. 8.



INVENTOR

William S. Dunning

BY Polachek & Saulsbury

ATTORNEYS.

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Fig - 10.

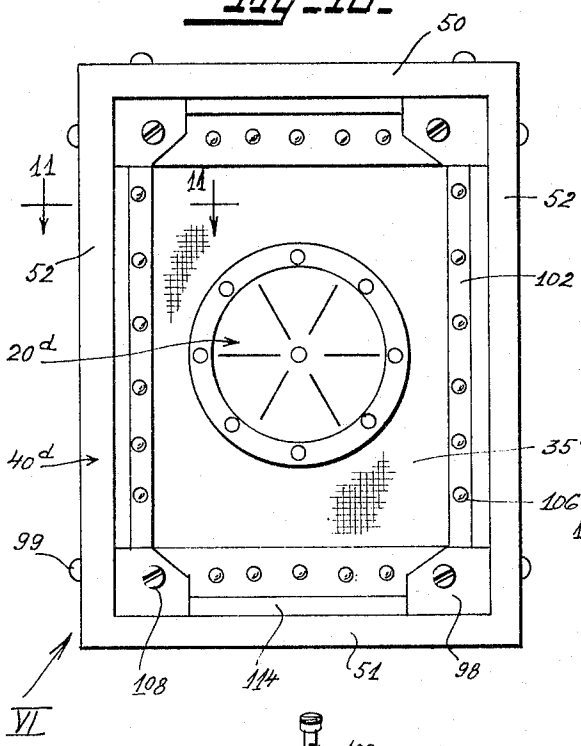


Fig - 11.

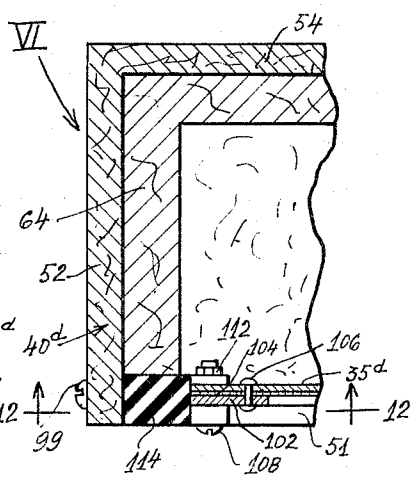
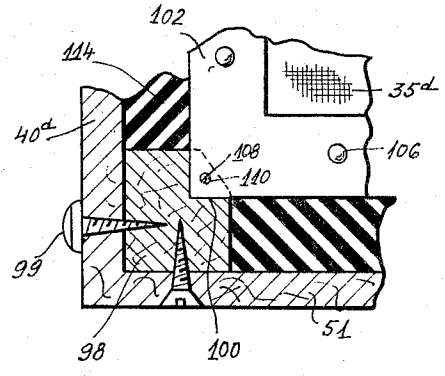


Fig - 12.



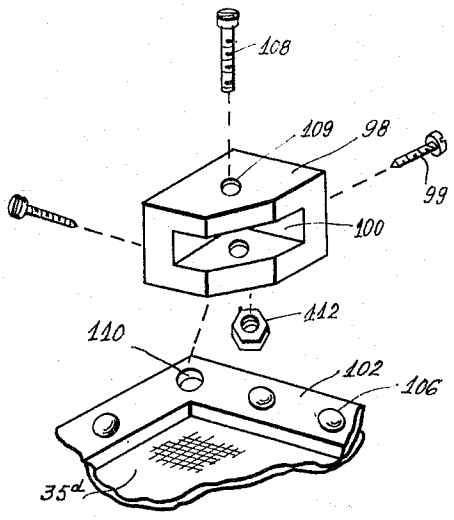


Fig - 13.

INVENTOR

William S. Dunning

BY Patchek & Saulsbury

ATTORNEYS.

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3,275,100

LOUDSPEAKER ASSEMBLY HAVING LOUDSPEAKER WHOLLY SUPPORTED BY VIBRATORY DIAPHRAGM

William S. Dunning, Kampfe Lake, Bloomingdale, N.J.

Filed June 16, 1965, Ser. No. 464,451
4 Claims. (Cl. 181—31)

The invention concerns a novel diaphragm or membrane for loudspeakers.

Magnetic loudspeakers are conventionally mounted in box-like enclosures having loudspeaker mounting boards which are as rigid and non-resonant as possible. Heavy bracing is also used to prevent any vibrations of the walls of the enclosure and the mounting boards of the loudspeakers.

