March 8, 1966 W. A. MURRAY 3,239,028

SOUND REPRODUCTION SYSTEM

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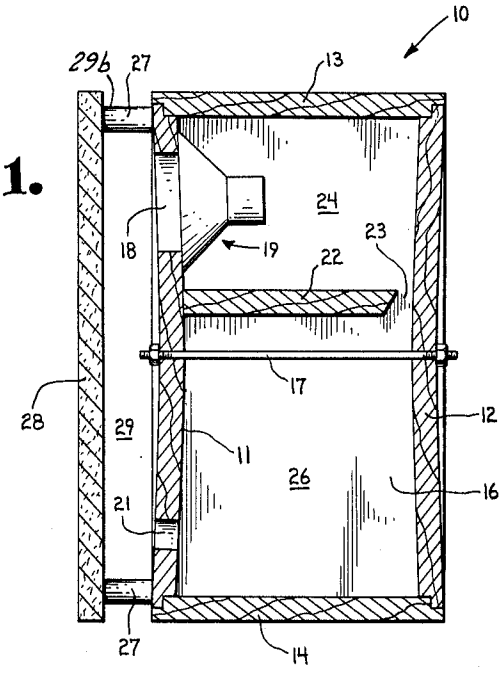
Fig. 1.



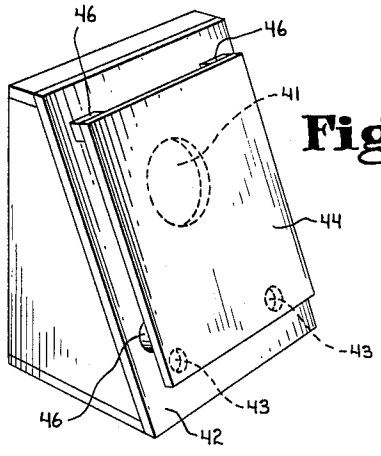


Fig. 2.

