June 27, 1967 H. B. SHAPER 3,327,808

LOUD SPEAKER HOUSING

Filed June 10, 1965

FIG. 1.

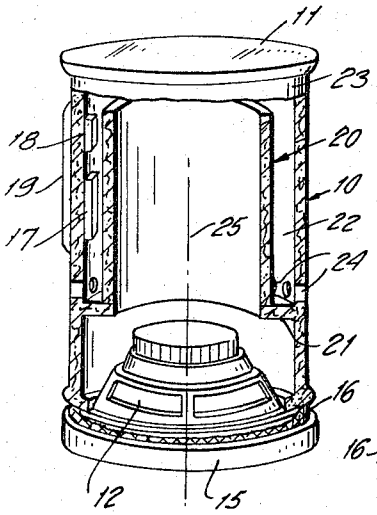



FIG. 2.

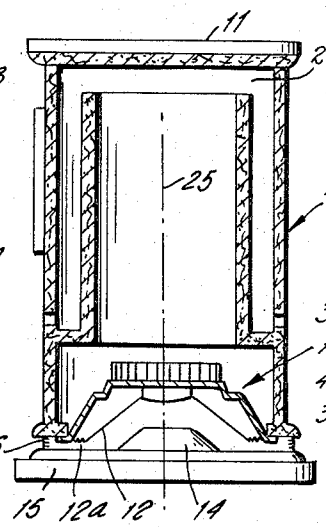



FIG. 3.

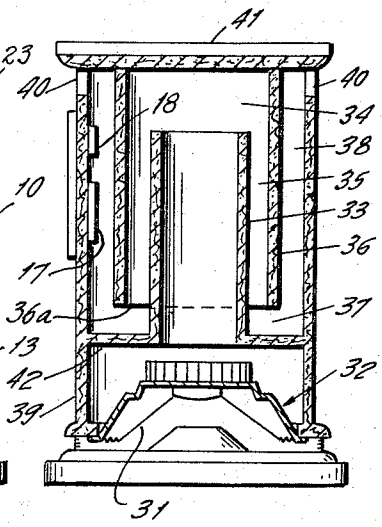



FIG. 4.

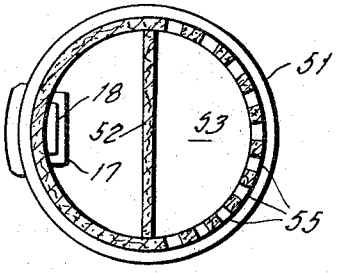



FIG. 5.

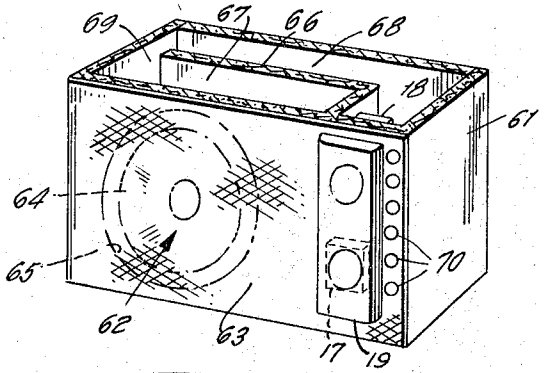



FIG. 4A.

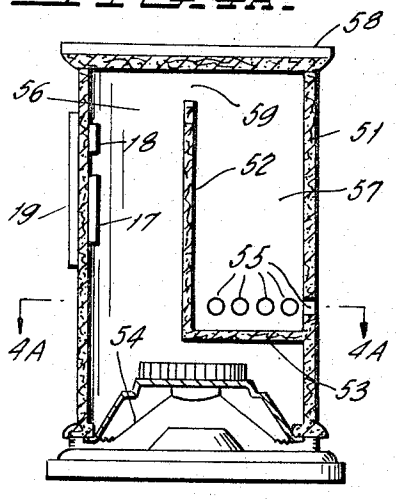
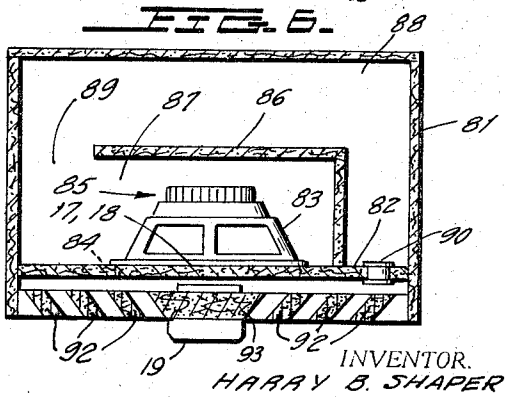



FIG. 6.