I have found that such non-vibratile rigid mounting panels absorb and deaden many of the overtones and harmonics which impart unique qualities and characteristics to sounds. These overtones and harmonics have very low amplitudes and are readily damped out or modified. Thus, clarity is reduced and the unique identifying characteristics of various musical sounds and instruments are lost. To compensate partially for this condition, it is conventional to raise the volume of sound reproduction to unusually high levels, thus reproducing some of these low amplitude sound components. The overall result is unpleasant because the loudspeaker cones are strained beyond their reproduction capabilities; intermodulation distortion occurs and general high fidelity of sound reproduction is degraded.

I have further found that the above and other difficulties and disadvantages of prior loudspeaker mountings can be avoided, and improved sound reproduction can be attained by mounting magnetic loudspeakers on a diaphragm or membrane which has a large radiating surface and which is free to vibrate. Such a diaphragm has no inherent mechanical resonant frequency due to its low mass and lack of inherent stiffness. It does not impede or modify the vibrations of the loudspeaker cones. The diaphragm mountings of the present invention are analogous to the stretched membranous heads of drums. The diaphragms vibrate freely as compressional waves emitted by the loudspeaker cones or reflected from enclosure walls impinge on them.

An effective diaphragm mounting for a loudspeaker according to the invention can be made from heavy sailcloth canvas, or film; such as that generally known as "Mylar." If the sheet material is of unshrinkable material it will be mounted in a taut condition over the open front of a cabinet or other enclosure. If the sheet material is of heat shrinkable material it can be stretched over the open front of the enclosure and then shrunk by application of heat. Prior to mounting the shrinkable sheet material on the enclosure, one or more loudspeakers will be mounted to the sheet material by use of external mounting rings and suitable fastening elements. Acoustic padding will be applied to interior walls of the enclosure where required. If desired, large, heavy loudspeakers can be supported by strings at the rear sides of the sheet material prior to shrinkage of the sheet material to fully taut condition.

A loudspeaker assembly fabricated in accordance with the invention will have no mechanical resonance of its own. It will make maximum utilization of the loudspeaker cone and enclosure for reproduction of bass frequencies, since compressional waves from within the enclosure will be freely transmitted through the entire face of the enclosure without interference or modification. Maximum amplitude of sound reproduction will result because the vibrations of the loudspeaker cone are not damped by non-resonant sound absorbing mounting

panels. Minimum interference with cone vibrations from sound waves inside the enclosure results. The sounds reproduced by the assembly have maximum clarity and purity. The membranous face of the enclosure vibrates with the loudspeaker cone so that there is minimum interference with movement of the cone. The vibrations of the mounting diaphragm or membrane vary along with the vibrations of the cone with minimum time delay. Thus the face of the enclosure serves as a bass radiator.

It is therefore a principal object of the invention to provide a loudspeaker mounting or suspension in the form of a freely vibratile diaphragm or membrane having a radiating surface not less than that of the cone of the loudspeaker.

A further object is to provide a loudspeaker assembly including an enclosure having an open side, a membrane stretched across said open side and hermetically sealed at the periphery of the membrane to the walls of the enclosure, with a loudspeaker having a vibratile cone wholly supported only by the membrane inside the enclosure, and with a sealed opening in the membrane through which the cone of the loudspeaker assembly is exposed.

Another object is to provide a loudspeaker assembly as described, wherein a resilient sealing gasket is provided all around the membrane between the periphery of membrane and the adjacent walls of the enclosure.

Other objects are to provide a loudspeaker assembly as described, wherein the enclosure has a curved wall lined with sound absorbing padding; wherein more than one loudspeaker is carried by the diaphragm; wherein the enclosure has a wall carrying one or more loudspeakers and the membrane closing the opening in the enclosure carries one or more loudspeakers.

For further comprehension of the invention, and of the objects and advantages thereof, reference will be had to the following description and accompanying drawings and to the appended claims in which the various novel features of the invention are more particularly set forth.

In the accompanying drawings forming a material part of this disclosure:

FIGURE 1 is a perspective view of a loudspeaker assembly embodying the invention.

FIG. 2 is an enlarged front view of the loudspeaker assembly of FIG. 1.

FIG. 3 is a vertical sectional view taken on line **3—3** of FIG. 2.

FIG. 4 is a further enlarged fragmentary sectional view similar to a part of FIG. 3.

FIG. 5 is a fragmentary sectional view similar to FIG. 4, of a second loudspeaker assembly.

