

June 30, 1953

W. R. ANTHONY

2,643,728

HIGH FIDELITY LOUD-SPEAKER CABINET

Filed Aug. 15, 1951

2 Sheets-Sheet 1

Fig. 1.

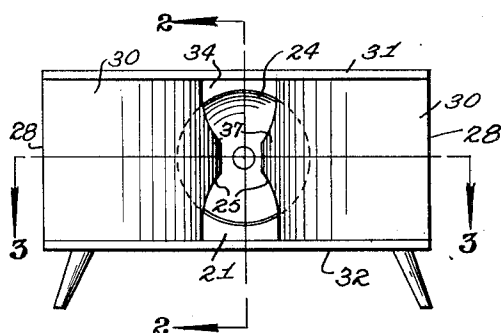


Fig. 2.

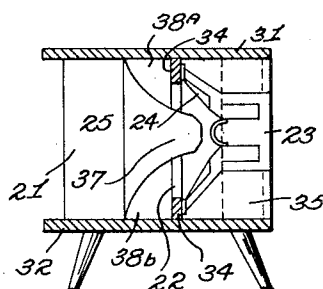


Fig. 3.

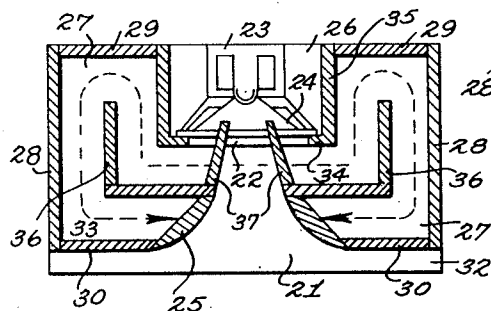


Fig. 4.

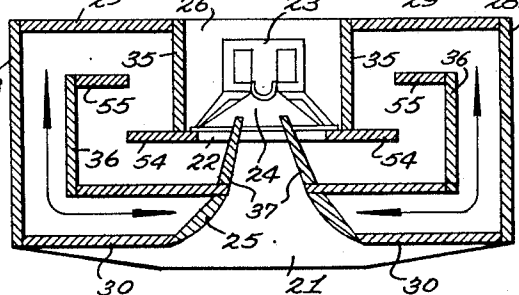


Fig. 5.

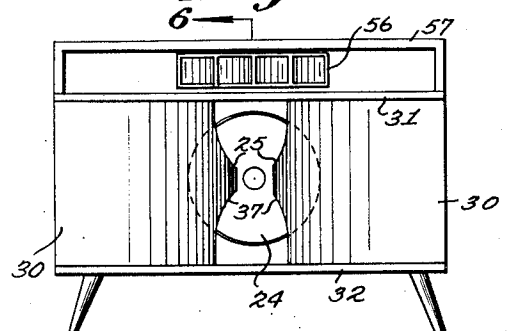
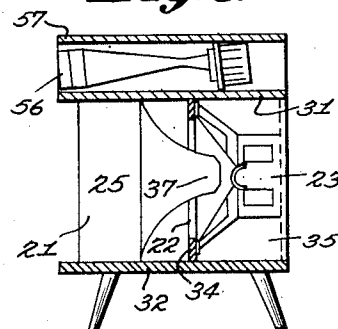


Fig. 6.



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Fig. 7.

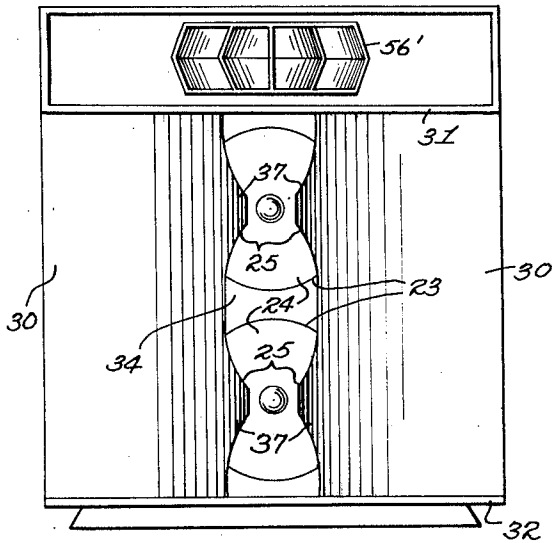


Fig. 8.

