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RESONANT, ACOUSTICAL BOOSTER WITH AIR DAMPING

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Fig. 1

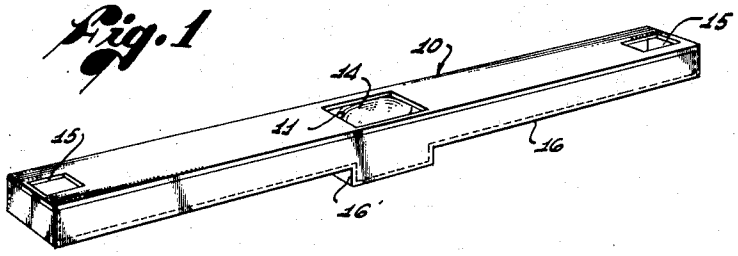


Fig. 2

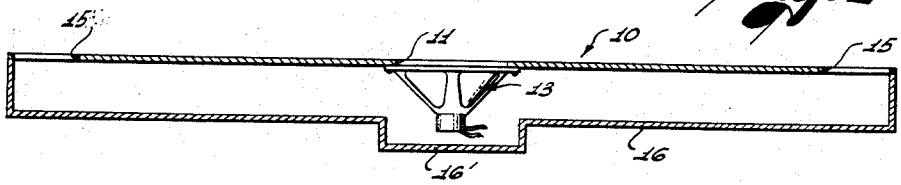
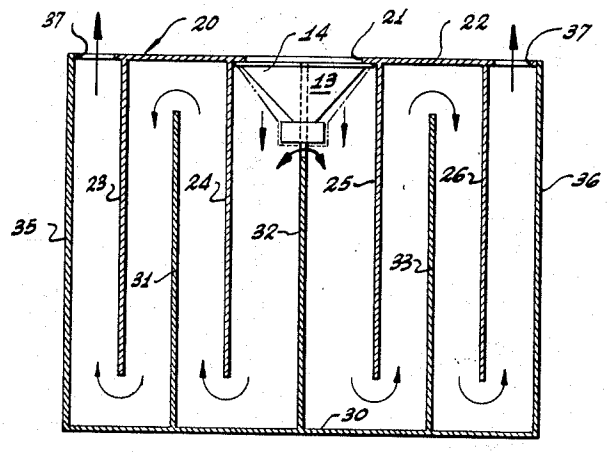


Fig. 3



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RESONANT, ACOUSTICAL BOOSTER WITH AIR DAMPING

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This invention relates to sound reproducing systems, and more particularly to an improved reflex-type resonant chamber for loudspeakers and the like wherein sounds produced at its center are also reproduced at its ends to develop composite sounds of greater realism than has heretofore been possible.

As is well known, many forms of loudspeaker systems have been developed in which it is endeavored to improve the tonal qualities of sound emanating from a loudspeaker. In this connection, considerable time, effort and expense have been devoted to the development of cabinet systems which utilize sound emitted from the back of a speaker cone to re-enforce sound emanating from the front of the cone.

Typically, "back loaded" speaker systems are those in which a speaker is mounted in an opening in one wall of a cabinet, and facing outwardly therefrom. Within the cabinet, baffles are arranged to force the air fluctuations directly behind the speaker to travel along a path of predetermined length before reaching an outlet. Sound emanating from such outlets adds to that produced by the front of the cone.

Conventionally, the length of the path within the cabinet is chosen to assure that it will act as a resonator at a desired low frequency, at which the speaker by itself cannot move enough air to maintain uniform base response. At its resonant frequency, the reflux enclosure within the cabinet inverts the phase of the sound from the rear of the cone, adding it to that produced by the front of the cone. The enclosure also loads the speaker acoustically, reducing cone movement and distortion.

As those skilled in the art are well aware, reflex speaker systems heretofore developed are generally characterized as unduly complex cabinet structures, in which elaborate pains are taken to install sound absorbing and/or reflecting materials of supposedly correct dimensions at strategic locations in order to minimize distortion in an attempt to produce a high fidelity speaker system. All of this, of course, results in an unduly bulky and expensive speaker system.

Furthermore, despite such expense and precautions, it is generally recognized that the tonal qualities of so-called high fidelity speaker systems leave much to be desired. While the ultimate goal is to effect a reproduction of sounds in such a manner that the listener is made to feel that he is in the presence of the source of the original sounds, attempts to attain this objective with prior art reflex speaker systems have failed. In such systems as heretofore known, it cannot be ascertained, for example, whether a beat note of low frequency is being made by a bass tuba, bass drum or bass viol, i.e., the discriminating listener can perceive only that it is a low frequency note, but cannot be certain what type of instrument created such a note.

