



US006016353A

United States Patent [19]
Gunness

[11] **Patent Number:** **6,016,353**
[45] **Date of Patent:** **Jan. 18, 2000**

[54] **LARGE SCALE SOUND REPRODUCTION SYSTEM HAVING CROSS-CABINET HORIZONTAL ARRAY OF HORN ELEMENTS**

4,969,196 11/1990 Nakamura .
4,982,436 1/1991 Cowan .
5,000,286 3/1991 Crawford et al. 181/145
5,020,630 6/1991 Gunness 181/192
5,109,419 4/1992 Griesinger .

[75] Inventor: **David W. Gunness**, Sutton, Mass.

Primary Examiner—Curtis A. Kuntz
Assistant Examiner—Rexford N. Barnie
Attorney, Agent, or Firm—Haynes and Boone, L.L.P.

[73] Assignee: **Eastern Acoustic Works, Inc.**,
Whitinsville, Mass.

[21] Appl. No.: **08/962,425**

[57] **ABSTRACT**

[22] Filed: **Oct. 31, 1997**

A loudspeaker system having a cross-cabinet horizontal array of loudspeakers for collectively generating a common acoustical wavefront when respective drivers associated with each of the loudspeakers of the array are similarly driven. The loudspeakers are secured to each other such that adjoining horn side walls for adjacent ones of the loudspeakers are substantially parallel to each other and are relatively deep in relationship to the total length of the loudspeakers, i.e., the length of the sidewalls is about 80% of the depth of the entire loudspeaker. Each horn is angled about 30 degrees off a central axis thereof to provide 30 degrees coverage in the horizontal plane and includes a first, essentially untapered, section which provides the aforementioned coverage in the horizontal plane and a second section having a taper of about 30% to prevent diffraction of the wavefront at the edges of the horn. To mount the loudspeakers to each other in a space efficient manner, each loudspeaker has a generally trapezoidal cross-section sized such that the drivers of the cross-cabinet horizontal array may be closely packed together such that only the walls of the cabinets separate adjacent drivers of the array.

Related U.S. Application Data

[63] Continuation-in-part of application No. 08/921,185, Aug. 29, 1997.

[51] **Int. Cl.**⁷ **H04R 1/02**; H04R 1/20

[52] **U.S. Cl.** **381/342**; 381/340; 381/82;
381/351; 181/152; 181/145; 181/199

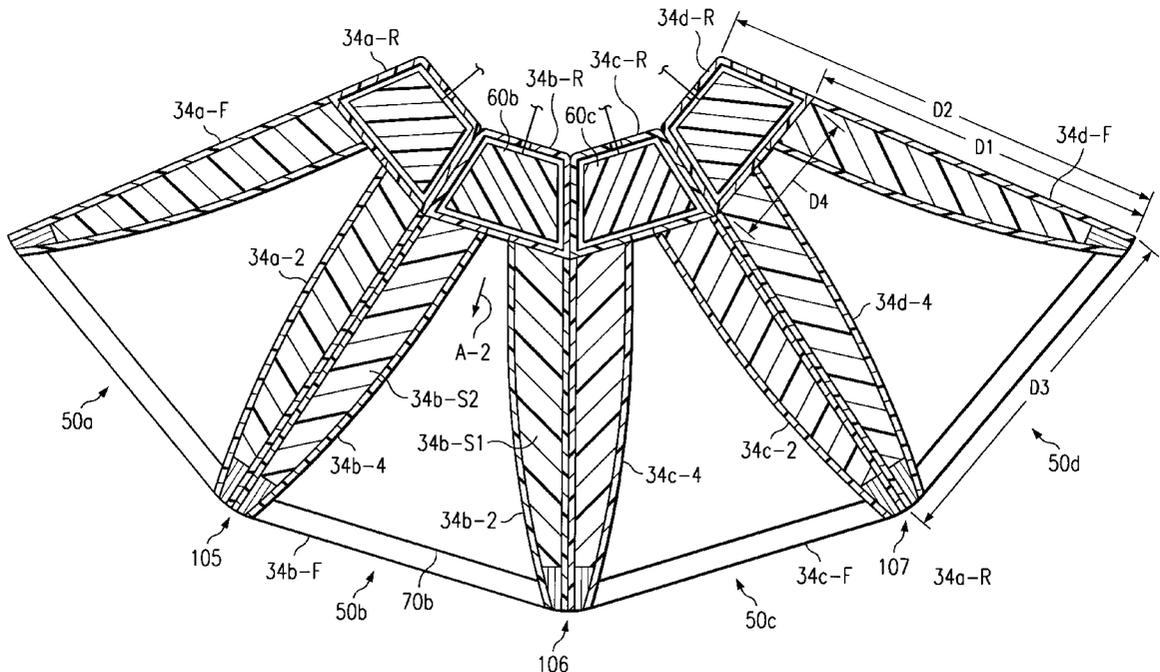
[58] **Field of Search** 381/82, 332, 335,
381/336, 339, 340, 342, 351, 182, 386;
181/144, 145, 152, 159, 199, 153

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,174,019 11/1979 Kramer .
4,308,932 1/1982 Keele, Jr. .
4,369,857 1/1983 Frazer et al. .
4,390,078 6/1983 Howze et al. .
4,503,930 3/1985 McDowell .
4,805,730 2/1989 O'Neill et al. 181/148

