

April 2, 1957

N. C. FULMER
LOUD-SPEAKER SYSTEM

2,787,332

Filed Sept. 6, 1952

3 Sheets-Sheet 1

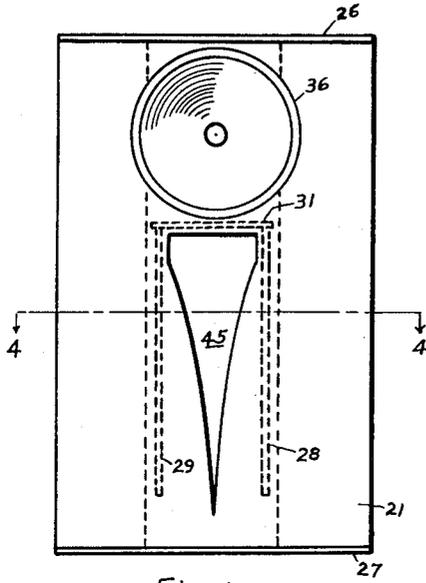


Fig. 1

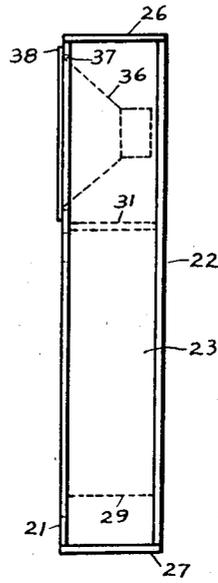


Fig. 2

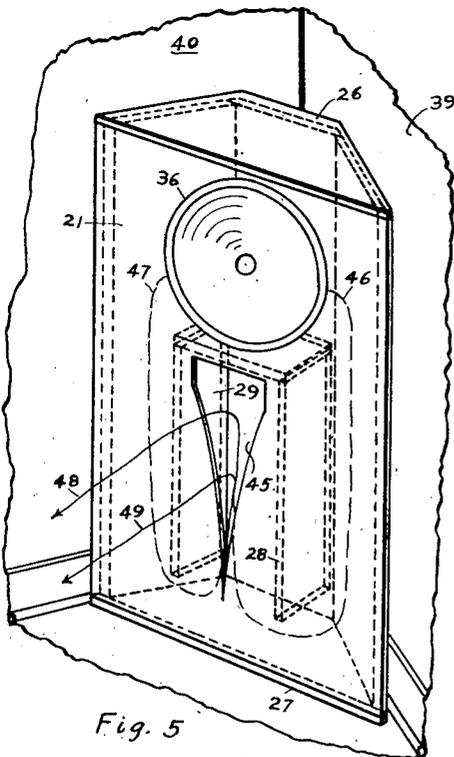


Fig. 5

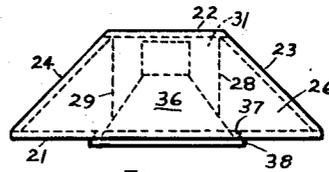


Fig. 3

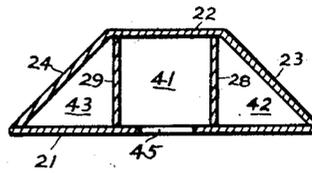


Fig. 4

INVENTOR.

Norman C. Fulmer

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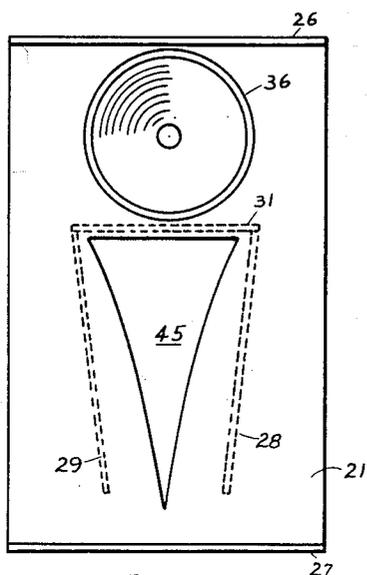


