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(71) Applicant(s):
Flare Audio Holdings Limited
(Incorporated in the United Kingdom)
Charles House, 5-11 Regent Street, St James,
LONDON, SW1Y 4LR, United Kingdom

(72) Inventor(s):
Davies Richard Roberts

(74) Agent and/or Address for Service:
Collier IP Management Limited
Fugro House, Hithercroft Road, Wallingford,
Oxfordshire, OX10 9RB, United Kingdom

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(56) Documents Cited:
EP 1460880 A2 **EP 1071308 A2**
US 6394223 B1 **US 6393131 B1**
US 5750943 A **US 20110069856 A1**

(58) Field of Search:
INT CL **H04R**
Other: **WPI, EPODOC**

(54) Title of the Invention: **Loudspeaker system**
Abstract Title: **Symmetric multi-horn loudspeaker system**

(57) A loudspeaker for use in the sub bass, bass and/or low mid frequency ranges incorporates multiple loudspeaker drivers 4a-d arranged in a curved configuration contained within an enclosure 1. Each loudspeaker driver is coupled to the enclosure outlet by way of a respective sound channel 5a-d. This symmetric multi-horn arrangement enables all associated loudspeaker drivers to couple their energy in phase coherence and time alignment to form one coherent sound wave upon exit of the loudspeaker. Low frequency sensitivity is greatly increased upon exit from the loudspeaker without creating resonance or transient decay. The arrangement also allows additional loudspeakers (figs. 2 & 4) to be added to form a larger system (fig. 9) that maintains phase coherence and time alignment over all the loudspeakers contained in the system. Each additional loudspeaker added to the system increases low frequency sensitivity.

Fig 1.

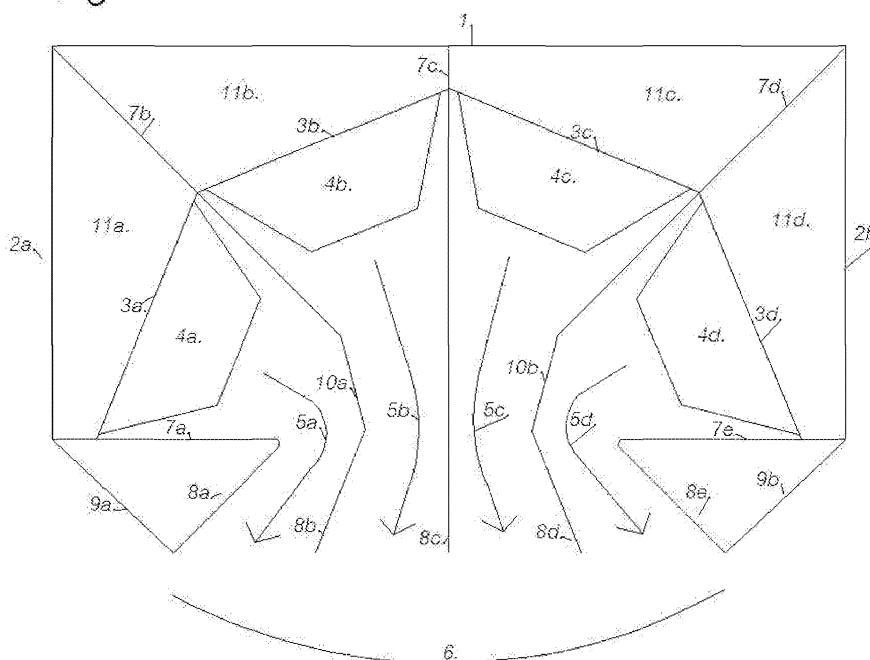


Fig 1.