35 Claims, 3 Drawing Sheets



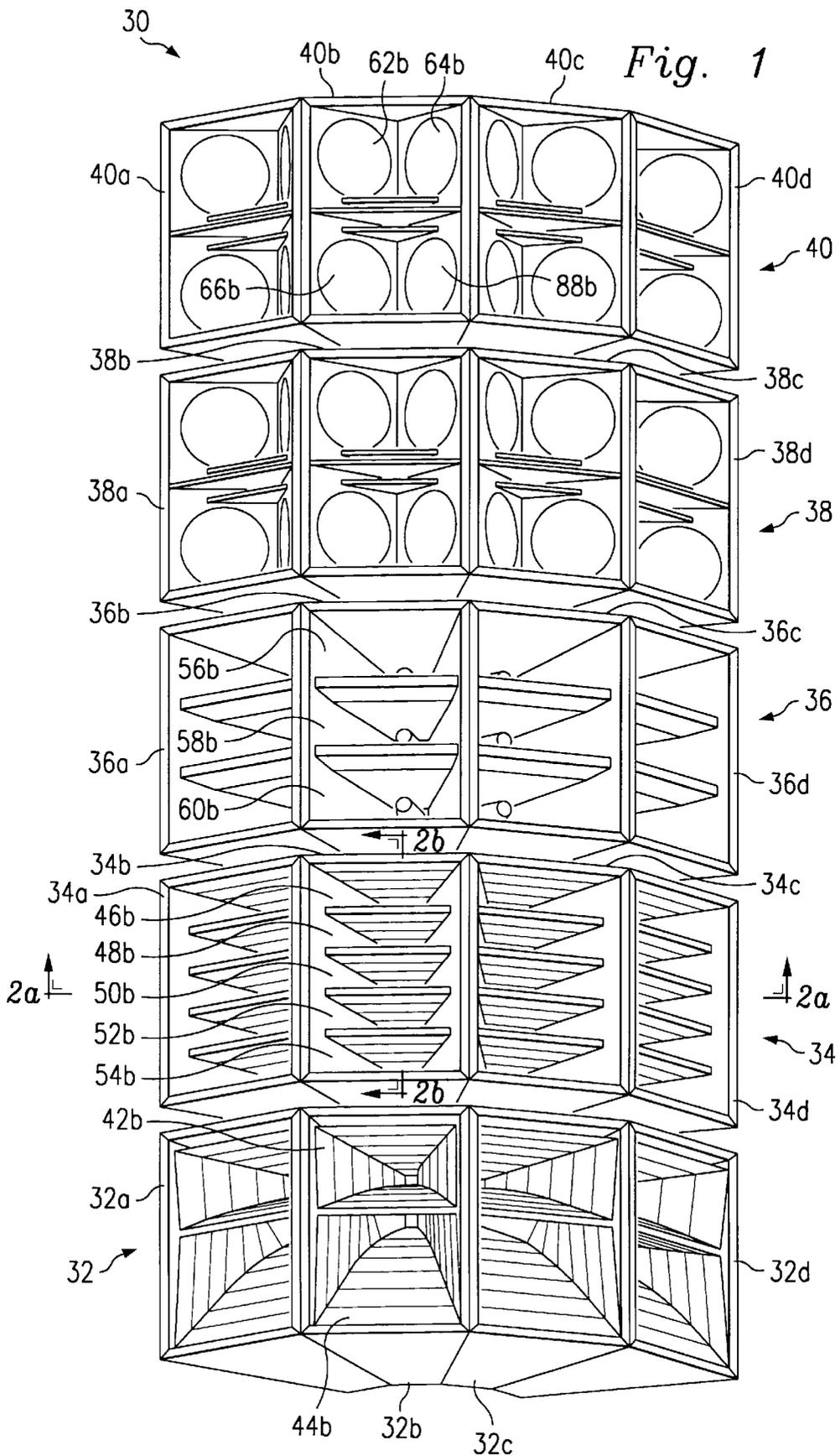


Fig. 2a

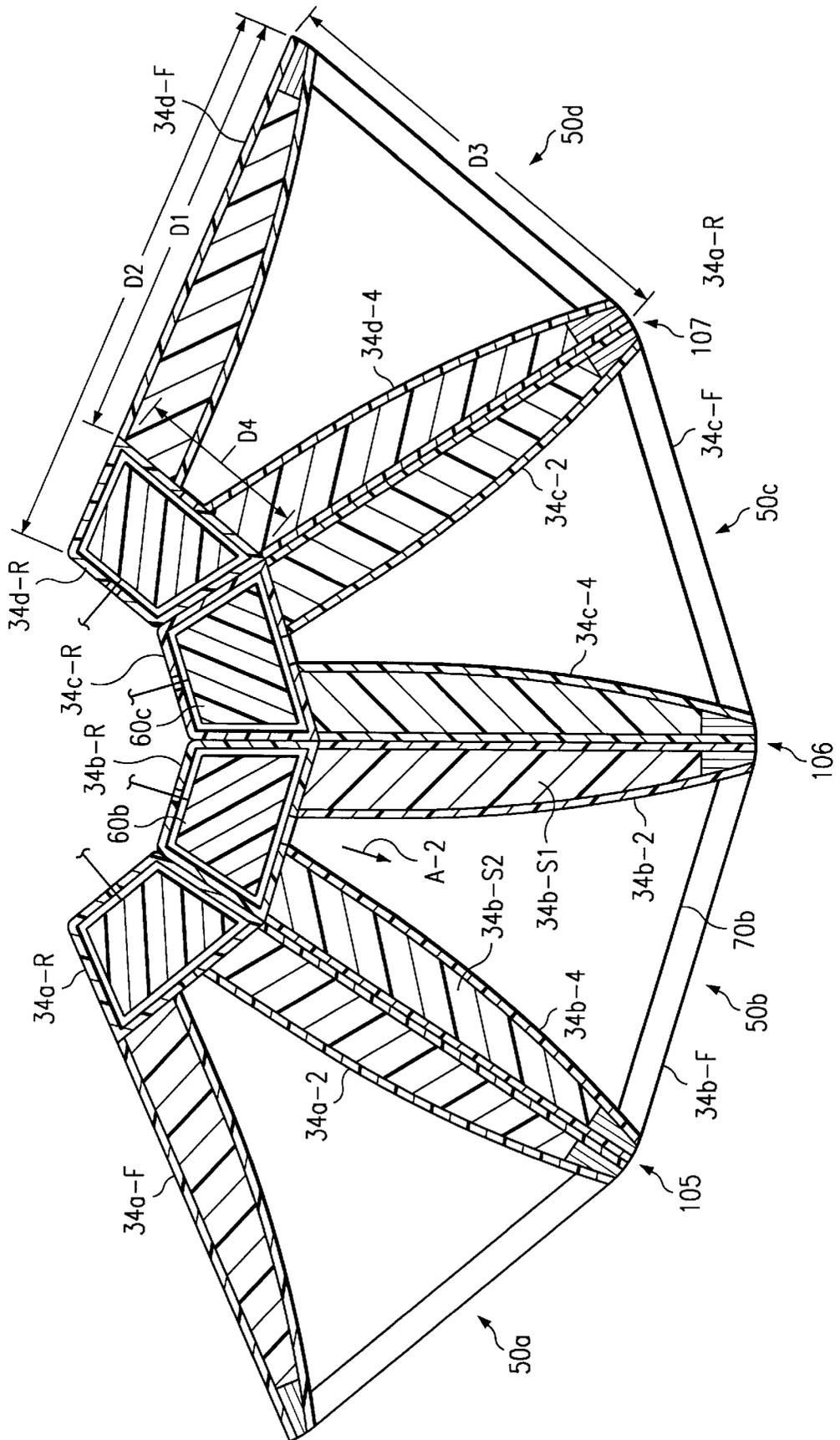
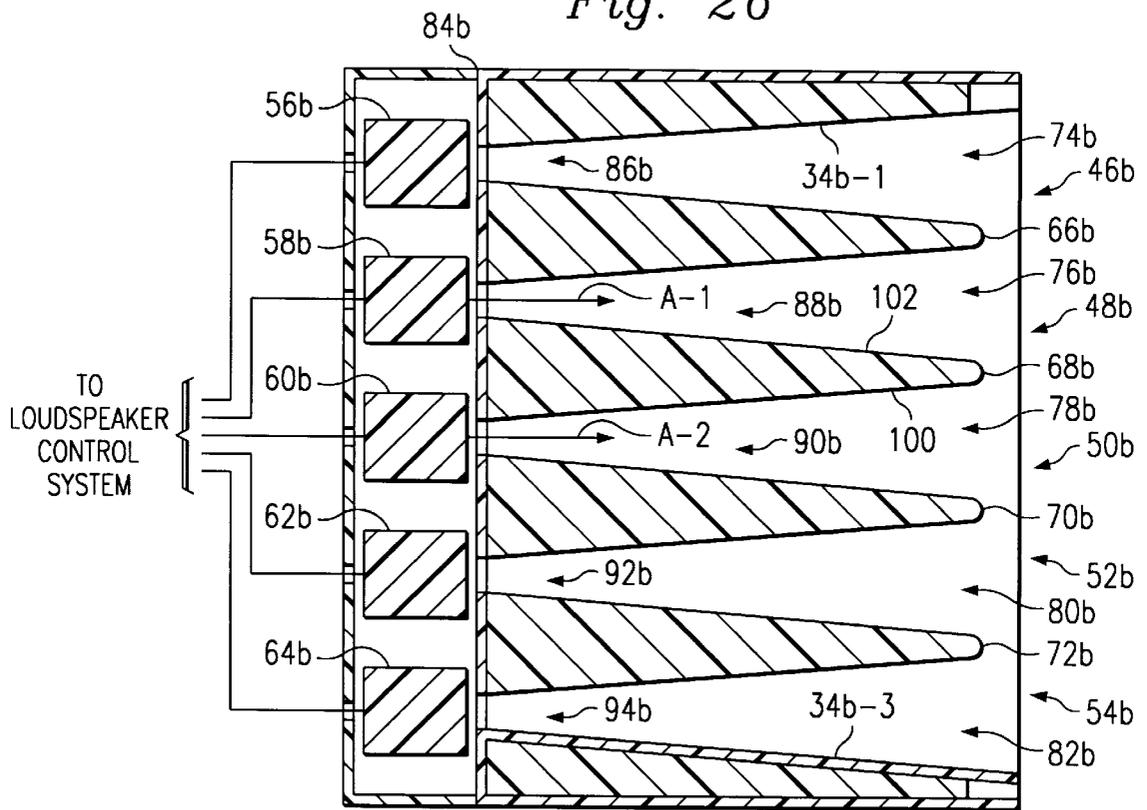