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Fig. 3

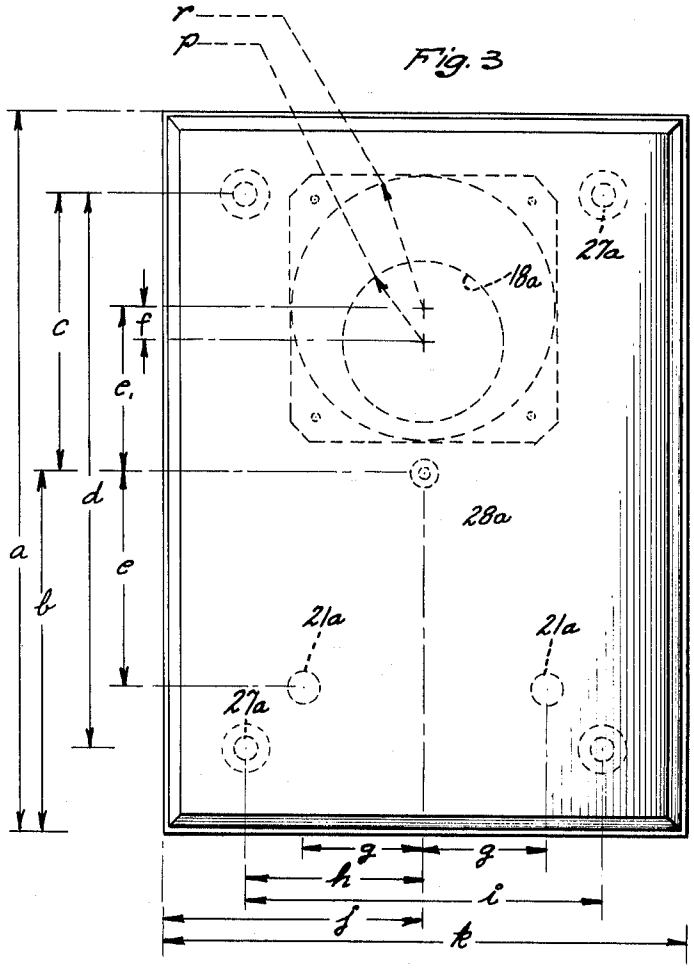


Fig. 4

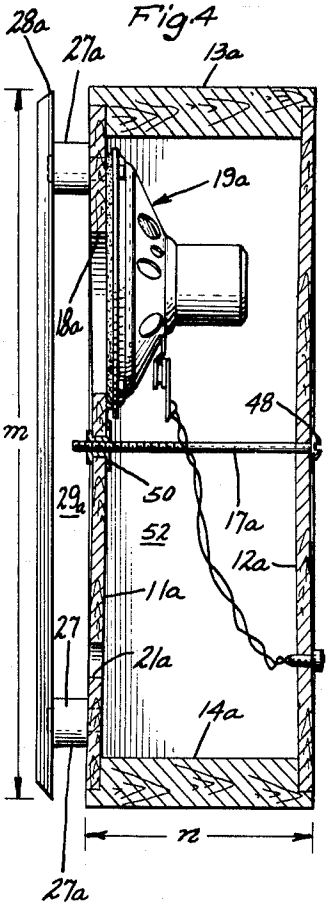
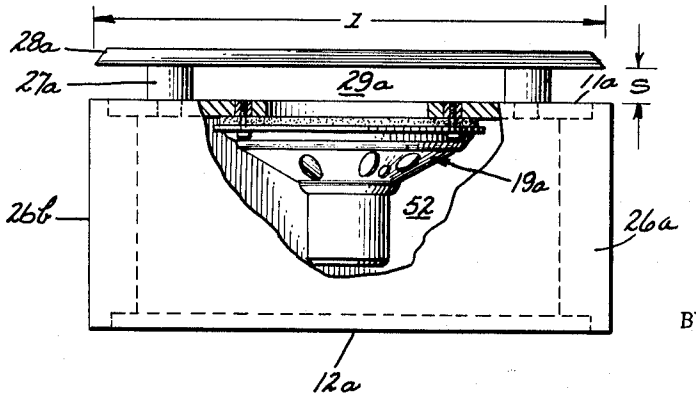


Fig. 5



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SOUND REPRODUCTION SYSTEM

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7 Claims. (Cl. 181—31)

This is a continuation-in-part of my U.S. application Serial No. 244,157, filed December 12, 1962, now abandoned.

This invention relates generally to sound reproduction systems or apparatus and in particular to a speaker assembly for reproducing recorded music or the like, the assembly being characterized by its relatively small size, clean, balanced reproduction over a wide range of frequencies and substantially omnidirectional propagation or radiation of sound.

Conventional speaker systems used in high fidelity reproduction of sound invariably utilize at least two speakers or transducers, more often three or more. For good audible reproduction of a large range of frequencies, with the lower end of the range extending to or near 20 cycles per second, these conventional speaker systems require relatively large enclosures, careful placement of the enclosures within a room and attention to the acoustic properties of the room. Even with careful attention to these details, the results leave much to be desired and the aesthetic problem in fitting the relatively large enclosure into what may be the rigid, period decor of the room remains.

The speaker system of the present invention utilizes only a single speaker or transducer which may be of the conventional, inexpensive cone type of small diameter. Because of the enclosure construction, the size of the enclosure may be quite small, of the order of 8½ x 11 x 2 inches and thus can be unobtrusively located within a room. Placement of the speaker system within a room is in no sense critical, radiation of sound is substantially omnidirectional, and no standing waves, producing audible discontinuities, are set up even in rooms which lack sound attenuating drapes or the like.

It is the primary object of the present invention to provide a speaker system or apparatus which accomplishes balanced, wide frequency range sound reproduction while utilizing a relatively small enclosure.

It is a further object of the present invention to provide a speaker system of the type referred to which utilizes but a single transducer or sound source.

It is a further object of the present invention to provide a speaker system of the type referred to in which the enclosure is braced so as to prevent loss of energy through movement of the enclosure walls ("breathing" of the enclosure) when the system is in operation and to control the resonant frequency of the enclosure.