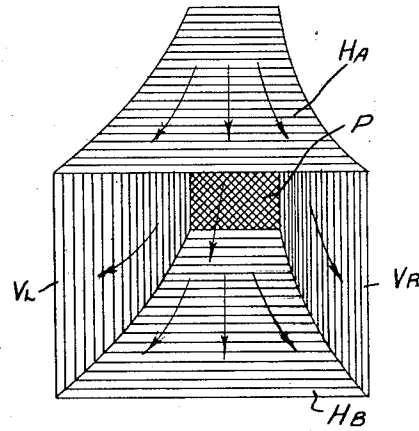


Fig. 11.

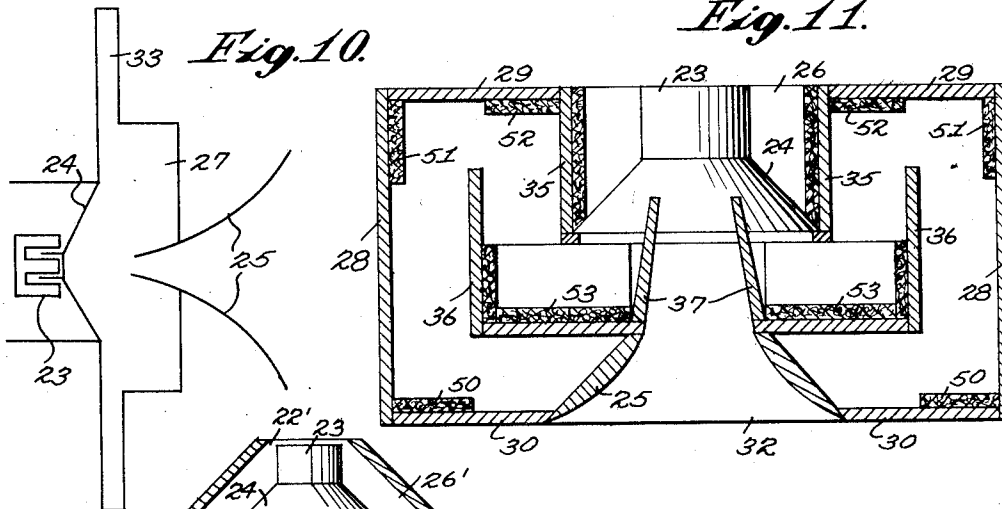
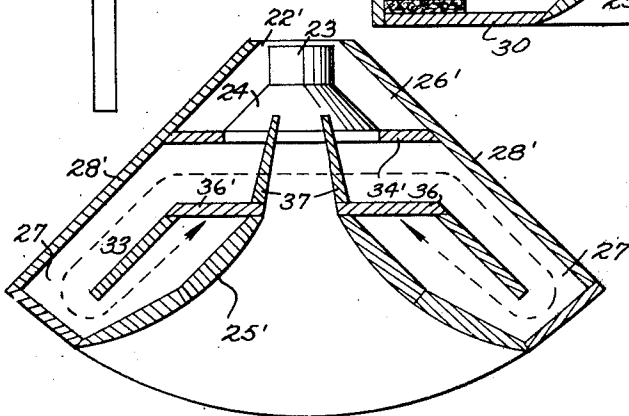


Fig. 9.



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HIGH FIDELITY LOUD-SPEAKER CABINET

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4 Claims. (Cl. 181—31)

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This invention relates to acoustical devices, and more particularly to a high-fidelity acoustical enclosure for a loud speaker.

A main object of the invention is to provide a novel and improved acoustical cabinet device for high fidelity reproduction of the sound vibrations from a loud speaker, said device being simple in construction, being relatively compact in size, and being neat in appearance.

A further object of the invention is to provide an improved high-fidelity loud speaker acoustical cabinet which provides accurate reproduction of the sound vibrations from a loud speaker over a range much wider than that obtained from loud speaker enclosures of comparable size and cost of the prior art.

A still further object of the invention is to provide an improved high-fidelity loud speaker cabinet which is inexpensive to manufacture, which is of pleasing proportions, and which accurately reproduces the high and low sound frequencies, as well as the middle range of sound frequencies of the loud speaker employed therewith.

A still further object of the invention is to provide an improved acoustical cabinet for a loud speaker, which is capable of high-fidelity, wide-range reproduction of sound vibrations, including the very low frequencies.

A still further object of the invention is to provide an improved loud speaker assembly of smaller dimensions than has heretofore been possible for equal acoustical results and efficiency.