Fig. 2b



**LARGE SCALE SOUND REPRODUCTION
SYSTEM HAVING CROSS-CABINET
HORIZONTAL ARRAY OF HORN
ELEMENTS**

**CROSS-REFERENCE TO RELATED
APPLICATION**

This application is a Continuation-in-Part of U.S. patent application Ser. No. 08/921,185 filed on Aug. 29, 1997 entitled "Down-Fill Speaker for Large Scale Sound Reproduction System" and hereby incorporated by reference as if reproduced in its entirety.

TECHNICAL FIELD

The invention relates generally to large scale sound reproduction systems and, more particularly, to a large scale sound reproduction system which includes a cross-cabinet horizontal array of loudspeakers configured to provide generally equal audible sound levels along a horizontal plane.

BACKGROUND OF THE INVENTION

Sound is a physical disturbance in the medium through which it propagates. For example, in air, sound consists of localized variations in pressure above and below normal atmospheric pressure. Accordingly, the vast majority of sound reproduction systems are comprised of electromagnetic transducers in which an electrical signal is transformed into a mechanical vibration which, in turn, is transformed into an acoustic signal. Sound reproduction systems typically include separate loudspeakers, each generating sound within a selected frequency range. For lower frequencies, i.e., frequencies below 300 Hz., loudspeakers are typically comprised of a diaphragm, most commonly, a relatively large cone, a support system in which the cone or other diaphragm is mounted and a driver which vibrates the cone in a desired fashion to produce sound waves. For higher frequencies, i.e., frequencies above 300 Hz., horn loudspeakers, which are characterized by a smaller cone or other type of driver and speaker walls, positioned forward of the cone, which follow a selected pattern are more common.

While sound reproduction systems have been the subject of numerous innovations over the years, pattern control of sound projection within a particular listening area has remained a problem. Effective pattern control is particularly problematic when the sound reproduction system is installed in a stadium or other large structure. While it would be very desirable to provide even sound levels throughout the stadium, various considerations has made such a goal quite difficult. One problem is the dramatic variation between the distance separating the closest and furthest listeners from the stage. Specifically, while the closest listener may be just a few meters from the stage, the furthest listener may be as far as 300 meters away. Thus, sound reproduction systems suitable for use in stadiums and other large venues must be capable of throwing sound considerable distances. As sound levels for high frequency sounds tend to drop off dramatically over distance, in order for high frequency sounds to travel these distances, the initial sound levels produced by the sound reproduction system must be quite high. For this reason, many sound reproduction systems capable of generating desired audible sound levels at the furthest reaches of the stadium inadvertently produce sound far in excess of the desired audible sound levels close to the stage.

A common sound reproduction system used in stadiums and other large venues is generally referred to as a cluster

system. Cluster systems are generally characterized by high efficiency, middle and high frequency range speakers having sharp vertical and horizontal directivity and high-power low frequency range speakers. In a cluster system, speakers are concentrated in one or two locations within the stadium or other large venue. While the location of a cluster system within a stadium or other large venue will vary depending on the particular uses contemplated therefor, in order for the cluster system to throw sound the requisite distances, cluster systems are typically elevated on the order of about 20 to 30 feet above their surroundings.