The above-mentioned and other features and objects of this invention and the manner of attaining them will become more apparent and the invention itself will be best understood by reference to the following description of an embodiment of the invention taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is a longitudinal sectional view of one embodiment of the present invention;

FIG. 2 is a perspective view of a second embodiment of this invention;

FIG. 3 is a front elevation substantially to scale of another embodiment;

FIG. 4 is a longitudinal sectional view of the embodiment of FIG. 3 substantially to scale; and

FIG. 5 is a top plan view, partially broken away and sectioned for clarity, of the embodiment of FIG. 3, and is substantially to scale.

Referring to the drawings, the vibratory body or enclosure 10 is of generally rectangular box configuration having members 11 and 12 forming front and rear enclosure faces, respectively. Upper and lower ends or panels 13 and 14 are rigidly joined to the members 11 and 12 and side panels (only one of which identified at 16 is visible in the drawing) complete the enclosure. In addition to being rigidly secured by glue, screws or other suitable means at the panel joints, a tension member 17 extends transversely across the enclosure and may take the form of a rod threaded at each end, extending through apertures in the members 11 and 12 and receiving, exteriorly of the enclosure, nuts which may be tightened to thereby place the member 17 under tension and to deform the members 11 and 12 inwardly somewhat so that they present a slightly convex surface to the interior of the enclosure.

The front face member 11 of the enclosure is provided with a front radiation aperture 18 and rigidly mounted over the aperture 18 is a conventional transducer which includes a vibratory element and herein shown as taking the form of a conventional diaphragm or cone type speaker identified generally at 19. The face member 11 also has formed therein an aperture or orifice 21. A baffle 22 is rigidly mounted on the inner face of the member 11 and extends contiguously with the side panels to a point adjacent the rear face of the member 12 thereby providing an elongated orifice 23. The baffle member 22 divides the interior of the enclosure into an upper portion 24 and a lower portion 26.

Spacers 27 rigidly support a plate 28 which overlies both the aperture 18 and the orifice 21, the plate 28 and the adjacent front face of the enclosure proper defining a space or chamber indicated at 29, this chamber 29 having a peripheral edge portion 29*b* which is open. As previously mentioned, the size of the enclosure may be of the order of 8½ x 11 x 2 inches.

The presence of the chamber 24 provides an acoustic stiffness against which the transducer diaphragm must move and this acoustic stiffness "seen" by the diaphragm is transferred, under control of the orifice 23, into the chamber 26. This stiffness is transformed by means of the volume of the chamber 26 and the duct 21 into high amplitude radiation at the mouth of the duct 21. The plate 28 acts as an acoustic lens serving to disperse the sound to the room in a substantially omnidirectional pattern. The mass of air in the space or chamber 29, that is, the mass vibrated by front radiation from the speaker 19 and from the port 21 also serves, in acting on the front of the speaker diaphragm, to balance the air load in the chamber 24 at the rear of the diaphragm. Vibration of the mass of air in the chamber 29 further is utilized to excite vibration in the plate 28 for the purpose of reinforcing any desired frequency range depending upon the size and material from which the plate 28 is formed. Substantially any frequency range may be reinforced as desired, it being only necessary to choose the correct material and size for the plate 28. It will be understood that

several superposed spaced-apart parallel plates 28 may be used in place of a single plate 28 if several frequency ranges are to be reinforced. These several plates 28 would be fixedly mounted on each other the same as plate 28 is mounted on front wall 11.

FIG. 2 shows an enclosure having a modified exterior configuration. This structure is provided with the interior member (not shown) dividing the enclosure into two chambers with an orifice communicating therebetween. A front radiation aperture 41 is provided comparable to aperture 18 in FIG. 1. The face member 42 is also provided with a plurality of orifices or ports 43. A plate 44 is rigidly supported by spacers 46, and overlies both the aperture 41 and the orifices 43, the plate and the adjacent face member 42 defining a chamber comparable in function to the chamber 29 of FIG. 1.