FIG. 6 is a sectional view similar to FIG. 3, of a third loudspeaker assembly.

FIG. 7 is a perspective view of a fourth loudspeaker assembly.

FIG. 8 is a perspective view of a fifth loudspeaker assembly.

FIG. 9 is a vertical sectional view taken on line **9—9** of FIG. 8.

FIG. 10 is a front view of a sixth loudspeaker assembly.

FIG. 11 is an enlarged fragmentary horizontal sectional view taken on line **11—11** of FIG. 10.

FIG. 12 is a fragmentary vertical sectional view taken on line **12—12** of FIG. 11.

FIG. 13 is an exploded perspective view of parts of the assembly of FIGS. 10–12.

Referring first to FIGS. 1–4, there is shown assembly I including a magnetic type of loudspeaker **20** having a vibratile cone **22**. Attached to its apical end is a voice coil form **23** carrying a voice coil which coacts with permanent magnet **24**. Wires **26** are connected to the

voice coil. A conical apertured frame **28** is provided for supporting the magnet **24** at the apical end of the frame. The frame has an annular flange **29** registering with and supporting the cone at its outer, wider annular edge **32**. To the extent described, the loudspeaker is conventional.

According to the invention, there is provided a large, tensioned diaphragm or membrane **35** which is rectangular in shape to conform with a rectangular front opening in cabinet **40**. The membrance is made of canvas or plastic sheeting such as tough, polyester film. The outer periphery of the membrane **35** is secured by a continuous adhesive layer **42** to one side of a rectangular flexible rubber ring or gasket **44**. The outer periphery of the gasket **44** is cemented by adhesive layer **49** to the rear side of a metal rectangular frame **46**. Screws, bolts or other fastening elements **48** are inserted through holes **43** in the frame. These elements pierce the gasket **44** and are seated in the forward edges of the top wall **50**, bottom wall **51** and side walls **52** of the cabinet **40**. The cabinet is closed at rear wall **54**. Wires **26** extend through a hole in wall **54**.

A hole **55** is formed near the center of the membrane **35**. A metal ring **56** is abutted to the membrane **35** all around the rim **57** of the hole and is secured thereto by continuous adhesive layer **58**. Adhesive layer **59** secures flange or edge **32** of the cone to rim **37**. Bolts **60** extend through ring **56**, rim **57**, the annular edge **32** of the cone and annular flange **29** of the frame **28**. Nuts **62** are engaged on the bolts. By the arrangement described the entire loudspeaker is supported by the membrane **35** without any rigid connection to the cabinet walls and the loudspeaker. The inner sides of all walls of the cabinet are lined with fibrous, sound absorbing material **64**.

The membrane is stretched tight like the head of a drum. It is free to vibrate. It has no resonant frequency of its own since it is fully compliant and has low mass. The loudspeaker cone is free to vibrate without interference from any rigid supporting structure or mounting panel. It transmits most faithfully the musical tones or other sounds electrically conveyed to it via wires **26** from some external audio amplifier or other audio signal source. The mounting prevents the cone damping caused by air vibrations escaping from the enclosure through the cone or cabinet openings as encountered in conventional loudspeaker systems. The sound waves generated in the cabinet enclosure by the rearward movements of the cone are partially absorbed by the fibrous material **64**. The remainder are free to move out through the thin membrane **35** closing the front of the cabinet. The movement of the cone is not impeded. The vibratile, membranous face of the enclosure improves the clarity and purity of tone. The reproduction of low tones or bass is so clear that the sound volume may be held at a comfortable level, unlike convention loudspeaker assemblies, which require high volume levels to reproduce low tones satisfactorily.

The arrangement of the loudspeaker mounted prevents the "boxy" or "booming" sound which is present in even the most expensive types of loudspeaker enclosures of conventional design. The membrane or drum-type mounting, vibrating in union with the loudspeaker cone, adds fullness to the tone, since the entire face of the enclosure radiates sound, rather than only the loudspeaker cone.

In FIG. 5 is shown a second type of loudspeaker assembly II which is similar to that of assembly I and corresponding parts are identically numbered. In this form of the invention, the outer periphery of the membrane **35***a* is disposed between rectangular sealing gasket **44***a* and the metal frame **46***a* and is secured by adhesive layer **65** to the inner side of the frame. The gasket **44***a* is narrower than gasket **44** so that the periphery of the membrane has a rigid mounting rather than the resilient mounting of assembly I. Screws **48***a* extend through the periphery of the membrane **35***a*.