A variety of problems are caused by the design of cluster systems. While low frequency range sounds are generally omnidirectional and can propagate, away from the cluster, in all directions, high frequency range sounds are highly directionalized and tend to propagate away from the cluster system in defined "beams" of sound. As a result, therefore, sound levels for high frequency range sounds tend to drop off dramatically outside the beam. Other problems are caused by the cluster system's use of multiple mid and/or high frequency range loudspeakers. For both of these frequency ranges, cluster systems typically include a horizontal array of loudspeakers. Typically each loudspeaker is directionalized to provide acoustical coverage for a selected portion along the horizontal plane. However, the coverage areas of adjacent loudspeakers often overlap, thereby causing a variety of interference problems. Overlap of coverage areas is of particular concern when the loudspeakers are placed in proximity to each other. Thus, the design of a compact, space-efficient array of mid or high frequency loudspeakers which provides uniform coverage in the horizontal plane remains problematic.

SUMMARY OF THE INVENTION

The present invention is of a multi-horn type loudspeaker system which produces generally even sound levels along a horizontal plane by collectively generating a generally continuous arc-shaped acoustic wavefront using plural horns arranged in a space-efficient, cross-cabinet horizontal array.

In one embodiment, the loudspeaker system includes first and second loudspeakers, each having a horn which includes first and second walls. By positioning the horns in a common, generally horizontal, plane and shaping the horns such that the second wall of the first horn and the first wall of the second horn are substantially parallel to each other, the collective wavefront produced when identically driving each of the loudspeakers is generally arc-shaped. Preferably, the second side wall of the first horn is joined to the first side wall of the second horn along their entire length. By angling each horn about 30 degrees off a central axis thereof, each horn provides 30 degrees coverage in the horizontal plane. Each horn includes a first, essentially untapered, section which provides the aforementioned coverage in the horizontal plane and a second section having a taper of about 30% to prevent diffraction of the wavefront at the edges of the horn. In selected aspects thereof, the first and second loudspeakers are supportably mounted within respective cabinets, each having an open front side, a walled rear side, adjoining sidewalls and substantially the same general trapezoidal cross-section.

In another embodiment, the present invention is of a loudspeaker system configurable to provide various coverages in a horizontal plane. The system includes a plurality of loudspeakers arranged in a common horizontal plane and secured to each other such that adjoining horn side walls for adjacent ones of the loudspeakers are substantially parallel

to each other. Preferably, each of the loudspeakers include an open front side generally positioned along a first curved line in the horizontal plane and a walled rear side generally positioned along a second curved line in the horizontal plane. In one aspect thereof, each loudspeaker provides 30 degrees of coverage in the horizontal plane. Accordingly, coverage provided by the loudspeaker system may be varied based upon the number of loudspeakers incorporated therein. In another aspect thereof, to facilitate mounting of the loudspeakers to each other such that front and rear sides are respectively positioned along the first and second curved lines, each loudspeaker is supportably mounted in a corresponding cabinet having a walled rear side having a first length, an open front side having a second length and a generally trapezoidal cross-section along a horizontal axis thereof.

In yet another embodiment, the present invention is of a loudspeaker cluster which includes a vertical stack of loudspeaker modules for generating audible sound in respective frequency ranges. Each of the loudspeaker modules is comprised of at least two cabinets in which a loudspeaker is supportably mounted. For at least one of the loudspeaker modules, each one of the cabinets has a side wall which is attached to a side wall of an adjacent cabinet in a substantially parallel relationship, thereby forming a generally horizontal, cross-cabinet array of loudspeakers. In one aspect thereof, the loudspeaker module includes multiple horizontal, cross-cabinet arrays of loudspeakers formed by supportably mounting similarly configured vertical arrays of loudspeakers in each one of the cabinets. In this aspect, the side walls of the cabinets define the side walls for each of the loudspeakers supportably mounted thereby and a separator defines a top wall for one loudspeaker in the vertical array and a bottom wall for a next loudspeaker in the vertical array. In other aspects thereof, others of the loudspeaker modules may similarly include one or more generally horizontal, cross-cabinet arrays of loudspeakers.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front view of a speaker cluster which includes a cross-cabinet horizontal array of loudspeakers constructed in accordance with the teachings of the present invention;

FIG. 2a is a cross-sectional view taken across lines 2a—2a of FIG. 1 to illustrate a horizontal axis of the cross-cabinet horizontal array of loudspeakers of FIG. 1; and

FIG. 2b is a cross-sectional view taken across lines 2b—2b of FIG. 1 to illustrate a vertical axis of the cross-cabinet horizontal array of loudspeakers of FIG. 1.

DESCRIPTION OF A PREFERRED EMBODIMENT

Turning now to the drawings, in FIG. 1, reference numeral 30 designates a loudspeaker cluster system which forms part of a large scale sound reproduction system. By the term “large scale” sound reproduction system, it is intended to refer to sound reproduction systems suitable for use in a stadium or other large venue. For example, those sound reproduction systems capable of propagating appreciable sound levels, i.e. sound levels on the order of about 75–100 DB at a distance of about 300 feet would be considered to be a large scale sound reproduction system. Of course, the foregoing is but one example of performance characteristics of a large scale sound reproduction system. It should be clearly understood, however, that the invention would be suitable for use in other sound reproduction systems as well.

The loudspeaker cluster 30 is comprised of a down-fill loudspeaker module 32, a high-frequency range loudspeaker

module 34, a mid-frequency range loudspeaker module 36 and first and second low-frequency range loudspeaker modules 38 and 40, stacked on top of each other in a generally vertical orientation. Further details as to the configuration and operation of the down-fill loudspeaker module 32 are set forth in my co-pending U.S. patent application Ser. No. 08/921,185, filed Aug. 29, 1997 (Atty. Docket No. 23422.4), entitled “Down-Fill Speaker for Large Scale Sound Reproduction System.”