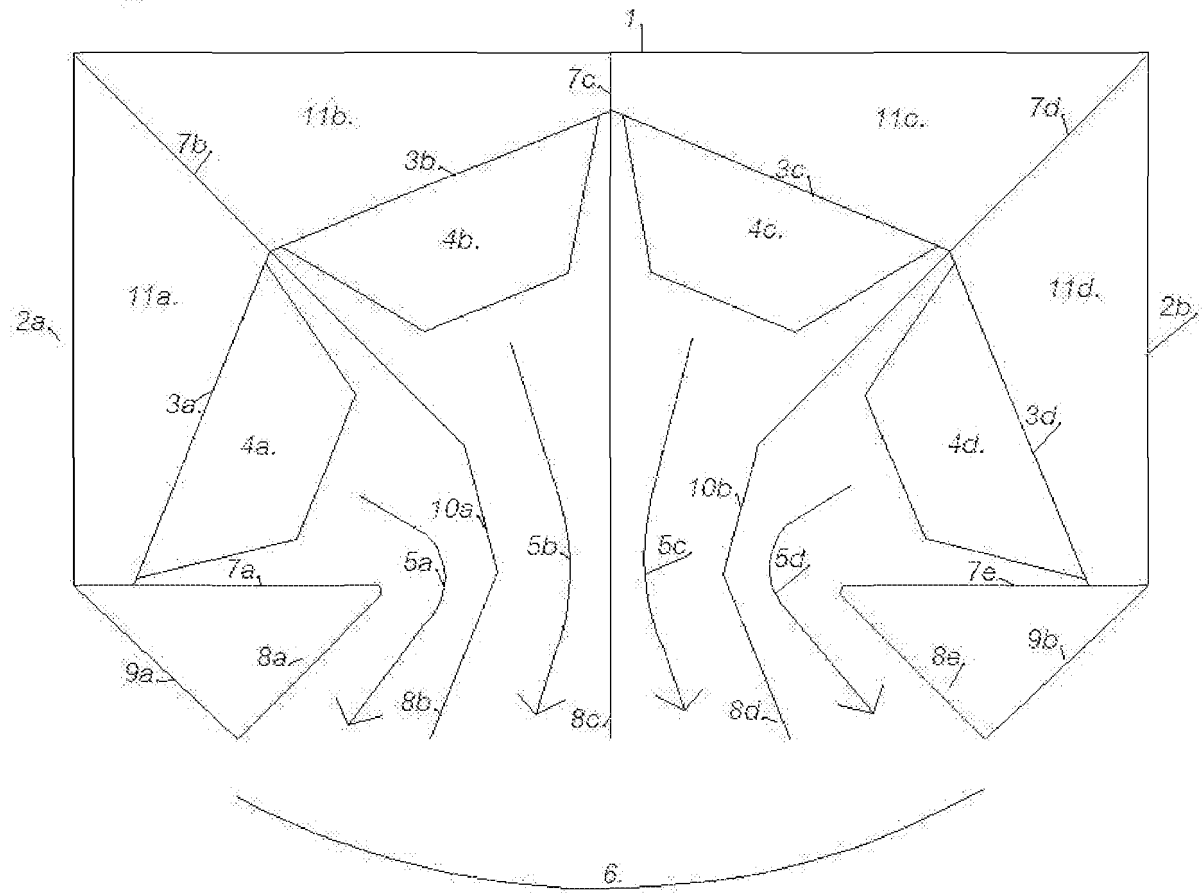
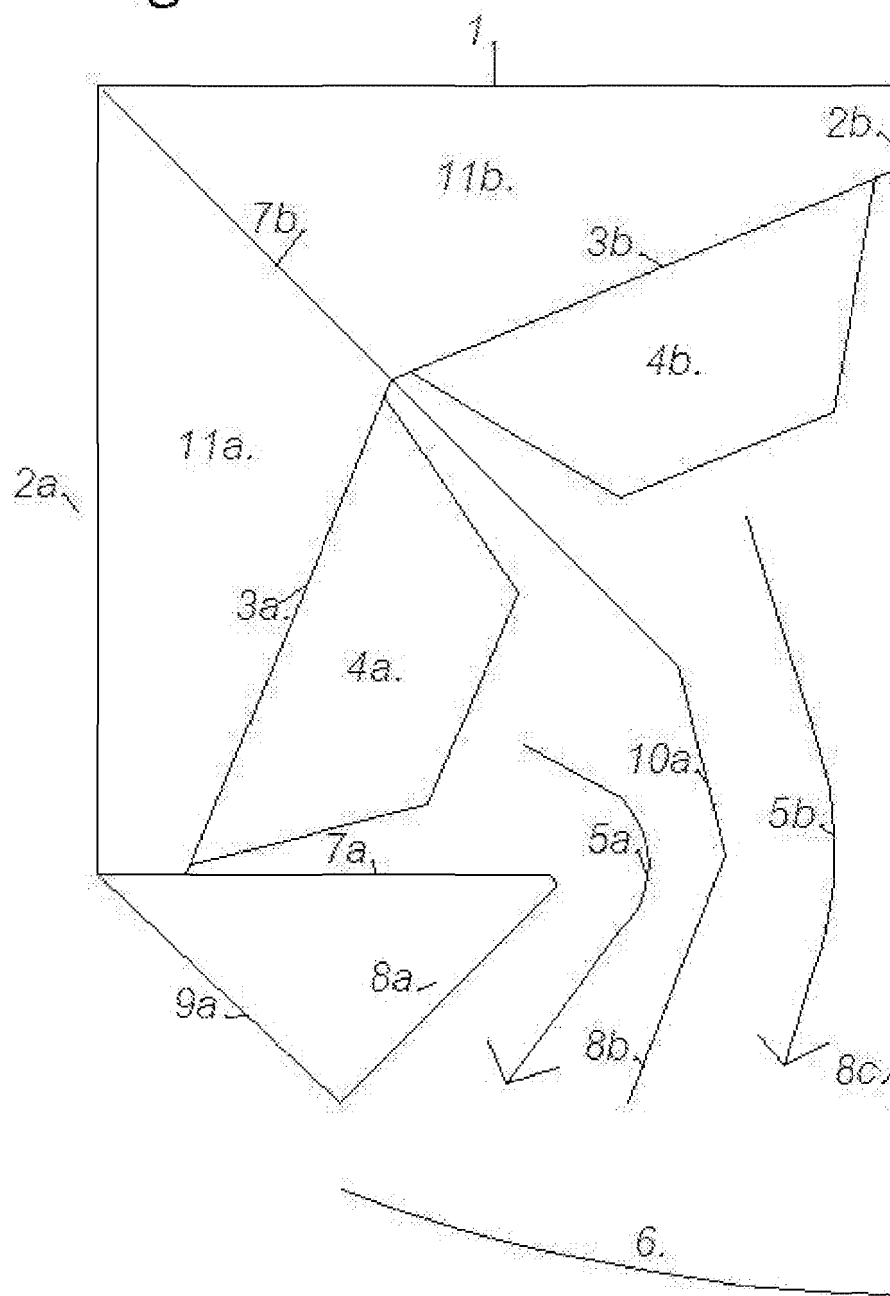