Fig. 12

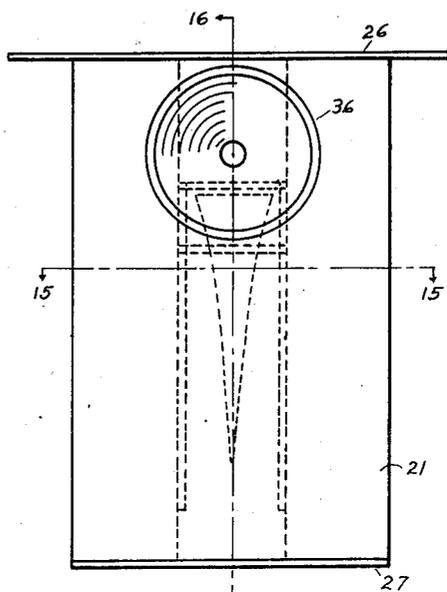


Fig. 13

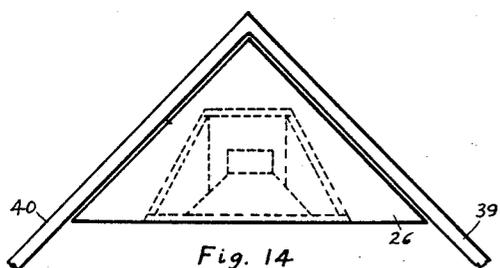


Fig. 14

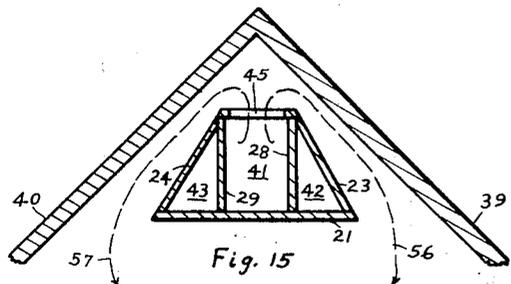


Fig. 15

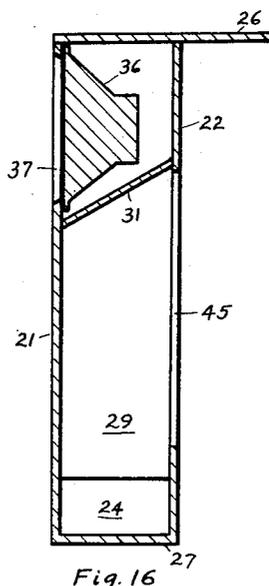


Fig. 16

INVENTOR.

Norman C. Fulmer

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LOUD-SPEAKER SYSTEM

Norman C. Fulmer, Pearl River, N. Y.

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22 Claims. (Cl. 181—31)

This invention relates to loudspeaker systems, and particularly to loudspeaker enclosures of the acoustic-path or labyrinth type.

Loudspeaker enclosures of the prior art have employed acoustic paths, for sound waves, comprising chambers, cavities, labyrinths, resonant tubes, and the like. These acoustic paths may be employed at either the front or rear of a loudspeaker cone. The far end of the acoustic path may be open or closed. The general purpose of an acoustic path is to provide acoustical loading on the loudspeaker cone and to strengthen the radiated sound energy.

It is a characteristic of acoustic-path enclosures of the prior art, that the acoustic response of the system is not uniform over a wide frequency range, due to the effect of the acoustic path-length upon certain frequencies of sound waves. For example, certain sound waves will be accentuated or attenuated which have a wave length equal to twice or four times the length of the acoustic path, depending on whether the far end of the path is open or closed.

It is an object of this invention to provide a loudspeaker system having an acoustic path which has uniform acoustic response to a wide range of frequencies.

Further objects are to provide a loudspeaker system which is physically compact, efficient, economical to construct, which provides balanced loading of the loudspeaker cone, and which is shaped to fit either against a wall or in a corner of a room. Other objects will be apparent.

The invention comprises, essentially, an acoustic sound path enclosure having transverse sound-escape openings along its path length. The sound-escape openings may comprise a plurality of port or vent openings, or a single slit or elongated tapered vent opening extending lengthwise along one or more sides of the acoustic path-length. The novel vented acoustic path structure provides uniform response to a wide range of acoustic wave-lengths, and overcomes the undesirable frequency-discriminating effects of prior-art acoustic-path structures.