A still further object of the invention is to provide an improved loud speaker assembly of simpler construction and which is less expensive to manufacture than previous loud speaker assemblies of equivalent performance, yet which is of pleasing proportions aesthetically while maintaining superior acoustical results and efficiency.

A still further object of the invention is to provide an improved loud speaker arranged so that its positioning and location in a room has no effect or limitation on its efficiency of operation, and which is further arranged so that directional effects of the sound reproduced thereby are minimized.

A still further object of the invention is to provide an improved loud speaker as above set forth, which may employ a plurality of driving units in accordance with the volume of sound desired, whereby the loud speaker may be employed in auditoriums, theaters, and other loca-

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tions of public assembly where a large volume of sound is required.

Further objects and advantages of the invention will become apparent from the following description and claims, and from the accompanying drawings, wherein:

Figure 1 is a front elevational view illustrating one form of the present invention.

Figure 2 is a vertical, transverse cross-sectional view taken on line 2—2 of Figure 1.

Figure 3 is a horizontal cross-sectional view taken on line 3—3 of Figure 1.

Figure 4 is a horizontal cross-sectional view similar to Figure 3, illustrating a modified form of the present invention.

Figure 5 is a front elevational view illustrating another modified form of the present invention.

Figure 6 is a vertical, transverse cross-sectional view taken on line 6—6 of Figure 5.

Figure 7 is a front elevational view illustrating still another modified form of the present invention.

Figure 8 is a perspective theoretical sketch illustrating the relationship between the three planes of sound reproduced by the improved loud speaker of the present invention.

Figure 9 is a horizontal cross-sectional view illustrating a still further modified form of the present invention, the loud speaker enclosure being arranged for placement in the corner of a room.

Figure 10 is a diagrammatic sketch illustrating the various acoustic elements of the loud speaker of the present invention.

Figure 11 is a horizontal cross-sectional view similar to Figure 3, illustrating a further modified form of the invention wherein sound deadening material is employed to prevent back reflections or standing sound waves.

Practical limitations have in the past restricted most wide-range sound reproducers to frequencies which did not include the very low frequencies. Extremely large theater-type horns and very complicated folded horns (see, for example, U. S. Patent No. 2,373,692 to Paul W. Klipsch) have been the best available means for reproducing the low frequencies. However, both of these methods have serious physical, constructional and acoustical limitations.

It has been generally recognized that very low frequencies must be included in the overall wide-range reproduction of sound for satisfactory high-fidelity results. Together with this requirement is the requirement that the loud-speaker

unit must be suitable for use where space is comparatively limited, such as in the home. Also, simplicity of construction is reflected in lower cost of manufacture.

The loud speaker assembly of the present invention is designed to fulfill all high-fidelity sound reproduction requirements, yet is of compact size, is simple in construction, and is of aesthetically pleasing proportions. The overall efficiency of the assembly is high and is not affected by variations in audio power. Therefore, it is suitable for both residential use and for circumstances where higher power is required, such as in theaters, and the like.

Previous designs have employed folded horns. The folded horn acts like a band pass filter in that it has a low-frequency cut-off, determined primarily by the dimensions at the mouth of the horn, and a high-frequency cut off, determined primarily by the number of folds. In the attempt to conserve space, previous designs employed multiple folds and hence lost the ability to reproduce high frequencies, because said frequencies cannot follow an excessively circuitous path and are dissipated by multiple reflections in the folds.

A straight horn, however, acts like a high pass filter, with only the low cut-off frequency, determined primarily by the mouth dimensions. A straight horn, however, would not be practical to use for very low frequencies because of size limitations. Therefore, in the present invention the straight horn is used only for the lower middle and higher frequencies.

Referring now to the drawings, wherein like characters of reference designate similar parts in the various views, Figures 1, 2 and 3 show a cabinet with the opening 21 in the front and the opening 22 in the back thereof. Mounted from the back over opening 22, against baffle 34 in chamber 26, is a suitable electroacoustical driver 23, such as a dynamic loud speaker, which includes at least one cone or diaphragm 24 and which should preferably be capable of reproducing a wide range of acoustic signals, especially including the very low frequencies. Compartment 26 for the acoustical driver 23 is formed by baffles 35, the solid top 31, the solid bottom 32, and the speaker mounting baffle 34.