The loudspeaker cluster 30 is supportably mounted, for example, by a platform, cables or other support structure (not shown) generally parallel to, and approximately 20–30 feet above, the ground or other listening area. Each loudspeaker module 32, 34, 36, 38 and 40 is comprised of first, second, third and fourth loudspeaker cabinets 32a through 32d, 34a through 34d, 36a through 36d, 38a through 38d and 40a through 40d, each identically configured to each other and fixedly mounted to each other along a generally curved line to form the corresponding loudspeaker module 32, 34, 36, 38 or 40. For example, FIG. 2a shows the generally curved line for the loudspeaker module 34 to be comprised of rear sides of the loudspeaker cabinets 34a through 34d. As will be more fully described below, frequencies above 300 Hz are directional in nature and, accordingly, the loudspeakers supportably mounted by each of the cabinets 32a through 32d of the down-fill loudspeaker module 32, each of the cabinets 34a through 34d of the high-frequency range loudspeaker module 34 and each of the cabinets 36a through 36d of the mid-frequency range loudspeaker module 36, respectively, have throats (not shown in FIG. 1) formed to have a throat angle, in the horizontal axis, of about 30 degrees, thereby providing 30 degrees of coverage along a horizontal plane of the stadium or other large venue. Thusly, for mid and high frequency sound, the loudspeaker cluster 30 provides coverage of 120 degrees in the horizontal plane. The loudspeakers supportably mounted by the cabinets 38a through 38d of the low frequency range loudspeaker module 38 and the cabinets 40a through 40d of the lower frequency range loudspeaker module 40, on the other hand, each provide omnidirectional coverage of varying magnitude throughout the stadium or other large venue.

As may be further seen in FIG. 1, each cabinet 32a through 32d, 34a through 34d, 36a through 36d, 38a through 38d and 40a through 40d supportably mounts plural loudspeakers. For example, for the loudspeaker cluster 30 illustrated in FIG. 1, each cabinet 32a through 32d of the down-fill loudspeaker module 32, for example, the cabinet 32b, supportably mounts a first loudspeaker 42b and a second loudspeaker 44b positioned below the first loudspeaker 42b. Each cabinet 34a through 34d, for example, the cabinet 34b, of the high frequency range loudspeaker module 34 supportably mounts first, second, third, fourth and fifth loudspeakers 46b, 48b, 50b, 52b and 54b arranged in a vertical array. Each cabinet 36a through 36d, for example, the cabinet 36b, of the mid-frequency range loudspeaker module 36 supportably mounts first, second and third loudspeakers 56b, 58b and 60b arranged in a vertical array. Finally, each cabinet 38a through 38d and 40a through 40d of the first and second low-frequency range loudspeaker modules, for example, the cabinet 40b, supportably mount first, second, third and fourth loudspeakers 62b, 64b, 66b and 68b.

Turning next to FIGS. 2a and 2b, the high frequency range loudspeaker module 34 which incorporates plural cross-cabinet arrays of horizontal loudspeakers and is constructed in accordance with the teachings of the present

invention will now be described in greater detail. The high frequency range loudspeaker module **34** is comprised of first, second, third and fourth cabinets **34a**, **34b**, **34c** and **34d**, each of which is identically configured to the others. Furthermore, as each cabinet **34a** through **34d** includes a vertical array comprised of first, second, third, fourth and fifth loudspeakers, for example, the vertical array comprised of first, second, third, fourth and fifth loudspeakers **46b**, **48b**, **50b**, **52b** and **54b** of the second cabinet **34b** shown in FIG. **2b**, the high frequency range loudspeaker module **34** includes a total of twenty loudspeakers **46a** through **46d**, **48a** through **48d**, **50a** through **50d**, **52a** through **52d** and **54a** through **54d**, grouped together in five cross-cabinet horizontal arrays, one of which is shown in FIG. **2a**.

Prior to further description of the cross-cabinet horizontal array **50a** through **50d**, the configuration of a single cabinet, for example, the cabinet **34b** shall first be described. As each of the cabinets **34a** through **34d** are identically configured along both the vertical and horizontal axes, the description of the configuration of the cabinet **34b** is equally applicable to the cabinets **34a**, **34c** and **34d**. As may be best seen in FIG. **2a**, the high frequency range cabinet **34b** is characterized by a generally trapezoidal cross-section along a horizontal axis thereof and, as best seen in FIG. **2b**, a generally rectangular cross-section along a vertical axis thereof. The cabinet **32b** may also be divided into a rear portion **32b-R** in which drivers **56b**, **58b**, **60b**, **62b** and **64b**, each corresponding to one of the loudspeakers **46b**, **48b**, **50b**, **52b** and **54b**, are positioned and a front portion **32b-F** in which the walls **34b-1**, **34b-2**, **34b-3**, **34b-4** and parabolic separators **66**, **68**, **70** and **72** which define the horns **74**, **76**, **78**, **80** and **82** are positioned. It should be clearly understood, however, that the drivers **56b**, **58b**, **60b**, **62b** and **64b** are schematically illustrated in FIGS. **2a-b** and are, therefore, shown as having solid cross-sections when, in fact, the drivers **56b**, **58b**, **60b**, **62b** and **64b**, if fully illustrated, would likely have cross-sections different from that illustrated herein.

The front and rear portions **32b-F** and **32b-R** of the cabinet **32b** are separated by an interior wall **84b**. To acoustically couple the drivers **56b**, **58b**, **60b**, **62b** and **64b** to the corresponding ones of the horns **74b**, **76b**, **78b**, **80b** and **82b**, throats **86b**, **88b**, **90b**, **92b** and **94b** are formed in the interior wall **84b**. Preferably, the throats **86b**, **88b**, **90b**, **92b** and **94b** are formed along the interior wall **84b** in the general center of the portion of the horn **74b**, **76b**, **78b**, **80b** and **82b** in communication therewith. Depending on the desired operational characteristics of the loudspeaker associated therewith, the shape of the throats **86b** through **94b** may be variously selected. For example, by varying the length, width and throat angle of selected ones of the throats **86b**, **88b**, **90b**, **92b** and **94b**, the acoustical propagation characteristics of the horn **74b**, **76b**, **78b**, **80b** and **82b** associated therewith may be selectively modified. Purely by way of example, a generally circular-shaped throat having a diameter of about 2 inches will be a suitable shape for each of the throats **86b** through **94b**. Furthermore a throat angle of 30 degrees in the horizontal axis and a throat angle of 15 degrees in the vertical axis will provide suitable acoustical coverage in the horizontal and vertical planes, respectively.