It is an object of this invention to provide an improved sound resonator that overcomes the above and other disadvantages of the prior art.

It is another object of this invention to provide an improved reflex-type loudspeaker system, in which sounds created by both the front and back of a speaker cone are combined in a manner to obtain a degree of realism not heretofore made possible with such speaker systems of the prior art.

It is another object of this invention to provide a

unique reflex-type loudspeaker system comprising a minimum number of component parts of simple design and rugged construction, capable of reliable operation to produce tones and overtones for greater realism over a wider frequency range than has heretofore been possible with speaker systems of the prior art.

The above and other objects and advantages of my invention will become apparent from the following description taken in conjunction with the accompanying drawings of illustrative embodiments thereof, in which:

FIGURE 1 is a perspective view of a straight resonant pipe showing a loudspeaker cone centrally mounted within the pipe to produce sounds through a central opening in one wall thereof, showing ports adjacent the opposite ends of the pipe in the same wall through which to project sounds created by the back of the speaker cone, and also showing a bulge in the center of the pipe in the vicinity of the speaker cone to insure the operation of the system in accordance with my invention;

FIGURE 2 is a longitudinal sectional view of the pipe of FIGURE 1, showing more clearly the central internal construction of the pipe; and

FIGURE 3 is a longitudinal sectional view of a folded pipe system in accordance with my invention, to illustrate the further utility of my invention in achieving compactness of form, and to further aid in understanding the variety of forms embraced by my invention.

Referring to FIGURES 1 and 2, there is shown an elongated, hollow pipe **10** that has a central opening **11** in one wall **12** thereof. Within a central portion of the pipe **10**, a loudspeaker structure **13** is secured to the interior of the wall **12** so that the loudspeaker cone, indicated at **14** in FIGURE 1, faces the opening **11**.

At the extreme ends of the pipe **10**, openings **15** are provided in the wall **12** through which to propagate sounds created by the back of the speaker cone. The openings **11** and **15** are preferably disposed along parallel axes. Thus, sounds emanate from the pipe **10** through openings that are all facing in the same direction. As will be seen, this arrangement facilitates stacking of a number of pipes in a multiple speaker system so that all openings through which sound emanate are facing in the same direction. Furthermore, and most important, the directing of sounds from all openings in the same direction gives the listener an "all out front" sensation in that he is made to feel that he is seated in front of the source of the sound.

The dimensions of the pipe **10** are extremely important in providing a degree of realism not heretofore possible with sound-reproducing systems. In this connection, a speaker system in accordance with my invention is arranged to insure that the volume of the air space directly behind the speaker structure **13** is the same as the volume of any other portion of the pipe of the same length. To this end, the wall **16** of the pipe **10** opposite the wall **12** is "bulged," as indicated at **16'**, to effectively replace the space taken up by the speaker structure **13**.

In addition, the length of the pipe **10** is chosen so that the distance between the center of the speaker and either of the ports **15** is only one-half the length of a pipe in which sound created at one end is caused to be emanated from the other end. For example, for a single length of pipe in which a speaker cone is mounted in one end to cause sound to be exhausted from the opposite end, a pipe of approximately 7 feet in length is needed to resonate at 40 cycles per second. On the other hand, for the center-excited system of my invention to be resonant at that frequency, only half that length is needed from the center of the speaker to each port.

Still further, the amplitude of sound radiated at the bass resonant frequency from each port is halved in a

speaker system of my invention, i.e., halved with respect to a pipe in which sounds from the back of the speaker are created at one end and projected from the opposite end. Therefore, interference at the lower frequencies with the radiation from the front of the speaker cone is minimized. It is for this reason that the ports may be terminated at the front of the system and in the same plane as the speaker cone. Thus, it is necessary in my invention that only one surface of a cabinet construction has any openings therein.

In addition, I have found that, for any given length of the pipe 10, and wherein the pipe is bulged as previously described, I am able to achieve a desired degree of damping, and maintain high efficiency and good, crisp reproduction, by limiting the size of the pipe. As previously indicated, it is known that the pipe enclosure loads the speaker acoustically, reducing cone movement and distortion. However, such damping as is obtained in prior art systems is achieved by dimensioning passageways without regard to any predetermined relationships among such factors as the space taken up by the speaker structure, the space to be "added" to the interior of the pipe, and the dimensions of the remainder of the pipe.

I have found that for best results, the cross-sectional area of any portion of the pipe outside the vicinity of the speaker structure varies from 20% to 25% of the cross-sectional area of the speaker as measured at its mouth. Although, by way of example, the invention is illustrated and described for a pipe having a rectangular cross-sectional configuration, it is to be understood that the invention is not so limited, and the pipe may have any desired cross-sectional shape such as circular, elliptical, hexagonal, etc.