A short, straight-axis horn 25, which preferably, but not necessarily, expands exponentially in a horizontal plane at its mouth portion, is located in the front section of the cabinet and loads the front of the diaphragm 24. By terminating at the opening 21, said horn serves to establish communication between the diaphragm 24 and the opening 21, as well as the atmosphere.

Chamber 26 may be partially closed, if desired, but the back of cone 24 of the acoustical driver 23 is preferably left open to free space, because the self-resonant frequency of said cone will then be lower than the resonance frequency in an enclosure. If desired, the back of compartment 26 may be covered with protective mesh material or perforated sheet material to provide protection against mechanical damage.

An acoustical resonator 27, externally excited by diaphragm 24 of the acoustical driver 23, is defined by completely enclosing a volume of air by means of side pieces 28, back pieces 29, and front pieces 30, together with top 31, bottom 32, and horn 25.

A long air column 33, externally excited at its midpoint by diaphragm 24 of the acoustical driver 23, is defined by baffles 36 together with

every other piece making up the cabinet structure.

Shown at 37, 37 are deflectors having a combined function, in that their opposing, inwardly facing surfaces form part of horn 25, extending said horn well into proximity to the diaphragm 24, thereby assuring the maximum possible acoustic coupling and resultant efficient reproduction of the higher frequencies by the horn; the surfaces of deflectors 37 facing the rim of diaphragm 24 serve to help deflect very low frequencies produced by diaphragm 24 into and out of the air column 33.

The horn 25 is employed to transmit middle and high audible frequencies with great efficiency, the resonator 27 is employed to transmit low audible frequencies with high efficiency, and the long air column 33 is employed to transmit very low audible frequencies with high efficiency. All three of these acoustic elements are coupled together and to the front side of the diaphragm 24 in the portion of the enclosure directly in front of baffle 34. All three acoustic elements then establish communication with the atmosphere through opening 21. Each of the three acoustic elements is designed to operate with highest efficiency over a relatively small frequency range. This results in a substantially constant acoustic loading of the driver diaphragm 24 over the entire very low to high frequency range, the efficiency therefore remaining relatively uniform at all volume levels.

The assembly thus described may be regarded as a "three-way" loud speaker because of the above described incorporation of three distinct acoustic elements into one loud speaker. Each of these elements operates independently of the other because of a novel inherent acoustic phasing effect, resulting in an acoustical crossover network. The crossover frequencies in this acoustical crossover network are adjustable in the dimensional design of the assembly, but are normally at approximately 60 cycles per second and 200 cycles per second, which values will be assumed in further discussion.

The present invention operates as a sound wave guide in its ability to transmit sound from the three distinct acoustic elements 25, 27 and 33. A separation or acoustic cross-over effect is due to a 90° acoustical phase difference between most of the sound waves transmitted by the respective acoustic elements, occurring at the single opening 21.

Heretofore, insufficient front air loading of the acoustic driver cone has demanded additional loading and damping from the rear of the cone, resulting in a dissipation of acoustic power merely as heat loss. The need for high loading has been generally accepted as a means for limiting otherwise excessive cone movement, especially when reproduction of audible frequencies at or near the natural resonant frequency of the cone is required.

In the present invention practically all air loading is accomplished on the front of the driver cone and is in turn coupled to the atmosphere, resulting in efficient acoustical work being accomplished by the air loading. The front air loading is so complete that cone movement is reduced to a minimum throughout the audio range, thus reducing non-linear distortions for given amounts of useful power output. The overall acoustic efficiency of a loud speaker system, exclusive of acoustic driver design factors, is

proportional to the effectiveness of the atmosphere air load upon the driver cone.

It is generally agreed that systems employing multiple acoustical crossovers produce less harmonic distortion than single-crossover systems. The harmonic distortion in the system of the present invention is low because the frequency range of at least two of the three acoustic elements in this system is preferably held to less than two octaves.

The exponential horn is a natural acoustical high pass filter, and the low frequency at which it begins to pass sound is its "cut-off frequency." The cut-off frequency of the exponential horn employed in the system of the present invention is made as low as possible compatible with size limitations. A horn of this nature is capable of excellent very high frequency distribution. However, at frequencies higher than approximately 1000 cycles per second the importance of external air loading is secondary to the capability of the acoustic driver cone or diaphragm, or multiple cones or diaphragms, to generate and properly distribute the higher frequencies.