As previously set forth, mounted within each of the cabinets **34a**, **34b**, **34c** and **34d** is a vertical array of horns, for example, the horns **74b**, **76b**, **78b**, **80b** and **82b**, separated by parabolic separators, for example, the parabolic separators **66b**, **68b**, **70b** and **72b**. Each of the horns **74b**, **76b**, **78b**, **80b** and **82b** provide acoustical coverage for a respective segment of the vertical plane. The angle of the side surfaces of the parabolic separators **66b**, **68b**, **70b** and **72b**, for

example the side surfaces **100** and **102** of the parabolic separator **68b**, relative to the interior wall **84b** should generally match the angle of the corresponding throat along the vertical axis. Thus, in the embodiment of the invention disclosed herein, the side surface **102** should be angled approximately 15 degrees below axis A-1 while the side surface **100** should be angled approximately 15 degrees above axis A-2. As their name suggests, the parabolic separators **66b**, **68b**, **70b** and **72b** are characterized by an increasingly higher slope as they extend away from a starting point. Accordingly, the parabolic separators **66b**, **68b**, **70b** and **72b** are gently curved at one end but are generally straight thereafter. By shaping the parabolic separators **66b**, **68b**, **70b** and **72b** in this manner, smooth transitions are achieved between adjacent horns in the vertical plane. While, as disclosed herein, it is contemplated that each of the parabolic separators **66b**, **68b**, **70b** and **72b** are similarly sized in the lengthwise dimension, it is contemplated that, in an alternate embodiment of the invention, the lengths of the parabolic separators **66b**, **68b**, **70b** and **72b** may be varied, for example, by staggering the parabolic separators so that the uppermost one is the longest while the lowermost one is the shortest.

Returning now to FIG. **2a**, certain aspects of the shape of the cabinet **34b** which enable it to function as part of a horizontal cross-cabinet array of loudspeakers shall now be described in greater detail. As previously stated, the cabinet **34b** is generally trapezoidal in shape in the horizontal plane. The generally trapezoidal shape is defined by a first pair of sides—an open front side **34b-F** and a walled rear side **34b-R**—which are generally parallel to each other and a second pair of non-parallel sides—first and second side walls **34b-S1** and **34b-S2**. It has been discovered that, by sizing the front side **34b-F** to be about three times the length of the rear side **34b-R**, the cabinet **34b** is particularly well suited to form a portion of a space-efficient cross-cabinet array of loudspeakers.

Continuing to refer to FIG. **2a**, certain other relational characteristics of the driver **60b**, the interior wall **84b**, the throat **90b** and the interior side surfaces of the side walls **34b-2** and **34b-4** shall now be described in greater detail. Axis A-2 is generally orthogonal to the interior sidewall **84b**. The throat **90b** is angled as it extends through the interior wall **84b** to acoustically couple the driver **60b** and the horn **78b**. This angle is commonly referred to as a beam angle for the loudspeaker in that, for high frequency sound generated thereby, the beam angle controls coverage for acoustical signals propagating therefrom. As previously stated, a suitable beam angle for the throat **90b** along the horizontal axis is 30 degrees. Preferably, the side surfaces **34b-2** and **34b-4** are closely matched to the beam angle. Accordingly, the side surfaces **34b-2** and **34b-4** are preferably angled 30 degrees on respective sides relative to the axis A-2.

The angle of the throat **90b** relative to the interior wall **84b** is about 30 degrees. Accordingly the coverage of the horn **50b** defined by a bottom side surface of the parabolic separator **68b**, an interior side surface of the side wall **34b-2**, a top side surface of the parabolic separator **70b** and an interior side surface of the side wall **34b-4** in the horizontal plane is about 30 degrees. A first portion of the sidewalls **34b-2** and **34b-4** are substantially straight along their length and closely match, therefore, the beam angle for the horn **74b**. Preferably, the first portion of the sidewalls **34b-2** and **34b-4** which are formed to be substantially straight with each other should be at least $\frac{2}{3}$ of the entire length of the respective sidewalls **34b-2** and **34b-4**. The remainder of the sidewalls **34b-2** and **34b-4** are slightly tapered to prevent

edges of the horn **70b** from acting like acoustic point sources. For example, a taper of about 30 degrees along the second portion of the sidewalls **34b-2** and **34b-4** would be suitable for this purpose. Preferably, the tapers of the sidewalls are shaped such that the wall separating adjacent horns is in the shape of a parabolic separator.

As previously set forth, in order to minimize interference of acoustic signals respectively generated by adjacent horns which collectively comprises a cross-cabinet horizontal array of loudspeakers such that the respective acoustic signals produced when the drivers associated with the respective horns are identically driven may be viewed as a common acoustical wavefront collectively generated by the cross-cabinet horizontal array of loudspeakers, certain relationships between various ones of the horns should exist. As may be seen in FIG. 2a, adjacent ones of the horns share a common wall. For example, the horns **50a** and **50b** share common wall **105**, the horns **50b** and **50c** share common wall **106** and the horns **50c** and **50d** share common wall **107**. Each common wall **105**, **106** and **107** is preferably formed in the shape of a parabolic separator, includes a portion of each of the adjacent pair of cabinets and has first and second side surfaces, each of which partially defines one of the adjacent horns. For example, the common wall **105** includes first and second side surfaces **34a-2** and **34b-4** which partially define the horns **50a** and **50b**, respectively. Similarly, the common wall **106** includes side surfaces **34b-2** and **34c-4** which partially define the horns **50b** and **50c**, respectively. Finally, the common wall **107** includes side surfaces **34c-2** and **34d-4** which partially define the horns **50c** and **50d**, respectively. In order for the acoustic signals respectively generated by the drivers **60a**, **60b**, **60c** and **60d** to form a common wavefront, the side surfaces **34a-2** and **34b-4**, **34b-2** and **34c-4**, **34c-2** and **34d-4** for each common wall **105**, **106**, **107**, must be substantially parallel to each other along a first portion thereof. Such a result may be achieved by shaping the common walls **105**, **106** and **107** as parabolic separators where, for a first portion comprising about $\frac{2}{3}$ of the common walls **105**, **106**, **107**, the side surfaces **34a-2** and **34b-4**, **34b-2** and **34c-4**, **34c-2** and **34d-4** thereof are substantially parallel to each other. To further enhance the common acoustical wavefront generated by the cross-cabinet horizontal array of loudspeakers, it is preferred that each of the horns **50a** through **50d** of the cross-cabinet array be "deep" relative to the cabinet in which it reside. For example, a horn having a length **D1** which is approximately 80% of the length **D2** of the cabinet in which it resides may be considered to be a "deep" horn.