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# LOUD SPEAKER HOUSING

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5 Claims. (Cl. 181—31)

This invention relates to loud speaker systems in general and more particularly relates to a means for obtaining improved bass response in speaker systems having moderate size cavities. One embodiment of this invention represents an improvement over the structure illustrated in my copending application Serial No. 421,008 filed December 24, 1964.

Loud speaker systems for home use have been deficient in reproducing sounds in the bass or low audio frequency range. Attempts to improve response in the base region have not met with great success apparently because of space limitations.

One such attempt at improving bass response is known as a bass-reflex or phase-inverter structure. This is essentially a Helmholtz resonator wherein the loud speaker diaphragm or driver unit is mounted so that the rear surface thereof drives an acoustic chamber and the front surface radiates into space. A port or opening in the chamber couples the chamber to the outside space. At certain low frequencies sound pressures radiating from this port are relatively in phase with radiation from the front surface of the diaphragm.

The bass-reflex system may be regarded as a double source of sound whose relative phase depends upon radiated frequency. Since the back wave is reversed in phase with respect to the front wave at the diaphragm, the rear wave must be reversed at the port with respect to the rear of the diaphragm in order that the rear wave radiated from the chamber may reinforce the front wave. Unfortunately, in common types of bass-reflex systems complete phase reversal of the back wave is not obtained in the desired frequency range. That is, in conventional size cabinets, say in the order of two cubic feet, complete phase reversal occurs only over a very narrow frequency band and generally well above 50 c.p.s.

In the device of the instant invention, with essentially the same size housing as prior art speaker systems, complete phase reversal will occur over a wide frequency range at the low end of the audio spectrum with this range being typically below 50 c.p.s. This is achieved by feeding the back wave into an elongated transmission line cavity loaded at its far end by a constricting port. Phase delay is introduced in the back wave by the length of the cavity and when this delay results in the wrong polarity, energy is cut off by the port. However, over the lowest portion of the frequency spectrum energy is radiated from the port with essentially the correct polarity to augment the front wave.

It is the nature of this transmission line cavity terminated by a constriction to attenuate higher multiple frequencies which would otherwise possess recurring resonances. Tuning of the transmission line together with the port characteristics results in a strong fundamental resonance which appears at the port 180° out of phase with radiation from the rear surface of the speaker diaphragm and therefore is fully in phase with radiation emanating from the front surface of the diaphragm. At the same time any tendency to produce antiresonances, multiple higher frequencies where cancellations occur, is sharply attenuated since the transmission line and port acts as a highly effective low pass filter. The structure of the instant invention should not be confused with an acoustic labyrinth. The latter achieves phase reversal



by virtue of time delay by conducting the back wave through a series of zig-zag channels to an opening in the speaker enclosure. However, because of the total length of the labyrinth the back wave will resonate in phase with that of the front wave at the first half wave length of duct length and thereafter be improperly phased.

A labyrinth approximately 11 feet long is required to achieve reinforcement of the front wave by the back wave at 50 c.p.s. At this frequency the labyrinth is so long that it requires an enclosure much larger than the two cubic foot size of the home speaker unit. In addition, in order to suppress anti-resonances the labyrinth must be lined with sound absorbing material resulting in excessive damping. Further, in order to achieve reasonable Q, the cross-sectional area of the labyrinth must be relatively large resulting in a shorter length for a given size cabinet. If cross-section is reduced to obtain greater length, then over damping results in diminished efficiency at the desired inverted frequency, thereby defeating the original intent of utilizing the labyrinth.