The structure of the present invention, in addition to the advantages pointed out above, also is characterized by a transient response which is substantially faster than that of conventional speaker systems because of the low inertia or capacitance of the present system due to its relatively small size.

Another embodiment of this invention is illustrated in FIGS. 3, 4 and 5 which are drawn substantially to scale. In these figures, like parts are indicated by like numerals with the suffix "*a*" being added thereto. In this embodiment, the tensioning element 17*a* is preferably an ordinary round-headed screw having a head 48 bearing against the outer surface of the midportion of the rear wall or panel 12*a* and a nut 50 thereon which bears against the outer surface of the midportion of the front wall or panel 11*a*. As shown, the nut 50 is threaded downwardly sufficiently to bow and tension the two walls 11*a* and 12*a* inwardly toward each other. The exact amount of bowing or curving is determined by all of the dimensions and parameters of the various components which make up the total apparatus, the speaker 19*a* being one such component. Alteration of the degree of bowing or tensioning serves to modify the resonance and radiation characteristics of the apparatus. In the final analysis, these walls 11*a* and 12*a* will be tensioned or bowed to an extent as determined by the response or radiation characteristics desired in the final design.

The speaker 19*a* is eccentrically mounted with respect to the smaller speaker opening 18*a* as shown more clearly in FIGS. 3 and 4. The four spacers 27*a*, which are preferably formed of wooden dowels, are located at the corner portions of the panel 28*a* and the front wall 11*a* as shown. These spacers 27*a* are securely fixed to the panel 28*a* and wall 11*a* by some suitable means such as by glue or screws, or both.

Instead of using a single aperture 21 as shown in FIG. 1, this embodiment uses two such apertures 21*a* which are spaced apart as shown. The sizes of these apertures 21 and 21*a* may be one-half inch to one inch in diameter depending on the results desired.

In the following are given dimensions and parameters of the embodiment of FIGS. 3–5 which is capable of reproducing music with high degree of fidelity. These dimensions are given by way of example only and are not to be considered as restrictive of the scope of the invention.

In this working embodiment, the walls 11*a*, 12*a* and the panel 28*a* are made of three-ply sheets of walnut plywood one-fourth inch thick, and the cabinet ends 13*a*, 14*a* and the cabinet sides 26*a* and 26*b* are made of three-fourths inch thick walnut hardwood. As shown more clearly in FIGS. 4 and 5, the ends and sides of the cabinet are rigidly secured together by gluing and the like to form a rigid rectangular frame for the apparatus. The edges of this frame are rabbeted to receive and flush mount the front and rear panels 11*a* and 12*a*, as shown more clearly in FIGS. 4 and 5. These panels 11*a* and 12*a* are securely glued to the frame to provide a rigid enclosure structure.

The dimensions are indicated in FIGS. 3, 4 and 5 by the lower case letters which are listed in the following, the actual figures in inches being listed oppositely:

a—11 inches	*i*—5½ inches
b—5 15/64 inches	*j*—3 47/64 inches
c—4¼ inches	*k*—8 inches
d—8½ inches	*l*—7¾ inches
e—3⅜ inches	*m*—10¾ inches
*e*1—2½ inches	*n*—3½ inches
f—½ inch	*p*—2 in. dia.
g—1⅞ inches	*r*—2 11/32 in. radius
h—2¾ inches	*s*—½ inch

Cavity 52—9½ x 3 x 6½ inches
Dia. of holes 21*a*—½ inch
Thickness of ends 13*a*, 14*a* and sides 26*a*, 26*b*—¾ inch
Bowing of panels 11*a* and 12*a* at the midpoints thereof—⅛ inch inwardly from the normal flat plane thereof
Speaker 19*a*—4 inch dia., ¾ inch voice coil, 1.47 ounce magnet, 8-ohm voice coil impedance (Model V4DX1–A as made by Utah Electronics Co., of Huntington, Indiana).