It has been further discovered that other relationships further enhance the present invention of a space efficient, cross-cabinet horizontal array of loudspeakers. Specifically, by forming each cabinet such that it has a generally trapezoidal cross-section along the horizontal axis thereof, the cabinets can be easily mounted to each other in a space efficient manner which avoids gapping between adjacent ones of the loudspeakers. It is further preferred that each of the cabinets be sized such that the width **D3** of the front side, i.e., the distance separating a pair of common walls is approximately twice the width **D4** of the interior wall **84** which separates the front and rear portions of the cabinet. By dimensioning the cabinets in this manner, it has been discovered that the drivers will predominately fill the rear portions of the cabinets, thereby closely positioning the drivers of the various horns included in a cross-cabinet horizontal array to each other such that, in most cases, only the walls which define the cabinets separate a driver of the cross-cabinet horizontal array from an adjacent driver of the

array, a highly space-efficient packing of the drivers of a cross-cabinet horizontal array which has, heretofore, not been achieved.

Although illustrative embodiments of the invention have been shown and described, other modifications, changes, and substitutions are intended in the foregoing disclosure. Accordingly, it is appropriate that the appended claims be construed broadly and in a manner consistent with the scope of the invention.

What is claimed is:

1. A loudspeaker system, comprising:

a first loudspeaker having a horn which includes first and second side walls, each of said first and second side walls having an interior side surface which partially defines said horn;

a second loudspeaker having a horn which includes first and second side walls, each of said first and second side walls having an interior side surface which partially defines said horn;

said horn of said first loudspeaker and said horn of said second loudspeaker being positioned in a generally horizontal plane;

said second side wall of said horn of said first loudspeaker engaging said first side wall of said horn of said second loudspeaker such that said interior side surface of said second side wall of said horn of said first loudspeaker is substantially parallel to said interior side surface of said first side wall of said horn of said second loudspeaker.

2. A loudspeaker system according to claim 1, wherein said second side wall of said horn of said first loudspeaker and said first side wall of said horn of said second loudspeaker are joined together along their length.

3. A loudspeaker system according to claim 2, wherein the angle of each of said horns in said generally horizontal plane is about 30 degrees.

4. A loudspeaker system according to claim 2, wherein each of said horns further comprises a first, essentially untapered, section along which said interior side surface of said second side wall of said horn of said first loudspeaker and said interior side surface of said first side wall of said horn of said second loudspeaker are substantially straight and a second section along which said interior side surface of said second side wall of said horn of said first loudspeaker and said interior side surface of said first side wall of said horn of said second loudspeaker have a taper of about 30%.

5. A loudspeaker system according to claim 4, wherein each one of said first and second loudspeakers further comprise a driver acoustically coupled to said horn.

6. A loudspeaker system according to claim 5, wherein each one of said first and second loudspeakers further comprise first and second portions separated by an interior wall, said horn residing in said first portion and said driver residing in said second portion.

7. A loudspeaker system according to claim 6, wherein the ratio of the length of said first portion to the length of said second portion is about 4:1.

8. A loudspeaker system according to claim 1, and further comprising:

a first cabinet in which said first loudspeaker is supportably mounted;

a second cabinet in which said second loudspeaker is supportably mounted;

said first cabinet having a first, generally trapezoidal, cross-section along a horizontal axis thereof and said second cabinet have a second, generally trapezoidal, cross-section along a horizontal axis thereof;

said first and second generally trapezoidal cross-sections being substantially the same.

9. A loudspeaker system according to claim 8 wherein: said first cabinet further comprises an open front side, a walled rear side and said first and second side walls of said first loudspeaker; and

said second cabinet further comprises an open front side, a walled rear side and said first and second side walls of said second loudspeaker; and

wherein said second side wall of said first cabinet is joined to said first side wall of said second cabinet along their entire length.

10. A loudspeaker system according to claim 8 wherein each of said horns further comprises a first, essentially untapered, section along which said interior side surface of said second side wall of said horn of said first loudspeaker and said interior side surface of said first side wall of said horn of said second loudspeaker are substantially straight and a second section along which said interior side surface of said second side wall of said horn of said first loudspeaker and said interior side surface of said first side wall of said horn of said second loudspeaker have a taper of about 30%.

11. A loudspeaker system according to claim 10, wherein: each one of said first and second loudspeakers include first and second portions separated by an interior wall, said horn residing in said first portion and said driver residing in said second portion; and

the ratio of the length of said first portion to the length of said second portion is about 4:1.

12. A loudspeaker system, comprising:

a plurality of loudspeakers arranged in a generally horizontal plane, each one of said plurality of loudspeakers having a horn which includes first and second side walls and is partially defined by an interior side surface of said first side wall and an interior side surface of said second side wall;

said second side wall of a first one of said plurality of loudspeakers fixedly secured to said first side wall of an adjacent one of said plurality of loudspeakers such that said interior side surface of said second side wall of said horn of said first one of said plurality of loudspeakers is substantially parallel to said interior side surface of said first side wall of said horn of said adjacent one of said plurality of loudspeakers.

13. A loudspeaker system according to claim 12, wherein each one of said plurality of loudspeakers further comprises an open front side and wherein said front side of each one of said plurality of loudspeakers is generally positioned along a first curved line in said generally horizontal plane.

14. A loudspeaker system according to claim 13, wherein each one of said plurality of loudspeakers further comprises a walled rear side and wherein said rear side of each one of said plurality of loudspeakers is generally positioned along a second curved line in said generally horizontal plane.

15. A loudspeaker system according to claim 14, wherein each one of said plurality of loudspeakers provides 30 degrees coverage in said generally horizontal plane.

16. A loudspeaker system according to claim 14 wherein: said second side wall of said horn of each one of said plurality of loudspeakers has a first length;

said first side wall of said horn of said adjacent one of said plurality of loudspeakers has a second length generally equal to said first length; and

said second side wall of said horn of said first loudspeaker is joined to said first side wall of said horn of said

adjacent one of said loudspeaker along said first and second lengths, respectively.

17. A loudspeaker system according to claim 16 wherein each one of said loudspeakers is supportably mounted in a cabinet having a generally trapezoidal cross-section along a horizontal axis thereof.

18. A loudspeaker system according to claim 17 wherein each one of said cabinets has a walled rear side having a first length and an open front side having a second length at least three that of said first length.

19. A loudspeaker system according to claim 18, wherein: each one of said first and second loudspeakers include first and second portions separated by an interior wall, said horn residing in said first portion and said driver residing in said second portion; and

the ratio of the length of said first portion to the length of said second portion is about 4:1.

20. A loudspeaker system according to claim 19, wherein the length of said second portion is substantially the same as the length of said driver residing therein.