Referring to the drawing,

Figure 1 is a front view of a loudspeaker system embodying the invention, certain internal structural details being shown by dotted lines,

Figure 2 is a side view of Fig. 1,

Figure 3 is a top view of Fig. 1,

Figure 4 is a cross-section view taken on the line 4—4 of Fig. 1,

Figure 5 is a perspective view showing the invention positioned in a corner of a room, the acoustic path being shown in dashed lines,

Figure 6 is a front view of a modification of the invention having a closed acoustic path,

Figure 7 is a cross-section view taken on the line 7—7 of Fig. 6,

Figure 8 is a front view of another modification of the invention having a closed acoustic path,

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Figure 9 is a cross-section view taken on the line 9—9 of Fig. 8,

Figure 10 is a cross-section view taken on the line 10—10 of Fig. 8,

5 Figure 11 shows a modification of the structure shown in Fig. 10,

Figure 12 is a front view of an embodiment of the invention having a tapered-horn acoustic coupling,

10 Figure 13 is a front view of an embodiment of the invention having a tapered opening at the rear thereof,

Figure 14 is a top view of the embodiment of Fig. 13 positioned in a corner of a room,

Figure 15 is a cross-sectional view taken on the line 15—15 of Fig. 13, and

15 Figure 16 is a cross-sectional view taken on the line 16—16 of Fig. 13.

In the preferred embodiments of the invention, the loudspeaker enclosure comprises a front member 21, a rear member 22, side members 23 and 24, a top member 26, a bottom member 27, internal vertical members 28 and 29, and an internal closure member 31. A loudspeaker 36 is positioned in a suitable opening 37 in the front member 21. Preferably, the loudspeaker 36 is provided with an annular rim 38 which is affixed to the front member 21 from the front side thereof. Thus, the loudspeaker may be installed or removed conveniently from the front of the enclosure, and also the depth dimension of the enclosure can be reduced. Alternatively, the loudspeaker may be installed from the rear of the front member by removing one of the external members, or a portion thereof, of the enclosure.

In the embodiment of the invention shown in Figs. 1—5, the internal vertical members 28 and 29 are positioned in engagement with the front and back members 21 and 22, and provide gaps with respect to the bottom member 27. The internal closure member 31 is positioned against the top ends of the vertical members 28 and 29 near the loudspeaker 36, and engages the front and rear members 21 and 22. The internal members, cooperating with the front and back members, form an airtight closure with respect to the loudspeaker except for the gaps between the bottom ends of the vertical members 28 and 29 and the bottom member 27.

The top and bottom members, and the overall vertical cross-section of the enclosure, preferably have a trapezoidal shape, the side members 23 and 24 forming 45-degree angles with respect to the front member 21. Thus, the side members 23 and 24 are positioned at a 90-degree angle with respect to each other. This 90-degree angle of the sides permits the enclosure to be conveniently positioned in a corner of a room, as shown in Fig. 5, with the sides 23 and 24 respectively near adjoining room walls 39 and 40. The enclosure also may be conveniently positioned against a wall of a room, with the back member 22 adjacent the wall.

The internal vertical members 28 and 29 form a center acoustic path 41 having a rectangular cross-section, and side acoustic paths 42 and 43 having substantially triangular cross-sections (refer to Fig. 4). The center acoustic path 41 preferably has a cross-sectional area twice as large as that of either of the side acoustic paths 42 and 43; that is, the combined cross-sectional areas of the side acoustic paths 42 and 43 are equal to the cross-sectional area of the center acoustic path 41. This provides an overall uniform cross-sectional area of acoustic path with respect to the loudspeaker, as will be described hereinafter.

An elongated opening 45 is provided in the front member 21 between the internal vertical members 28 and 29. The elongated opening 45 is preferably tapered, as shown, the wide part of the taper being at the top

thereof. An exponential taper has been found particularly suitable, although other forms of slits and multiple holes have proven satisfactory.

In operation, sound waves are emitted from the front of the loudspeaker 36. Also, sound waves are emitted from the rear of the loudspeaker, as shown by the dashed lines 46 and 47 in Fig. 5. The sound waves from the rear of the loudspeaker travel substantially horizontally away from both sides of the loudspeaker for a short distance, then downwardly through the respective side acoustic paths 42 and 43, around the bottom edges of the internal vertical members 28 and 29, upwardly through the center path 41, and out through the opening 45.