Fig 2.



24 11 11

Fig 3.

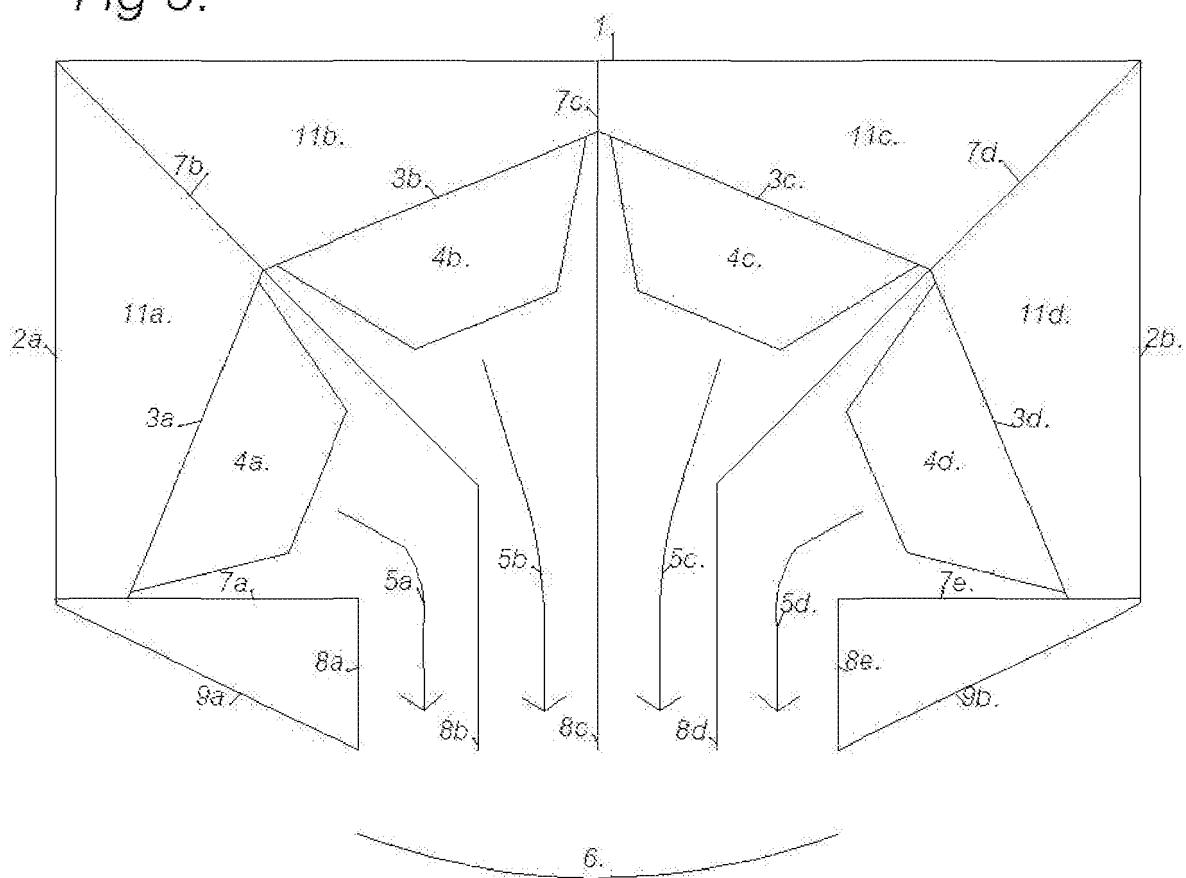