21. A loudspeaker system according to claim 20 wherein said horn of each one of said plurality of loudspeakers further comprises a first, essentially untapered, section along which said interior side surface of said second side wall of said horn of said first one of said plurality of loudspeakers and said interior side surface of said first side wall of said horn of said adjacent one of said plurality of loudspeakers are substantially straight and a second section along which said interior side surface of said second side wall of said horn of said first one of said plurality of loudspeakers and said interior side surface of said first side wall of said horn of said adjacent one of said plurality of loudspeakers have a taper of about 30%.

22. A loudspeaker cluster, comprising:

a first loudspeaker module; and

a second loudspeaker module vertically stacked on said first loudspeaker module;

said first loudspeaker module comprised of at least two cabinets, each one of said at least two cabinets of said first loudspeaker module being attached to an adjacent one of said at least two cabinets of said first loudspeaker module;

each one of said at least two cabinets of said first loudspeaker module supportably mounting a first loudspeaker;

said first loudspeaker of each one of said at least two cabinets of said first loudspeaker module forming a first, generally horizontal, cross-cabinet loudspeaker array;

each one of said at least two cabinets of said first loudspeaker module having first and second side walls which respectively define first and second side walls for said first loudspeaker supportably mounted thereby;

said second side wall of said first loudspeaker of a first one of said at least two cabinets of said first loudspeaker module being joined to said first side wall of said first loudspeaker of a second, adjacent, one of said at two cabinets;

wherein an interior side surface of said second side wall of said first loudspeaker of said first one of said at least two cabinets of said first loudspeaker module being substantially parallel to an interior side surface of said first side wall of said first loudspeaker of said second, adjacent, one of said at least two cabinets of said first loudspeaker module.

23. A loudspeaker cluster according to claim 22 wherein: each one of said at least two cabinets of said first loudspeaker module supportably mounts a second loudspeaker;

said first and second loudspeakers of each one of said at least two cabinets of said first loudspeaker module being arranged in a first, generally vertical, loudspeaker array;

said second loudspeaker of each one of said at least two cabinets of said first loudspeaker module forming a second, generally horizontal, cross-cabinet loudspeaker array;

said first and second side walls of each one of said at least two cabinets of said first loudspeaker module further defining first and second side walls for said second loudspeaker supportably mounted thereby;

wherein an interior side surface of said second side wall of said second loudspeaker of said first one of said at least two cabinets of said first loudspeaker module being substantially parallel to an interior side surface of said first side wall of said second loudspeaker of said second, adjacent, one of said at least two cabinets of said first loudspeaker module.

24. A loudspeaker cluster according to claim 23 wherein each one of said at least two cabinets of said first loudspeaker module further comprises a separator which defines a top wall for said first loudspeaker supportably mounted thereby and a bottom wall for said second loudspeaker supportably mounted thereby.

25. A loudspeaker cluster according to claim 24 wherein: said second loudspeaker module is comprised of at least two cabinets, each one of said at least two cabinets of said second loudspeaker module being attached to an adjacent one of said at least two cabinets of said second loudspeaker module;

each one of said at least two cabinets of said second loudspeaker module supportably mounting a first loudspeaker;

said first loudspeaker of each one of said at least two cabinets of said second loudspeaker module forming a third, generally horizontal, cross-cabinet loudspeaker array;

each one of said at least two cabinets of said second loudspeaker module having first and second side walls which respectively define first and second side walls for said first loudspeaker supportably mounted thereby;

said second side wall of said first loudspeaker of a first one of said at least two cabinets of said second loudspeaker module being joined to said first side wall of said first loudspeaker of a second, adjacent, one of said at two cabinets of said second loudspeaker module;

wherein an interior side surface of said second side wall of said first loudspeaker of said first one of said at least two cabinets of said second loudspeaker module being substantially parallel to an interior side surface of said first side wall of said first loudspeaker of said second, adjacent, one of said at least two cabinets of said second loudspeaker module.

26. A loudspeaker cluster according to claim 25 wherein: each one of said at least two cabinets of said second loudspeaker module supportably mounts a second loudspeaker;

said first and second loudspeakers of each one of said at least two cabinets of said second loudspeaker module being arranged in a second, generally vertical, loudspeaker array;

said second loudspeaker of each one of said at least two cabinets of said second loudspeaker module forming a fourth, generally horizontal, cross-cabinet loudspeaker array;

said first and second side walls of each one of said at least two cabinets of said second loudspeaker module further defining first and second side walls for said second loudspeaker supportably mounted thereby;

wherein an interior side surface of said second side wall of said second loudspeaker of said first one of said at least two cabinets of said second loudspeaker module being substantially parallel to an interior side surface of said first side wall of said second loudspeaker of said second, adjacent, one of said at least two cabinets of said second loudspeaker module.

27. A loudspeaker cluster according to claim 26 wherein said first loudspeaker module generates sound in a first frequency range and said second loudspeaker module generates sound in a second frequency range.

28. A loudspeaker cluster according to claim 27 wherein each one of said at least two cabinets of said second loudspeaker module further comprises a separator which defines a top wall for said first loudspeaker supportably mounted thereby and a bottom wall for said second loudspeaker supportably mounted thereby.

29. A loudspeaker system according to claim 4 wherein, for each of said horns, the length of said first, essentially untapered, section is at least twice the length of said second, tapered, section.

30. A loudspeaker system according to claim 10 wherein, for each of said horns, the length of said first, essentially untapered, section is at least twice the length of said second, tapered, section.

31. A loudspeaker system according to claim 21 wherein, for each of said horns, the length of said first, essentially untapered, section is at least twice the length of said second, tapered, section.

32. A loudspeaker system, comprising:
 a first side wall having an interior side surface;
 a second, shared, side wall having first and second interior side surfaces;
 a third side wall having an interior side surface;
 said interior side surface of said first side wall and said first interior side surface of said second, shared, wall partially defining a first horn of said loudspeaker system;
 said second interior side surface of said second, shared, side wall and said interior side surface of said third side wall partially defining a second horn of said loudspeaker system;
 said first and second interior side surfaces of said second, shared, wall being substantially parallel to each other.

33. A loudspeaker system according to claim 32 wherein said second, shared, wall is formed in the shape of a parabolic separator.

34. A loudspeaker system according to claim 33 wherein each of said first and second interior side surfaces of said second, common, wall are comprised of first and second portions and wherein said first portion of said first interior side surface of said second, common, side wall is substantially parallel to said first portion of said second interior side surface of said second, common, side wall.

35. A loudspeaker system according to claim 34 wherein the ratio of the length of said first portion of said first interior side surface of said second, common, wall to the length of said first interior side surface of said second, common, wall is about 2:3.