It is well known that different wave lengths of sound energy prefer, or are responsive to, different physical path-lengths. For example, longer wave-lengths of sound prefer, and are responsive to, longer path-lengths than is the case with shorter wave-lengths. The novel elongated opening 45, extending along all or a portion of the acoustic sound-wave path, permits the various sound-wave vibrations to exit from the acoustic path at various points therealong which are the most suitable for the respective wave-lengths of the sound vibrations. Thus, a longer wave-length (lower frequency) of sound will tend to exit from the opening 45 at a relatively far point 48 along the acoustic path whereas a shorter wave-length (higher frequency) of sound will tend to exit at a relatively shorter point 49, as is illustrated in Fig. 5.

Because of this novel feature, the system is substantially non frequency-discriminating. In effect, each wavelength of sound energy seeks and makes its own exit from the acoustic path at the appropriate point thereon. A tapered opening 45, as shown, tends to provide uniform frequency response, whereas a straight-sided slit may tend to favor the higher frequencies. The preferred length of tapered opening is, as shown, equal to about one third or one half of the total length of acoustic path.

The novel structure of the enclosure provides not only a shape suitable for positioning in a corner or against a wall of a room, but also provides an acoustic path having balanced loudspeaker loading on two opposite sides thereof and a uniform overall cross-sectional area throughout the length of the acoustic path. The balanced loudspeaker loading prevents distortion of the cone which otherwise may occur in acoustic-path structures of the prior art wherein the sound energy travels away from one side only of the loudspeaker, thereby subjecting the cone to unequally distributed or lop-sided pressures.

Figures 6 through 11 show structures of closed-end acoustic paths embodying the invention. A closed-end acoustic path is sometimes desirable to isolate or dissipate the sound from the rear side of the loudspeaker.

In the structure of Figs. 6 and 7, a cavity 51 is provided in front of the tapered opening 45, and preferably contains sound absorbing material 52 which absorbs the sound waves which enter the cavity 51. The opening 45 provides uniform loudspeaker response over a wide frequency range, by permitting the various wave-lengths of sound to exit from the acoustic path at various distances thereon, thereby preventing undesired reflections from the end of the acoustic path.

In the embodiment shown in Figs. 8 through 11, tapered openings 53, 54 are provided in the internal vertical members 28, 29 which in this embodiment extend downwardly to the bottom 27 of the enclosure. There is no opening in the front member 21 other than the loudspeaker opening 37. In this embodiment, the center acoustic path 41 of Figs. 1 through 5 serves as a sound-absorbing cavity 51, aided by sound-absorbing material 52 contained therein. The dashed lines 46, 47 in Fig. 8 illustrate how the various wave-lengths of sound enter through the openings 53, 54 into the absorbing cavity 51.

The tapered openings of the various embodiments can be supplanted by a plurality of holes suitably placed and of suitable sizes. The smaller end of the taper can be

approximated by smaller-size holes, or by spacing the holes farther apart, as shown in Fig. 11.

Figures 12 through 16 show embodiments of the invention having tapered-horn acoustic paths which function to efficiently couple the sound vibrations within the acoustic path into the relatively greater volume of air external to the loudspeaker system.

In the embodiment of Fig. 12, the internal vertical members 28, 29 are positioned in a slanting manner, as shown, to provide an acoustic path having an ever-increasing cross-sectional area between the loudspeaker 36 and the acoustic opening 45.

The embodiment of Figs. 13-16 utilizes a tapered acoustic opening 45 in the back member 22 between the internal vertical members 28 and 29 which may be exactly vertical as shown, or slanted as shown in Fig. 12. The loudspeaker system having the rear acoustic opening may be positioned near a corner of a room, as shown in Figs. 14 and 15, so that the room walls 39 and 40 cooperate with the side members 23 and 24, respectively, to form tapered-horn acoustic paths between the opening 45 and the room air through which the acoustic waves pass as shown by dashed lines 56 and 57 in Fig. 15. The enclosure may be constructed so that the side members 23 and 24 thereof are at proper angles to form the acoustic horn. The top member 26 may form a large triangular shape, as shown, to properly position the enclosure in the corner and to aid in directing the sound waves outwardly into the room. The internal closure member 31 may be slanted, as shown in Fig. 16, to provide a longer acoustic path in the enclosure.