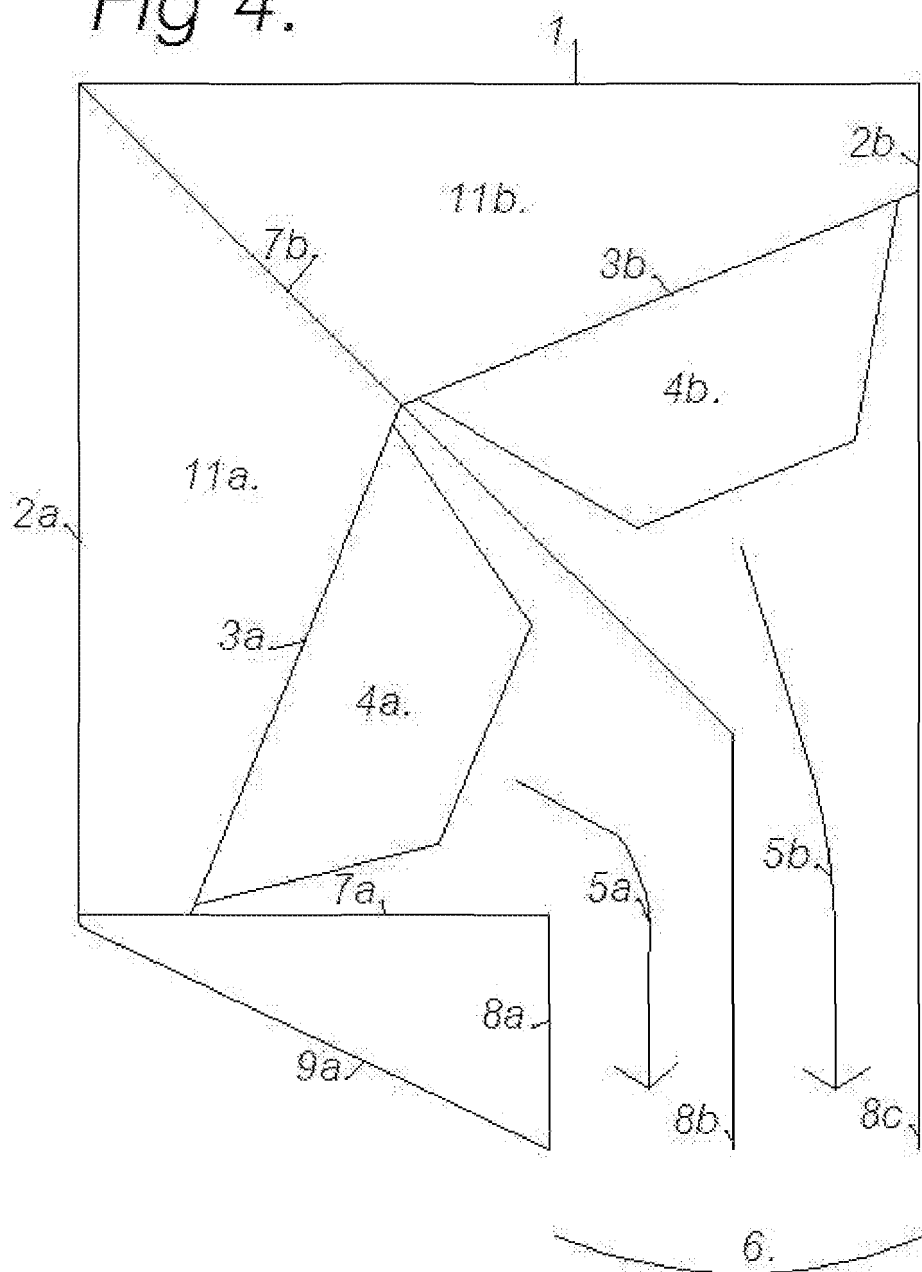


Fig 4.