In the present invention, at the cut-off frequency of the exponential horn 25, another acoustic element comes into operation, namely, the resonator 27. The resonator 27 also has a cut-off frequency, just below its natural resonant frequency. Therefore, at the cut-off frequency of the resonator 27, another acoustic element, namely, the long air column 33, comes into operation to provide efficient very low frequency response, thus adding the full and desirable "bottom" range of audible frequencies.

The response characteristics of a resonator are normally not quite as smooth as those of an exponential horn, but because a straight exponential horn would have to be of enormous size to cover the same frequency range, resonator 27 proves to be a much more practical acoustical element. In the present invention the strategic use of sections of sound deadening material, as shown, for example, at 50, 51, 52 and 53 in Figure 11, results in a much smoother response from resonator 27 than has heretofore been possible in an ordinary resonator. As shown in Figure 11, the sound deadening material is placed at the interior corners of the resonator, to prevent disturbing reflections at said corners.

The long air column 33 serves as an acoustic impedance matching device between the acoustic driver cone or diaphragm 24 and the atmosphere, in the frequency range which includes the natural resonant frequency of said cone or diaphragm. If said acoustic driver has multiple cones and/or diaphragms, the frequency range of said air column covers the natural resonant frequency of the cone or diaphragm used to reproduce the very low frequencies. The length of said air column is adjusted so that its acoustic capacitive effect on said cone or diaphragm effectively damps the otherwise excessive cone or diaphragm excursions. The very low frequency cut-off depends only on the natural resonant frequency of said acoustic driver cone or diaphragm and the proper matching length of said air column. Therefore, for best very low frequency response, said acoustic driver cone or diaphragm should have as low a natural resonant frequency as is practical.

Sound waves in the frequency range of the exponential horn 25 reach the atmosphere through opening 21 in a manner approaching vertical polarization, or in "vertical planes" of sound per-

pendicular to the front of the loud speaker, as shown, for example, at V_L and V_R in the theoretical diagram of Figure 8. Sound waves in the frequency range of the acoustic resonator 27 reach the atmosphere through opening 21 in a manner also approaching vertical polarization, but in a vertical plane parallel to the front of the cabinet, or a "pressure plane," as shown at P in the diagram of Figure 8. Sound waves in the frequency range of the long air column 33 reach the atmosphere through opening 21 in a manner approaching horizontal polarization, or in "horizontal planes" of sound perpendicular to the front of the loud speaker, as shown, for example, at H_A and H_B in the theoretical diagram of Figure 8.

Deflectors 37 serve both horn 25 and air column 33, and indirectly affect resonator 27. Not only do said deflectors complete the physical form of horn 25, but do so primarily in the aforesaid "vertical planes," therefore delivering to said horn sound waves primarily vertically polarized, as required. The shape of said deflectors is such that they deflect very low frequency sounds into the air column 33 in horizontal planes symmetrically located above and below the horizontal center line of acoustic driver 23. The return paths of very low frequency sounds are in two horizontal planes, one plane being in space 33a near the top piece 31, and the other plane being in space 33b near the bottom 32. Thus, upon returning to opening 21, two "horizontal planes" of very low frequency sounds are coupled to the atmosphere in phase with the very low frequency sounds reaching opening 21 by direct radiation from the upper and lower sides of the acoustic driver cone or diaphragm 24.

The indirect effect of deflectors 37 on resonator 27 is that the size and shape of said deflectors control the efficiency and quantity of acoustic output in the frequency ranges of both air column 33 and horn 25, thus allowing the efficiencies of said air column and horn to be adjusted to match the best attainable efficiency of said resonator, the final result being to obtain substantially the best possible frequency response curve for a given type of acoustic driver.

As shown in Figure 4, the lengths of the resonators may be effectively increased, if so desired, by employing speaker baffle elements 54, 54 which extend laterally a substantial distance beyond the side baffle elements 35, 35, and by employing inwardly extending wing elements 55, 55 at the ends of the walls 36, 36, opposing and parallel to the baffle elements 54, 54.

As shown in Figures 5 and 6, a conventional "tweeter" unit 56 may be mounted at the top of the cabinet to provide additional high frequency emphasis, said "tweeter" unit being located immediately over the central portion of the top wall 31, as shown, and being housed in a suitable enclosure 57, which may form part of the main enclosure.