A suitable loudspeaker system in accordance with the invention may comprise a 15-inch diameter loudspeaker mounted in an enclosure having overall dimensions of 30 inches wide, 48 inches high, and 11 inches deep, constructed from 1/2-inch or 3/4-inch plywood, with a tapered opening 45 having a length of 26 inches and a maximum width of 8 inches.

While preferred embodiments of the invention have been shown and described, it will be apparent to those skilled in the art that the invention is applicable to various sorts of acoustic enclosures, cavities, chambers, labyrinths, resonant tubes, tapered horns, and the like, and that sound from either the front or back of the loudspeaker may be directed into the acoustic path enclosure. Various modifications may be made without departing from the spirit and scope of the present invention, which is defined in the following claims.

What is claimed is:

1. A loudspeaker system comprising a loudspeaker and an enclosure therefor, said enclosure comprising a plurality of walls defining a plurality of elongated acoustic paths extending from said loudspeaker and a single elongated terminating acoustic path coupled at an end thereof to the ends of said plurality of paths which are remote from said loudspeaker, the cross-sectional area of said terminating path being substantially equal to the combined cross-sectional areas of said plurality of paths, at least one of said walls being provided with an elongated opening positioned lengthwise along said terminating acoustic path.

2. A loudspeaker system comprising a housing composed of a plurality of walls defining a central acoustic path closed at one end and side acoustic paths flanking said central acoustic path and parallel thereto, a loudspeaker positioned near said closed end and beyond said central path and adapted to emit sound waves into said side acoustic paths, and means coupling said side paths to said center path at the ends thereof farthest from said closed end.

3. The system in accordance with claim 2 in which at least one of said walls is provided with an elongated opening positioned lengthwise along said central acoustic path.

4. The system in accordance with claim 2 in which said walls define a central acoustic path which has a rectangular

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lar cross-section and side acoustic paths which have triangular cross-sections, thereby forming an overall trapezoidal cross-section.

5. A loudspeaker system comprising an enclosure having a rectangular front member, a rectangular back member, side members connecting the vertical edges of said front and back members, top and bottom members respectively engaging the ends of said front, back and side members, a pair of internal substantially vertical members spaced apart and extending between and in engagement with said front and back members thereby defining an elongated central acoustic path and elongated side acoustic paths which flank said central acoustic path, an internal closure member engaging the top ends of said internal vertical members and said front and back members, said internal vertical members being provided with openings to communicate said central path with said side paths, said front member being provided with an opening between the top thereof and said internal closure member, and a loudspeaker positioned at said opening.

6. The system in accordance with claim 5, in which at least one of said rectangular members is provided with a vertical elongated acoustic opening communicating said central acoustic path with external air.

7. The system in accordance with claim 5, in which at least one of said rectangular members is provided with a vertical elongated acoustic opening positioned along said central acoustic path, and including a plurality of walls defining a cavity positioned over said acoustic opening.

8. The system in accordance with claim 6, adapted to be positioned at a corner of a room, in which said acoustic opening is in said back member said system being positioned with the back thereof near said corner of said room, whereby said side members and the walls of said room form a continuation of said acoustic paths.

9. The system in accordance with claim 5, in which said internal substantially vertical members are slanted to cause said elongated side and central acoustic paths to have tapered cross-sectional areas.

10. A loudspeaker system comprising an enclosure having a rectangular front member, a rectangular back member horizontally narrower than said front member, side members connecting the vertical edges of said front and back members, trapezoidally shaped top and bottom members respectively engaging the ends of said front, back and side members, a pair of internal substantially vertical members spaced apart and extending between and in engagement with said front and back members thereby defining an elongated central acoustic path and elongated side acoustic paths which flank said central acoustic path, an internal closure member engaging the top ends of said internal vertical members and said front and back members, said internal vertical members being provided with openings to communicate said central path with said side paths, said front member being provided with an opening between the top thereof and said internal closure member, and a loudspeaker positioned at said opening.

11. The loudspeaker system in accordance with claim 10, in which at least one of said rectangular members is provided with a vertically elongated opening communicating said central acoustic path with external air.