24 11 11

Fig. 5

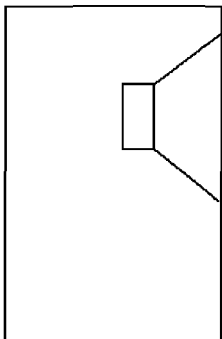


Fig. 6

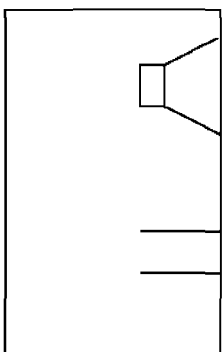


Fig. 7

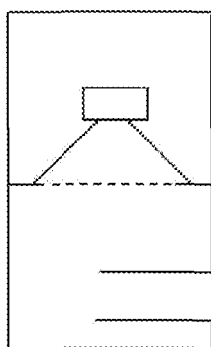


Fig. 8

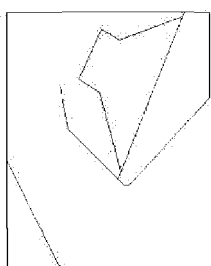
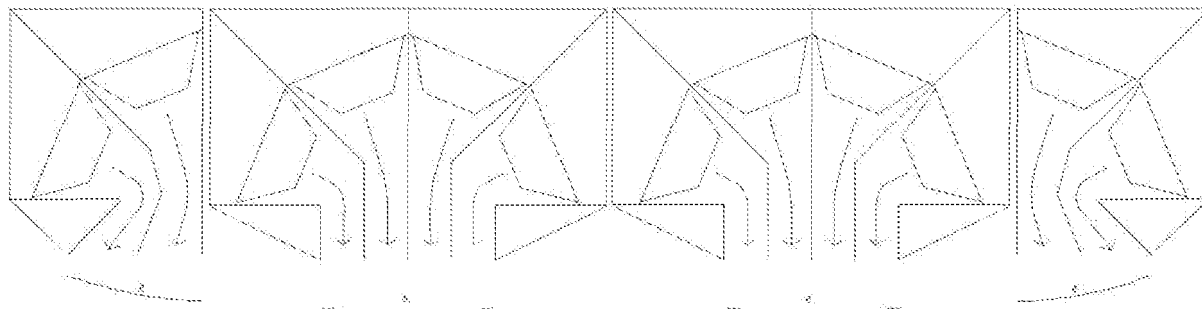


Fig 9.



BACKGROUND OF THE INVENTION

Title: Loudspeaker system

Field of the Invention

This invention relates to equipment for use in sound reinforcement and reproduction, more specifically, to a loudspeaker enclosure and system for sub bass, bass and low mid frequencies between 1Hz and 850Hz.

Description of the Prior Art

There have been many designs of loudspeaker enclosures for sound reinforcement of low mid and bass frequencies. The prior art includes a variety of designs with the most popular being front loaded (infinite baffle), bass reflex, band pass and horn loaded. These prior art designs have their advantages and disadvantages but in general suit specific styles of music and have associated problems when working together to form larger sound systems.

Front loaded or infinite baffle designs produce accurate sound reproduction but lack lower frequency strength and controlled directionality. This is due to the loudspeaker driver lacking in the ability to couple effectively without the use of some form of acoustic transformer to guide sound wave energy. Sound waves produced by this design are not focused and lack any form of directional control, reducing the ability for sound to travel long distances.

Bass reflex designs provide increased low frequency sensitivity when compared to front loaded but suffer from increased transient decay and resonance. Transient decay and resonance is created by the opposite phase of the sound wave which is produced by the rear of the loudspeaker driver reflecting within the enclosure in order to enhance bass frequencies. When this secondary sound wave emanates from the bass reflex port later than the sound wave produced by the front of the loudspeaker driver it causes multiple sound wave arrivals to the sound field. This transient decay and resonance damages overall coherence and intelligibility in the bass frequencies produced by this design.

Band pass designs produce very high bass frequency response through the use of a resonant chamber. This design creates a large amount of resonance within the enclosure which provides an enhanced bass response. The opposite phase of the loudspeaker driver is sealed within a second internal chamber contained within the enclosure to stop frequency cancellation from the opposite phase of the loudspeaker driver. This design lacks definition which is due to the sound waves reflecting inside the enclosure, destroying intelligibility and resulting in an undefined sound field being produced.

Horn loaded designs produce high sensitivity over a wide range of frequencies and can be adapted to suit specific designs of loudspeaker and styles of material being played. Horn loaded bass enclosures are generally designed to produce frequencies from 35Hz-125Hz and use a large loudspeaker driver in order to produce the required bass frequencies.

Designs vary but in general the opposite phase of the loudspeaker driver is sealed within a secondary internal chamber to stop interference and enable greater power to be used without the loudspeaker driver reaching its limit of deflection. Horn loaded bass designs produce enhanced bass frequency response over a wide frequency range and have the ability to throw long distances due to the large horn coupling the sound wave effectively.

This design creates resonance within the large horn as the sound wave becomes reflected within the large space which causes the sound wave to exit non-coherently. When additional loudspeakers are added to increase a systems size (in phase and out of phase) frequencies collide between separate loudspeakers unpredictably on exit causing a lack of definition, lack of linearity and reduction of sensitivity to the overall sound field. This creates unpredictable audio nodes over a wide area which affects linearity resulting in an increased level of bass in some parts and a reduction of bass in others.

In general horn loaded bass designs are larger and heavier than other designs.