While the theory of operation of my system to achieve its unique results may not be precisely defined, it has been found that my center-loaded pipe structure lends itself to maximum critical damping, which even further enhances its tonal quality, presence and natural timbre of reproduced musical sounds, and without the usual losses in efficiency found in previous systems. Also, the high damping factors permissible in my invention cannot be tolerated in prior art speaker systems, wherein efficiency falls off rapidly.

It is believed that my system is unique in that the center-loaded resonant pipe allows air within the pipe and at the external surface to communicate with the free atmosphere to sustain the ultimate in critical damping and still maintain a high ratio of undistorted acoustical power output to speaker cone amplitude of travel. This is believed to be due in part to utilizing or reclaiming the same air for sound propagation that is used for damping, coupled with the high efficiency of the resonant pipe and the reflex action of the sounds from the ports added to the sounds from the front of the speaker cone.

As for the more exact reproduction of the original sound waves (however complex) which I claim for my invention, this is believed to be accomplished by confining the rarefication and compression of air in the pipe until it communicates with the ports or open ends of the pipe so that the sound propagation coincides with the original sound timbre (instead of being exhausted into a large hollow area, closed or partially open, where it can expand and lose the original "snap" or timbre). The action of the front of the cone is a reflection of the action within the pipe and is therefore controlled by the pipe and radiates the same lifelike timbre that is dictated by the center-excited, air damped resonant pipe.

In further elaboration on my theory, damping is at a minimum at low audio excitation and increases in step as audio power input is increased. This is fully automatic and works in much the same way as, and is analogous to negative feedback in an audio amplifier. Also, in my resonant pipe system, heavy duty magnets to provide high flux density for the voice coil are unnecessary. Only a small percentage of the usual required magnetism is needed for sensitivity and a maximum amount of audio input capabilities.

Tests on actual structures demonstrate the superiority of my invention over reflex-type speaker systems of the prior art. Such tests reveal that for small speakers, e.g., 4-in. x 6-in. oval speakers and 5-inch round speakers, my system exhibits a flat response throughout the desired range, and is easily capable of extending the bass response of such small speakers down to a usable frequency of less than 35 cycles per second.

The bulging of the pipe above described is effected for straight pipes, i.e., unfolded pipes. In folded enclosures, the space occupied by the speaker structure is compensated for by merely positioning and spacing partitions forming the passageways in a proper manner. Such a folded structure is illustrated in FIGURE 3.

Referring to FIGURE 3, a box-like cabinet 20 is shown wherein the speaker structure 13 is mounted in a central opening 21 in one outer wall panel 22 of the cabinet. Spaced inner partitions or baffles 23, 24 extend from the inner surface of the panel 22 adjacent the rim of the speaker structure 13, and additional outer partitions 25, 26 extending from the panel 22 are spaced the same distances from the partitions 23, 24.

The bottom panel 30 supports partitions 31, 32, 33 that extend, respectively, midway between the partitions 23—24, 24—25, and 25—26. Thus, the center partition 32 extends along the axis of the speaker structure 13. As shown, the center partition 32 extends from the panel 30 to the innermost portion of the speaker structure 13.

End panels 35, 36 extend between the ends of the panels 22, 30. The lengths of the panels 22, 30 are such that the end panels 35, 36 are spaced the same distances from the adjacent partitions 23, 26. The end panels 35, 36 and all of the partitions are the same width, so that their edges abut side panels (not shown) of the cabinet 20. Furthermore, the inner ends of the partitions other than the center partition 32 are spaced the same distances from the adjacent panels 22, 30. In this manner, a labyrinth is formed on each side of the partition 32, so that sound created by the rear movements of the speaker cone 14 travel around the inner ends of the partitions away from the speaker and toward the ends of the cabinet 20.

The panel 22 is provided with openings or ports 37 at the tops of the passages defined by the end panels 35, 36 and the adjacent partitions 23, 26. The speaker structure thus formed is effectively a compact form of an elongated pipe that is folded back and forth, with its ends terminating in the plane of the mouth of the speaker structure 13. Sounds created by the back movements of the speaker cone 14 are thus caused to emanate from the acoustically remote openings 37 to boost the sounds emanating from the front of the speaker cone 14.

In the speaker structure of FIGURE 3, the distances from the end panels 35, 36 to the adjacent partitions 23, 26 are the same as the distances between the partitions 31, 33 and the partitions on either side thereof. All partitions comprising the total pipe length are evenly spaced, and all are of the same length except the center partition 32. The length of the center partition is determined by the depth of the speaker. In this latter connection, the center partition 32 preferably is a panel extending all the way between the front and rear panels 22, 30 and is provided with a substantially V-shaped notch to accommodate the speaker. There is sufficient clearance between the innermost portion of the speaker structure and the bottom of the notch to allow an air space through the back of the speaker. The cross-sectional area of this clearance space, plus the cross-sectional area of the space taken up by the speaker structure in the center partition 32, is equal to the cross-sectional area of any space between the ends of the partitions and the adjacent panels. Thus, there is provided a uniform cross-sectional area from one end of the pipe to the other.