12. The loudspeaker system in accordance with claim 10, in which said internal substantially vertical members are spaced farther apart at the top ends thereof than at the bottom ends thereof to form a tapered acoustic path.

13. The loudspeaker system in accordance with claim 12, adapted to be positioned in a room having walls defining a corner, in which said back member is provided with a vertically elongated opening to communicate said central acoustic path with external air, said loudspeaker system being positioned near said corner with said vertically elongated opening facing said corner, the vertical edges of said front member being farther from said walls

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than the vertical edges of said back member to form tapered acoustic paths between said side members and said walls.

14. A loudspeaker system comprising an enclosure having a rectangular front member, a rectangular back member positioned in aligned spaced parallelism to said front member and horizontally narrower than said front member, side members connected respectively between the vertical edges of said front and back members, said front, back and side members having the same vertical height, the top edges thereof defining a top horizontal plane and the bottom edges thereof defining a bottom horizontal plane, trapezoidally shaped top and bottom members positioned respectively at said top and bottom horizontal planes and connected respectively to the top and bottom edges of said front, back and side members to form a structure having a generally trapezoidal horizontal cross-section, a pair of internal substantially vertical members spaced apart and extending between and in perpendicular engagement with said front and back members thereby forming a rectangular central acoustic path and triangular side acoustic paths, the top and bottom ends of said internal members being spaced respectively from said top and bottom members, an internal closure member positioned substantially horizontally and engaging the top ends of said internal vertical members and said front and back members, said front member being provided with an opening between the top thereof and said internal closure member, a loudspeaker positioned at said opening, the front of said loudspeaker communicating with external air and the rear thereof communicating with internal air, said front member being provided with a vertically tapered opening between said internal vertical members to communicate said central acoustic path with external air, the width of said tapered opening being greatest at the top end thereof.

15. An acoustical system for radiating sound waves, comprising a plurality of walls arranged to define an elongated acoustic path, and means for inducing sound waves into an end of said path whereby said sound waves move toward the other end of said path, at least one of said walls containing a plurality of escape paths positioned lengthwise therealong, said walls having substantially uniform thickness at said escape paths, said escape paths being substantially unobstructed thereby permitting said sound waves to move freely therethrough and into space externally of said acoustic path, the total effective cross-section area of said escape paths being sufficiently great so that substantially all of the sound waves radiated from said acoustic path emerge from said escape paths.

16. An acoustical system as claimed in claim 15, in which at least one of said walls is provided with an elongated slot extending lengthwise along said acoustic path thereby to provide said plurality of escape paths.

17. An acoustical system for radiating sound waves, comprising a plurality of walls arranged to define an elongated acoustic path, and means for inducing sound waves into an end of said path whereby said sound waves move toward the other end of said path, at least one of said walls containing an elongated tapered slot positioned lengthwise therealong, said tapered slot being substantially unobstructed thereby permitting said sound waves to move freely therethrough and into space externally of said acoustic path, the effective cross-section area of said tapered slot being sufficiently great so that substantially all of the sound waves radiated from said path emerge from said tapered slot.

18. An acoustical system as claimed in claim 17, in which said tapered slot is relatively wider at the end thereof nearest said other end of the acoustic path.

19. An acoustical system as claimed in claim 18, in which said plurality of walls define a tapered elongated acoustic path having a relatively greater cross-section area in the vicinity of the wider end of said tapered slot.

20. An acoustical system for radiating sound waves,

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comprising a plurality of walls arranged to define an elongated acoustic path, means for inducing sound waves into an end of said path whereby said sound waves move toward the other end of said path, at least one of said walls containing an elongated slot positioned lengthwise therealong, said slot being substantially unobstructed thereby permitting said sound waves to move freely therethrough and into space externally of said acoustic path, and means substantially closing said other end of the acoustic path so that substantially all of the sound waves radiated from said path emerge from said slot.

21. An acoustical system as claimed in claim 20, in which said elongated slot is tapered, the wider part of said taper being at the end of said slot which is nearest said closed end of the acoustic path.

22. An acoustical system as claimed in claim 21, in which said plurality of walls define a tapered elongated acoustic path having a relatively greater cross-section area in the vicinity of the wider end of said tapered slot.

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