Prior art designs of sub bass and bass frequency loudspeakers lack the capability to work together in coherent phase and time alignment when forming a larger sound system. At events such as music concerts this causes the overall sound field to lack linearity and proper definition of bass frequencies. This is caused by destructive and constructive interference occurring between multiple bass loudspeakers, comb filtering and the lack of proper time alignment between the multiple drivers.

Sound waves travel in a circle formation so if a sound system is to be setup to use multiple loudspeakers it needs to have the ability to control its sound wave dispersion in a similar way to natural wave formation in order to produce high quality sound.

If a sound system is to achieve a truly high quality sound field multiple loudspeakers need to have the capability to couple their energy together and focus that energy over a prescribed sound field with a high degree of accuracy. The sound system must also ensure that all frequencies arrive simultaneously in one coherent sound wave. Time delays between loudspeakers of less than a millisecond can be detected by the human ear which appears to the listener as distortion or lack of definition.

The common way to try and correct interference and time alignment issues between multiple loudspeakers with larger prior art sound systems is with the use of electronic processing in the signal path. Processing the sound system electronically enables voltages to be increased or decreased at specific frequencies that are fed to the individual loudspeaker drivers. This electronic correction helps to mask resonance, increase weak frequencies lost by destructive interference and decrease strong frequencies created by constructive interference. This approach does enable a prior art sound system to achieve a flat frequency response, however, it also causes the transient attack and transient decay of the frequency adjusted to become reduced and lose phase coherence. Fast transient attack and fast transient decay is crucial to the overall definition of sound. Transient attack represents the front portion of a sound wave whilst transient decay represents the rear portion. Any reduction to transient attack or decay of a sound wave from the source material causes the sound to become less defined resulting in a reduction of definition and quality.

This adjustment of phase coherence by electronic processing causes sound at the adjusted frequency to become out of phase with the majority which alters the effective phase angle at that frequency. This reduces definition, transient attack and transient decay which results in a reduction of audio quality at the adjusted frequency.

Electronic processing is also used to mask the effects of resonance in prior art designs by reducing the sound level of the affected resonant frequency. However, this electronic mask cannot repair the damage done by resonance, meaning that detail in those frequencies is lost and cannot be replaced electronically.

Summary of the Invention

A new low mid and bass loudspeaker invention is detailed which produces a greatly increased sub bass and bass frequency sensitivity with substantially lower resonance when compared to prior art. The invention overcomes the issue of a non-coherent sound field enabling multiple loudspeakers of this invention to be used together in coherent phase and time alignment over the entire sound field.

The invention incorporates multiple loudspeaker drivers arranged in a semi-circle configuration contained within an enclosure that is acoustically open to the front. Each loudspeaker driver produces separate sound waves that propagate into a dedicated sound channel which is sealed to the rear and each side whilst being acoustically open to the front. These said separate sound channels are aligned through an arrangement that mimics natural sound wave propagation in order to produce one time aligned and phase coherent sound wave at the acoustically open front. This combined sound wave produces greatly increased lower frequency sensitivity with a very high degree of definition.

Low frequency sensitivity is increased as the combined sound wave exits the loudspeaker. With each additional loudspeaker added to the system the low frequency sensitivity continues to increase. This combined sound wave acts as one coherent force able to reproduce defined sub bass, bass and low mid frequencies without creating resonance or transient decay.

Overall efficiency is increased as each individual sound wave coherently combines on exit to form one coherent sound wave which reduces static particle friction between the separated waves. Efficiency is further increased by the minimal internal surface area inside the separated sound channels which leads to a reduction in friction as the sound waves travel through the enclosure.

The invention allows further loudspeakers of a similar design to be added on top and to both the sides whilst maintaining coherent phase and time alignment of every loudspeaker and every loudspeaker driver.

The semi-circle arrangement of the loudspeaker drivers combined with the lack of a resonant chamber to enhance low frequency sensitivity minimises the external size of the enclosure, reducing the overall weight.

Brief description of the Drawings

A specific embodiment of the invention will now be described by way of example with reference to the accompanying drawings wherein:

Sheet 1

FIG. 1 is a top cut through cross section view of the invention being a full enclosure with a fanned dispersion arrangement.

FIG. 2 is a top cut through cross section view of the invention being a half enclosure with a fanned dispersion arrangement.

FIG. 3 is a top cut through cross section view of the invention being a full enclosure with a straight dispersion arrangement.

FIG. 4 is a top cut through cross section view of the invention being a half enclosure with a straight dispersion arrangement.

Sheet 2

FIG.5 is a side cut through cross section view of a prior art example drawing being a typical design of a front loaded enclosure.

FIG.6 is a side cut through cross section view of a prior art example drawing being a typical design of a bass reflex enclosure.

FIG.7 is a top cut through cross section view of a prior art example drawing being a typical design of a band pass enclosure.