In FIG. 6 is shown loudspeaker assembly III which is similar to assembly I and corresponding parts are identically numbered. A parabolic or elliptically curved shell **70** is provided around the loudspeaker **20**. Fibrous material **64'** fills substantially all the space between the shell and the walls of the cabinet. The concave side of the shell is covered with further fibrous sound absorbing material **72**. The shell is supported by brackets **75** at its convex side attached to the rear wall **54** of the cabinet. The forward lateral edges of the shell are spaced from the periphery of the membrane which is cemented to and is supported by resilient gasket **44** as in loudspeaker assembly I. If desired, the fibrous material **64'** may be omitted for small loudspeakers. The loudspeaker is located at the focal plane of the curved shell **70**. Any sound reflected from the shell and passing through the fibrous material **72** is impinged on the membrane **35** and passes through to intensify and amplify the sound emitted by the loudspeaker cone **22**.

In FIG. 7, loudspeaker assembly IV is similar to assembly I. The cabinet **40***b* has an open front in which vibratile membrane **35***b* is cemented to and is supported by resilient gasket ring **44***b*. The outer edge of the ring **44***b* in turn is secured to rectangular frame **46***b* by screws **48***b* and adhesive in the same manner as described in connection with assembly I. A plurality of loudspeakers, including two low frequency woofers **20***a*, **20***b*, a mid-range loudspeaker **20***c* and a high frequency tweeter **20***d* are all supported at holes **55***b* solely by the tensioned vibratile membrane **35***b*. This assembly will produce high fidelity quality of sound reproduction over an extended frequency range.

In FIGS. 8 and 9 there is shown assembly V including cabinet **40***c* provided with a rigid front panel **80** which only partially covers the front of the cabinet leaving a bottom rectangular opening **82**. Mid-range loudspeakers **94** are mounted in openings **93** in the rigid front panel. On membrane **35** are two corner tweeters **95***a*, **95***b* and a larger low frequency loudspeaker **20***c*. Membrane **35***c* is supported by resilient gasket **44***c* which in turn is supported by frame **46***b* at opening **96** of panel **80**. The assembly is otherwise similar to assembly I, and corresponding parts are identically numbered. If desired more or less loudspeakers can be provided on membrane **35***b* and panel **80**.

In FIGS. 10–13 the loudspeaker assembly VI employs four blocks **98** located at inside front corners of the open front of cabinet **40***d*. Screws **99** are inserted through the walls of the cabinet and support the corner blocks. Each block has a groove **100** in which seats one corner of rigid metal frame **102**. Membrane **35***d* is secured by adhesive layer **104** to the metal frame. The edges of the membrane are further held by spaced rivets **106** to the frame. Bolts **108** extend through registering holes **109** and **110** in the sides of the blocks and corners of the frame. The bolts are secured by nuts **112**. The loudspeaker **20***d* is supported centrally solely by the membrane. Resilient rubber or plastic strips **114** are inserted in the spaces between outer edges of the vertical frame **102** and adjacent walls **50**, **51** and **52** of the cabinet to seal off the interior of the cabinet.

It should be understood that the membrane loudspeakers each employed in loudspeaker assembly described above has an exposed vibratile area at least as large as or considerably larger than the effective vibrating area of all the loudspeaker cones supported by each membrane. This is necessary in order to provide a sufficient radiating area for sound reflected from walls of the cabinet.

A convenient way of assembling each of the loudspeaker assemblies described is first to mount a canvas or plastic sheet on a mounting frame or on the front of a cabinet in a stretched condition. Then the loudspeaker or loudspeakers will be attached to part of the taut membrane, or diaphragm, edges. After the outer mounting

ring or rings 48 are applied and secured, excess portions of the membrane within the ring covering the loudspeaker cone or cones can be cut away leaving the cones open and exposed and the membrane fully tensioned.

While I have illustrated and described the preferred embodiments of my invention, it is to be understood that I do not limit myself to the precise constructions herein disclosed and that various changes and modifications may be made within the scope of the invention as defined in the appended claims.