Figure 7 illustrates a modified form of the present invention suitable for use in an auditorium, theater, or other location where a large volume of sound is required. In this form of the invention, a double enclosure is employed, containing two acoustic drivers 23, 23, arranged in vertically spaced relation and cooperating with respective resonators 27 and 33, and respective horns 25, similar to those shown in the single enclosure of Figures 1 to 3. As shown in Figure 7, the deflectors 37 define the rear portions of the sides of the respective horns 25, 25, and extend adjacent the

cones 24, 24 in the same manner as in Figures 1 to 3. Similarly, since the horizontal cross-section of the enclosure, taken through the axes of the drivers 23, 23, is the same as in Figure 3, respective low and very low frequency resonators are provided for each of said drivers, as in the single enclosure of Figures 1 to 3. A conventional "tweeter" unit 56' may be mounted at the top of the cabinet to provide additional high frequency emphasis, as shown.

The loud speaker assembly illustrated in horizontal cross-section in Figure 9 is generally similar acoustically to the assembly of Figures 1 to 3, except that it is arranged to fit into a corner of a room. The enclosure of Figure 9 comprises a cabinet having side walls 28', 28' at right angles to each other and converging rearwardly toward the rear opening 22' of the cabinet. The acoustic driver unit 23 is mounted in the rear of the cabinet against baffle 34', as shown. The compartment 25' for driver unit 23 is formed by baffle 34' and the rear portions of side walls 28', 28'. A straight-axis horn 25' is located at the front section of the cabinet, said horn having the inner deflectors 37, 37 terminating adjacent the cone 24 of the driver, said horn establishing communication between the cone 24 and the atmosphere in front of the loud speaker assembly. Designated at 36', 36' are internal wall elements which are arranged to define respective air columns 27, 27 extending from the inner sides of the deflectors 37, 37 to the sides of the forward portion of horn 25', said air columns 27 having low frequency natural resonance, and the relatively long air column 33 defined above and below the deflectors 37, 37, having very low frequency natural resonance, as in the enclosure illustrated in Figures 1 to 3. As in the previously described embodiments of the invention, the air columns 27 extend from cone 24, along the deflectors 37, and around the baffle elements 36' to the regions rearwardly adjacent the forward portions of the horn 25'. The air column 33 extends from the region rearwardly adjacent one side of the forward portion of horn 25', around the baffle element 36' at said one side, above and below the deflectors 37, 37, and around the baffle element 36' at the other side of the horn to the region rearwardly adjacent the forward portion of the horn at said other side.

While certain specific embodiments of an improved acoustical cabinet device for high fidelity reproduction of the sound vibrations from an acoustical driver unit have been disclosed in the foregoing description it will be understood that various modifications within the spirit of the invention may occur to those skilled in the art. Therefore it is intended that no limitations be placed on the invention except as defined by the scope of the appended claims.

What is claimed is:

1. A loud speaker cabinet comprising a main housing having a top wall, a bottom wall, respective side walls connecting said top and bottom

walls, wall means extending between said top and bottom walls connecting the rear portions of said side walls, and a front wall extending between said top and bottom walls and connected to the forward portions of said side walls, said means including a chamber arranged to receive an acoustic driver unit, said chamber having a forward wall formed with an opening, said front wall including a pair of rearwardly convergent vertical wall elements extending between said top and bottom walls, said vertical wall elements having rear end portions which are reduced in height and which extend into but are spaced from the side edges of said opening, and respective inner vertical baffles connected to and extending from the intermediate portions of said convergent wall elements into the opposite side portions of the main housing between the respective side walls thereof and said chamber, said baffles extending between said top and bottom walls and being spaced at their free vertical edges from the inner vertical surfaces of the housing to define respective folded air conduits of relatively low resonant frequency communicating with said opening, the vertical height of said reduced rear end portions being substantially less than the vertical height of the opening, whereby said folded air conduits communicate with each other adjacent said opening and define a resultant air chamber having a still lower resonant frequency.

2. In combination with the structure of claim 1, a cone speaker mounted in said chamber with the cone of the speaker facing forwardly through said opening, said reduced rear end portions being spaced inwardly from the opposite side edges of said cone, whereby the outer side portions of the cone are acoustically coupled to said folded air conduits and a remaining outer portion of the cone is acoustically coupled to said resultant air conduit.

3. The structure of claim 1, and wherein said housing is substantially rectangular in plan.

4. The structure of claim 1, and wherein said side walls are substantially at right angles to each other, whereby the housing may be received in the corner of a room.

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