FIG.8 is a side cut through cross section view of a prior art example drawing being a typical design of a horn loaded enclosure.

Sheet 3

FIG.9 is a top cross section view of a complete sound system.

Description of the preferred embodiment

Referring to Fig 1 this is a cross section top view of the preferred embodiment. This drawing illustrates the invention which is a sub bass, bass and low mid frequency (1 Hz – 850 Hz) loudspeaker enclosure. The top and bottom pieces (not shown) are solid flat panels which have been removed to show the vertical parts and are detailed as follows...

Item 1 is the solid rear wall which has removable door panels (not shown) to allow loudspeaker driver access. Items 2a & 2b are solid side walls also with removable door panels (not shown) to allow for loudspeaker driver access. Items 3a, 3b, 3c, 3d are the driver baffles in which mounts the loudspeaker drivers (4a, 4b, 4c, 4d). The loudspeaker drivers are mounted in reverse to aid cooling and through a hole cut in the baffle matching the size required by the driver. Items 7b, 7c, 7d, 8b, 8c, 8d, 10a, 10b divide each loudspeaker driver's sound wave into separate sections; this stops sound interference between each loudspeaker driver. Sound waves produced from each loudspeaker driver travel toward the centre and forward as shown by items 5a, 5b, 5c and 5d. Each sound wave is guided through each channel by items 7a, 7b, 7c, 7d, 7e, 10a and 10b which lines up each sound wave coherently into an arrangement created by items 8a, 8b, 8c, 8d, and 8e. This arrangement correctly forms each separate sound channel in time and phase alignment to form one coherent sound wave at point 6.

The loudspeaker drivers are arranged in a semi-circle arrangement with channel dividers 7b, 7c and 7d separating each channel. Items 7a and 7e form the side channels for drivers 4a and 4d. It is crucial that the angle of the baffles 3a, 3b, 3c and 3d follow a semi-circle arrangement. The angle between each channel on the semi-circle can be increased or decreased to suit alternative designs and sizes as required.

Multiple Fig.1 loudspeakers can be stacked vertically to increase the overall sound system size whilst maintaining correct time and phase coherence.

In Fig.2 the overall design is half that as shown in Fig.1, the construction method is the same as shown in Fig.1 with the exception of it being half the horizontal size. Multiple Fig.2 loudspeakers can be stacked vertically or two placed side by side in mirror formation to form a complete Fig.1 enclosure to enable an increase in overall sound system size whilst maintaining correct time and phase coherence of the entire system.

In Fig.3 a straight exit channel arrangement is shown that allows multiple Fig.3 loudspeakers to be setup alongside and on top of each other. One Fig.2 enclosure could be setup on each end in mirror formation to mimic natural sound wave formation. This would allow the sound system to increase in size both vertically and horizontally whilst maintaining correct time and phase coherence over the entire system as shown in Fig.9

It has been found that compressing the sound wave channels inside the enclosure as shown by items (7a 7b), (7b 7c), (7c 7d), (7d 7e) at an angle similar to that of the loudspeaker driver's cone (not shown) reduces sound resonance and increases efficiency.

The area behind each of the loudspeaker drivers 11a, 11b, 11c and 11d needs to be sealed and air tight. Sealing this area enables greater power to be put through the loudspeaker driver without reaching its limit of displacement. This sealing also prevents the negative phase of the sound wave created by the loudspeaker driver interfering with the positive sound wave.

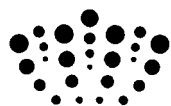
The amount of loudspeaker drivers and channels can be increased to suit a particular design.

It has been proved through testing that this invention produces very high sound definition at highly increased sensitivities in sub bass, bass and low mid frequencies with a greater control of dispersion that far exceeds that found in prior art.