It is well understood by persons skilled in the art that different speaker systems have different response and radiation characteristics and that when they are used in the reproduction of music, different systems will appeal to different people. An individual desiring to purchase a speaker system usually will listen to a variety of differently designed systems before making a selection. Thus, there is no single response or radiation characteristic which can satisfy all demands; hence, designs of almost all speaker systems are varied somewhat to provide different models. With respect to the present invention, the sound-reproducing characteristics thereof may be varied by altering any one or more of the parameters given in the preceding. However, the actual working embodiment of the invention as disclosed in connection with FIGS. 3–5 provides reproduction characteristics which are generally pleasing in connection with the reproduction of music. The sound emitted by the speaker 19*a* is modified by the resonance characteristics of the cavity 52 inside the cabinet 10, by the size of the aperture 21*a*, the spacing of the panel 28*a* from the front wall 11*a*, and the materials of the cabinet and panel 28*a* whereby the sound emitted by the speaker 19*a* throughout the audible spectrum is reinforced in certain areas and attenuated in others, the total response characteristic being substantially flat within the definition of the speaker art. This flatness in response extends from the low regions of approximately 50–100 cycles per second up to the higher regions of from 10,000 to 12,000-cycles. This response is acquired even though the enclosure is of miniature size and only a single driver is used therein.

While earlier in the discussion of the embodiment of FIG. 1 it was theorized that chamber 24 provided acoustic stiffness with the air load in the chamber being balanced, it should be realized that the present invention comprehends an increase in transient response (as compared to prior art systems) which results in a reduction of air load quantities and the development of a number of impact areas, these areas having different impact values (instantaneous pressure).

With respect to directivity of emitted sound, the present invention may be considered as omnidirectional, or in other words as emitting sound in a spherical pattern. Thus, the present invention may be operated in any position, sitting on its end, side, back or the like, or it may be operated while hung on a wall without impairing its omidirectional radiation.

While the invention has been disclosed and described in some detail in the drawings and foregoing description, they are to be considered as illustrative and not restrictive in character, as other modifications may readily suggest themselves to persons skilled in this art without de-

parting from the scope of this invention as defined by the appended claims.

What is claimed is:

1. Sound-reproducing apparatus comprising cabinet means which defines an enclosed cavity, said cabinet means having front and rear wall portions, said front wall portion being provided with a speaker opening and at least one aperture, a diaphragm speaker mounted within said cavity on said front wall portion with the diaphragm over said speaker opening, and panel means spaced from and mounted on said front wall portion on the side opposite said speaker and defining a chamber therewith having a peripheral edge portion which is open, said panel means over lying said opening and aperture, said cabinet means being of a vibration transferring material; said cavity, said chamber, said opening and said aperture being of such sizes as will vibrationally couple said diaphragm to said cabinet means to produce omnidirectional radiation of sound by said diaphragm, said cabinet means and said panel means as a common sound source; said sizes also being such as to reduce the amplitude of vibration of said diaphragm in comparison with that which would be existent with said speaker operating in the absence of said cabinet means.

2. Sound-reproducing apparatus comprising cabinet means which defines an enclosed cavity, said cabinet means having front and rear wall portions, said front wall portion being provided with a speaker opening and at least one aperture, a diaphragm speaker mounted within said cavity on said front wall portion with the diaphragm over said speaker opening, and panel means spaced from and mounted on said front wall portion on the side opposite said speaker and defining a chamber therewith having a peripheral edge portion which is open, said panel means overlying said opening and aperture, said chamber as defined by said panel means and said front wall portion being substantially flat and opening radially outwardly through said edge portion beyond said cabinet means, said cabinet means being of a vibration-transferring material; said cavity, said chamber, said opening and said aperture being of such sizes as will vibrationally couple said diaphragm to said cabinet means to produce omnidirectional radiation of sound by said diaphragm, said cabinet means and said panel means as a common sound source; said sizes also being such as to reduce the amplitude of vibration of said diaphragm in comparison with that which would be existent with said speaker operating in the absence of said cabinet means.