What is claimed is:

1. A loudspeaker assembly comprising a magnetic loudspeaker having a rigid conical apertured frame with an annular flange at its wider end, a magnet secured to the apical end of the frame, a conical vibratory cone nested in the frame, electrically energized driving means carried by the magnet and operatively connected to the apical end of the cone to drive the same axially, said cone having a peripheral rim registering with and abutted to said flange, a membranous diaphragm having an opening therein, means securing both the flange of the frame and the rim of the cone to the edge of said opening in sealing relationship, so that the entire magnetic loudspeaker is supported only by the diaphragm and is free from all other external support, a resilient, narrow gasket extending all around the periphery of the diaphragm and secured thereto at one edge of the gasket, an enclosure having an opening therein, and means securing the other edge of said gasket in hermetic sealing relationship all around the opening in the enclosure so that the diaphragm is supported in flat, stretched vibratile condition with the loudspeaker carried only by the diaphragm, the diaphragm having a free vibratory area at least as large as that of the cone.

2. A loudspeaker assembly, comprising an enclosure having a plurality of integrally joined walls lined with acoustical padding, said enclosure having an open side, a narrow resilient gasket secured at its outer edge all around the periphery of said open side in hermetic sealing relationship, a membranous diaphragm secured at its periphery to the inner other edge of said gasket in hermetic sealing relationship, said diaphragm being supported in a flat stretched, taut, freely vibratile condition, said diaphragm having an opening therein, a loudspeaker having a rigid conical apertured frame with an annular flange at its wider end, a magnet secured to the apical end of the frame, a conical vibratory cone nested in the frame, electrically energized driving means carried by the magnet and operatively connected to the apical end of the cone to drive the same axially, said cone having a peripheral rim registering with and abutted to said flange, means securing both the flange of the other frame and the rim of the cone to the edge of said opening in sealing relationship, so that the entire magnetic loudspeaker is supported only by the diaphragm and is free from all other external support, whereby the diaphragm vibrates with the cone to pass sound waves freely through the diaphragm from inside the enclosure, a curved shell disposed inside said enclosure surrounding and spaced from said loudspeaker, and acoustic padding material lining said shell facing said loudspeaker, whereby sound waves reaching said shell and reflected therefrom are uniformly distributed upon said diaphragm for transmission thereby from the enclosure.

3. A loudspeaker assembly, comprising an enclosure having a plurality of integrally joined walls lined with acoustic padding, said enclosure having an open side, a membranous diaphragm secured at its periphery to the periphery of said open side and hermetically sealing the same, said diaphragm being supported in a flat, stretched, taut, freely vibratile condition, said diaphragm having an opening therein, a magnetic loudspeaker having a rigid conical apertured frame with an annular flange at its wider end, a magnet secured to the apical end of the frame, a conical vibratory cone nested in the frame, electrically energized driving means carried by the magnet and operatively connected to the apical end of the cone to drive the same axially, said cone having a peripheral rim registering with and abutted to said flange, means securing both the flange of the frame and the rim of the cone to the edge of said opening in sealing relationship, so that the entire magnetic loudspeaker is supported only by the diaphragm and is free from all other external support, whereby the diaphragm vibrates with the cone to pass sound waves freely through the diaphragm from inside the enclosure, said diaphragm being rectangular in form, said open side of the enclosure being rectangular in form, blocks joining corners of the diaphragm to corners of the said open side of the enclosure, a rigid rectangular frame secured to the periphery of diaphragm, and gasket strips interposed between the periphery of said frame and the periphery of said open side of the enclosure.

4. A loudspeaker assembly, comprising an enclosure having a plurality of integrally joined walls lined with acoustic padding, one of said walls having at least one opening therein, at least one loudspeaker having a vibratory cone mounted at said opening in said one wall, said enclosure having an open side, a narrow resilient gasket secured at its outer edge all around the periphery of said open side in hermetic sealing relationship, a membranous diaphragm secured at its periphery to the inner other edge of said gasket in hermetic sealing relationship, said diaphragm being supported in a flat, stretched, taut, freely vibratile condition, said diaphragm having at least one opening therein, at least one magnetic loudspeaker having a rigid conical aperture frame with an annular flange at its wider end, a magnet secured to the apical end of the frame, a conical vibratory other cone nested in the frame, electrically energized driving means carried by the magnet and operatively connected to the apical end of the other cone to drive the same axially, said other cone having a peripheral rim registering with and abutted to said flange, means securing both the flange of the frame and the rim of the other cone to the edge of said one opening in the diaphragm in sealing relationship, so that the entire magnetic loudspeaker is supported only by the diaphragm and is free from all other external support, said diaphragm having a free vibratory area at least equal in area to that of the cones of all the loudspeakers, whereby the diaphragm vibrates with the cones to pass sound waves freely through the diaphragm from inside the enclosure.

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RICHARD B. WILKINSON, *Primary Examiner.*

STEPHEN J. TOMSKY, *Examiner.*