Patent Claims

1. A loudspeaker enclosure and system which incorporates multiple loudspeaker drivers arranged in a semi-circle configuration contained within an enclosure, each loudspeaker driver is separated into a separate sound channel arranged in a semi-circle configuration that combine to form one phase coherent and time aligned sound wave which upon exit increases lower frequency sensitivity, multiple loudspeakers being able to be placed on top and on each side to enable increased system size whilst maintaining phase coherence and time alignment of all loudspeakers which produce upon exit increasing lower frequency sensitivity with each additional loudspeaker added whilst maintaining one coherent sound wave.
2. A loudspeaker enclosure as set forth in claim 1 wherein the loud speaker drivers are arranged in an arc configuration.
3. A loudspeaker enclosure as set forth in claim 1 wherein the loud speaker drivers are arranged in a curved configuration.
4. A loudspeaker enclosure as set forth in claim 1 wherein the loud speaker drivers are arranged in an inverse semi-circle configuration.
5. A loudspeaker enclosure as set forth in claim 1 wherein the loud speaker drivers are arranged in an inverse arc configuration.
6. A loudspeaker enclosure as set forth in claim 1 wherein the loud speaker drivers are arranged in an inverse curved configuration.
7. A loudspeaker enclosure as set forth in claim 1 wherein the separated sound channels at points 5a, 5b, 5c and 5d are of unequal size and degree increments from one another.
8. A loudspeaker enclosure as set forth in claim 1 wherein the external enclosure size and shape can be altered to suit requirements at points 1, 2a, 2b, 8a, 8b, 9a and 9b.
9. A loudspeaker enclosure as set forth in claim 1 wherein the baffles at points 3a, 3b 3c and 3d are of unequal size from one another.
10. A loudspeaker enclosure as set forth in claim 1 wherein the baffles at points 3a, 3b 3c and 3d are of unequal degree increments from one another.
11. A loudspeaker enclosure as set forth in claim 1 wherein the loudspeaker drivers at points 4a, 4b 4c and 4d are of unequal size from one another.
12. A loudspeaker enclosure as set forth in claim 1 wherein the arrangement of sound channels form a straight combined sound wave as shown in Fig.3 and Fig.4.
13. A loudspeaker enclosure as set forth in claim 1 wherein the amount of loudspeaker drivers and separated channel sections shown in Fig.1 at points 5a, 5b, 5c and 5d are increased to 5 or more separated channels.
14. A loudspeaker enclosure as set forth in claim 1 wherein the amount of loudspeaker drivers and separated channel sections shown in Fig.1 at points 5a, 5b, 5c and 5d are increased to 6 or more separated channels.
15. A loudspeaker enclosure as set forth in claim 1 wherein the amount of loudspeaker drivers and separated channel sections shown in Fig.1 at points 5a, 5b, 5c and 5d are increased to 7 or more separated channels.
16. A loudspeaker enclosure as set forth in claim 1 wherein the amount of loudspeaker drivers and separated channel sections shown in Fig.1 at points 5a, 5b, 5c and 5d are increased to 8 or more separated channels.

17. A loudspeaker enclosure as set forth in claim 1 wherein the amount of loudspeaker drivers and separated channel sections shown in Fig.1 at points 5a, 5b, 5c and 5d are reduced to 3 separated channels.
18. A loudspeaker enclosure as set forth in claim 1 wherein the amount of loudspeaker drivers and separated channel sections shown in Fig.1 at points 5a, 5b, 5c and 5d are reduced to 2 separated channels.
19. A loudspeaker enclosure as set forth in claim 1 wherein the vertical angle shown in Fig. 1 at points 8a, 8b, 8c, 8d and 8e are altered to suit any vertical dispersion degree required.
20. A loudspeaker enclosure as set forth in claim 1 wherein the vertical angle shown in Fig.1 at points 10a and 10b are altered to suit any loudspeaker driver sizes.
21. A loudspeaker enclosure as set forth in claim 1 wherein the loudspeaker driver arrangement as shown in Fig.1 is halved in size to that shown in Fig.2.
22. A loudspeaker enclosure as set forth in claim 1 wherein multiple enclosures as shown in Fig.9 can be setup vertically or horizontally to increase system size whilst maintaining combined sound wave coherence.
23. A loudspeaker enclosure as set forth in claim 1 wherein multiple loudspeaker drivers are individually channelled with coherent phase and time alignment to increase low frequency sensitivity upon exit of the loudspeaker.
24. A loudspeaker enclosure as set forth in claim 1 wherein lower frequency sensitivity is increased external the loudspeaker.
25. A loudspeaker enclosure as set forth in claim 1 wherein lower frequency sensitivity increases exponentially by adding additional loudspeakers.
26. A loudspeaker enclosure as set forth in claim 1 wherein multiple loudspeaker drivers are individually channelled with coherent phase and time alignment to increase low frequency sensitivity upon exit of the enclosure without the use of resonant chambers.



Application No: GB1114353.4

Examiner: Peter Easterfield

Claims searched: 1 to 26

Date of search: 9 December 2011

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1 at least	EP 1071308 A2 (ADAMSON) see fig 7
X	1 at least	US 2011/0069856 A1 (BLORE et al) see figs 8, 9 & 10
X	1 at least	US 6394223 B1 (LEHMAN) see figs
X	1 at least	US 6393131 B1 (REXROAT) see figs 3, 4 & 5
A	-	EP 1460880 A2 (ANDREWS)
A	-	US 5750943 A (HEINZ)

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

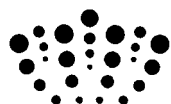
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H04R

The following online and other databases have been used in the preparation of this search report

WPI, EPODOC



International Classification:

Subclass	Subgroup	Valid From
H04R	0001/30	01/01/2006
H04R	0001/34	01/01/2006
H04R	0001/40	01/01/2006