At each of the openings 37 in my speaker structure, the cross-sectional area may be equal to the cross-section of any portion of the pipe, or as much as 20%–25% less than the cross-section of the pipe. Varying the sizes of the openings varies the port damping, and making the openings smaller increases bass response slightly at very low sound levels. The total cross-section of both openings 37 is equal to 40%–50% of the usable cone area in a critically damped system, as opposed to 90%–95% in a normal pipe.

The interior walls of a speaker enclosure of my invention preferably are smooth and rigid. The materials used for the construction may vary as desired, both in type and thickness. However, all parts preferably are rigid, and are characterized in that sounds will not pass through the walls and partitions but only along their surfaces. In this connection, I have found it unnecessary to use quantities of sound absorbent padding and the like in my speaker system.

From the foregoing, it will be apparent that although I have illustrated and described particular embodiments of my invention, it will be apparent that various modifications can be made therein without departing from the spirit and scope of my invention. It embraces the use of any vibratable device for producing sounds, even including a simple membrane installed flush with a wall of the enclosure. Further, my invention works as efficiently and well as a transducer, and is especially useful where small area cones or diaphragms are used. Accordingly, I do not intend that my invention be limited, except as by the appended claims.

I claim:

1. In sound reproducing apparatus, the combination of: a hollow member having a pair of spaced openings disposed along parallel axes, said hollow member also having a central opening disposed along an axis parallel to and midway between said pair of openings; a sound producing membraneous element within a portion of said hollow member and attached to said hollow member at said central opening, said element being adapted to direct sound waves outwardly and inwardly of said central opening, said hollow member being a conduit to direct the inwardly directed sound waves through said pair of openings, said hollow member also having a shape such that any portions of said member which are of the same length as that portion of said member including said element are of the same volume.

2. Sound reproducing apparatus comprising: a hollow element having a central opening in one wall portion thereof; a loudspeaker structure mounted within said element on said one wall portion and having a cone facing said opening; and a pair of hollow pipes extending from and communicating with said element, each pipe being dimensioned so that any portion thereof of the same length as said element occupies the same volume as the space in said element that is not occupied by said loudspeaker structure, said pipes having respective openings in the outer ends thereof.

3. Sound reproducing apparatus as defined in claim 2, wherein said openings are all in the same plane.

4. Sound reproducing apparatus as defined in claim 2, wherein said element and said pipes are coaxial, and wherein said openings are all in the same plane.

5. Sound reproducing apparatus comprising: a loudspeaker structure supporting a cone; and a hollow element of predetermined length supporting said loudspeaker structure therein adjacent the center portion of one wall thereof, said element having a central opening in said one wall of substantially the same dimensions as the mouth of said cone, the portions of said element on either side of said central opening being of uniform cross-section, the portion of said element between said loudspeaker structure and the wall portion opposite said one wall having the same volume as in any other portion of the same length as said center portion.

6. Sound reproducing apparatus as set forth in claim 5, wherein the cross section of said portions of said element on either side of said loudspeaker structure have a cross-sectional area in the range of twenty percent to twenty-five percent of the cross-sectional area of the mouth of said cone.

7. An acoustic booster system comprising: a loudspeaker structure including a cone; and a hollow element of predetermined length supporting said loudspeaker structure therein adjacent the center portion of one wall thereof, said elements having a central opening in said one wall of substantially the same dimensions as the mouth of said cone, the portions of said element on either side of said central opening being of uniform cross-section, the portion of said element between said loudspeaker structure and the wall portion opposite said one wall having the same volume as in any other portion of the same length as said center portion, the cross-section of the portions of said hollow element on either side of said loudspeaker structure being no greater than twenty-five percent of the cross-section of the mouth of said cone.

8. Acoustic boost means comprising: a pipe of predetermined length having a central opening and end openings, said central and end openings being in the same wall portion of said pipe; sound-producing means including a membraneous element and magnetic means for actuating said element to cause sounds to be emanated from opposite surfaces thereof, said structure being mounted within said pipe with said element positioned to cause sounds created by one surface to be projected through said central opening; and a hollow extension from the wall portion opposite said central opening, the volume defined by said hollow extension being equal to the volume within said pipe that is occupied by said element.

9. Acoustic boost means as defined in claim 8, wherein the cross-section of said pipe is less than twenty-five percent of the cross-section of said central opening.

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