3. Sound-reproducing apparatus comprising cabinet means having spaced apart first and second wall portions and defining an enclosed cavity, said wall portions being self-supporting and vibratory at frequencies within the audible spectrum, means rigidly interconnecting the central portions of said wall portions together, a speaker opening and an aperture in said first wall portion, a diaphragm speaker mounted within said cavity on said first wall portion with said diaphragm over said speaker opening, and panel means spaced from and mounted on said first wall portion on the side opposite said speaker and defining a chamber therewith having a peripheral edge portion which is open, said chamber having substantially unobstructed communication with the surrounding atmosphere in a direction radially outwardly beyond said edge, said panel means overlying said opening and aperture, said panel means being vibratory at predetermined frequencies within the spectrum of audible frequencies; said cavity, said chamber, said aperture and said opening being of such sizes as will vibrationally couple said diaphragm to said cabinet means to produce omnidirectional radiation of sound by said diaphragm, said cabinet means and said panel means as a common sound source; said sizes being such as to reduce the amplitude of vibration of said diaphragm in comparison with that which would be existent with said speaker operating in the absence of said cabinet means.

4. Sound-reproducing apparatus comprising cabinet means having spaced apart first and second wall portions and defining an enclosed cavity, said wall portions being self-supporting and vibratory at frequencies within the audible spectrum, means rigidly interconnecting the central portions of said wall sections together and also for applying forces to said central portions which curve said wall portions inwardly toward each other, a speaker opening and a radiating aperture in said first wall portion, a diaphragm speaker mounted within said cavity on said first wall portion with said diaphragm over said speaker opening, and panel means spaced from and mounted on said first wall portion on the side opposite said speaker and defining a chamber therewith having a peripheral edge portion which is open, said chamber having substantially unobstructed communication with the surrounding atmosphere in a direction radially outwardly beyond said edge, said panel means overlying said opening and aperture, said panel means being vibratory at predetermined frequencies within the spectrum of audible frequencies; said cavity, said chamber, said aperture and said opening being of such sizes as will vibrationally couple said diaphragm to said cabinet means to produce omnidirectional radiation of sound by said diaphragm, said cabinet means and said panel means as a common sound source; said sizes being such as to reduce the amplitude of vibration of said diaphragm in comparison with that which would be existent with said speaker operating in the absence of said cabinet means.

5. A sound-reproducing apparatus comprising a cabinet which defines an enclosed cavity, said cabinet being of rectangular shape and having opposite front and rear walls, two ends and two sides, said front and rear walls being of substantially the same area which is larger than the area of said ends and sides, said walls, sides and ends being securely fixed together, a speaker opening provided in one end portion of said front wall, at least one radiating aperture provided in the opposite end portion of said front wall and spaced from said speaker opening, a cone-type loudspeaker of larger diameter than said speaker opening disposed in said cavity and mounted on said front wall with the cone over said speaker opening, said speaker being disposed eccentrically with respect to said speaker opening, said ends and sides having greater rigidity than said walls, a rigid rod-like element having opposite ends secured to the opposite central portions of said walls, respectively, and forcing said central portions inwardly toward each other by a predetermined amount, a flat rigid panel which is vibratory at predetermined frequencies in the audio spectrum, said panel being of substantially the same size and shape as said front wall and congruently mounted on the latter in parallel spaced relation therewith, four rigid spacing elements securing said panel to said front wall at the four corner portions of the latter, said panel overlying said speaker opening and said aperture, said front and rear walls and said panel being vibratory at predetermined frequencies in response to sounds emitted by said speaker, the sizes of said speaker opening, aperture, cavity, spacing of said panel from said front wall, and the inward force exerted on said front and rear walls being such as to reduce the amplitude of the vibration of said cone in comparison with that which would be existent with said speaker operating alone in the absence of said cabinet.

6. The apparatus of claim 5 wherein said cabinet and panel are flat and of hardwood.

7. The apparatus of claim 5 wherein said cavity has dimensions of approximately nine and one-half inches in length, three inches in depth and six and one-half inches in width, said speaker opening being two inches in diameter, said aperture one-half to one inch in diameter, the spacing of said panel from said front wall one-half inch, said walls and panel being hardwood one-fourth inch thick.

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