Accordingly, a primary object of the instant invention is to provide a novel construction for a loud speaker system in which the back wave generated by the woofer diaphragm is radiated from the system enclosure in phase with the front wave over a relatively wide frequency band at the low end of the audio spectrum.

Another object is to provide a loud speaker system of this type in which the back wave of the woofer or bass speaker is directed along an elongated path terminated by constricting opening venting to the atmosphere.

Still another object is to provide a loud speaker system of this type in which the back wave of the woofer is directed through a series of elongated parallel duct sections joined end to end with the end of the duct remote from the speaker having a constricted opening venting to the atmosphere.

A further object is to provide a loud speaker system of this type in which the woofer faces downwardly with the front wave venting through an annular opening positioned below the woofer and the back wave being conducted through an elongated transmission line cavity loaded at the far end by a constricting port which acts as a low pass filter.

A still further object is to provide a loud speaker system of this type in which the back wave of the woofer feeds into an elongated transmission line cavity comprised of a plurality of concentric telescoped tubes.

These as well as other objects of this invention will become readily apparent after reading the following description of the accompanying drawings in which:

FIGURE 1 is a perspective of a speaker system constructed in accordance with the teachings of the instant invention with portions of the enclosure and internal partitions thereof cut away to better reveal details of construction.

FIGURE 2 is a longitudinal cross-section of the speaker system of FIGURE 1.

FIGURES 3 and 4 are views similar to FIGURE 2 illustrating other embodiments of the instant invention.

FIGURE 4A is a cross-section taken through 4A—4A of FIGURE 4 looking in the directions of arrows 4A—4A.

FIGURE 5 is a perspective of another embodiment of this invention with portions of the enclosure broken away to reveal elements disposed therein.

FIGURE 6 is a plan view of a further embodiment of the instant invention similar to the embodiment of FIGURE 5, with the top of the enclosure cut away to reveal the elements within the enclosure.

Now referring to the figures and more particularly to FIGURES 1 and 2. The structure illustrated in FIGURES 1 and 2 is for the most part described in detail in my afore-

said copending application 421,008. Briefly, the structure described in my copending application 421,008 is the cylindrical tubular housing **10** closed at its top by rigid cover **11** and at the bottom by the diaphragm **12** of woofer **13**. The latter is located at the bottom of cylinder **10** with diaphragm **12** facing downwardly so that the front wave generated thereby is directed toward a truncated conical acoustic impedance element **14**. The latter is mounted to the upper surface of circular base plate **15** positioned in closely spaced relationship with respect to the bottom edge of cylinder **10** with the spaced relationship being maintained by means of standoffs (not shown). Thus, the front wave generated by diaphragm **12** is radiated through a narrow 360° aperture at the bottom edge of cylinder **10**, this aperture being covered with decorative cloth **16**. Mid range speaker **17** and tweeter **18** are secured to the back surface of plate **19** which covers a side opening in cylindrical enclosure **10**.

The improvement provided by the instant invention consists of cylindrical tubular partition **20** telescoped within cylinder **10** and concentric therewith. Annulus **21**, extending outwardly from the lower edge of inner tube **20** to the inner surface of outer tube **10**, prevents upward propagation of the back wave generated by diaphragm **12** in the space **22** between tubes **10** to **20**. The upper edge of tube **20** is spaced from top cover **11** so as to provide an annular window **23** leading from the center of tube **20** to space **22**. Annular window **23** is a projection of tube **20** extending up to top cover **11**.

The back wave generated by diaphragm **12** is directed upwardly through inner tube **20**, to the sides through window **23** and then downwardly in space **22** to apertures **24** where a portion of the back wave is radiated into space. Apertures **24** extend through tube **10**, are arranged in a circular array about the cylindrical axis **25** and are positioned immediately above partition **21**. The path taken by the back wave is effectively an elongated transmission line terminated by a constriction formed by apertures **24**. This constriction produces inductive effects acting to cut off higher frequencies and thereby prevent radiation thereof into space. The portion of the back wave emitted through apertures **24** is made to be in phase with the front wave generated by diaphragm **12** over a relatively wide frequency range falling below 50 c.p.s. by appropriately proportioning tubes **10**, **20**, window **23** and apertures **24**. The area of window **23** should be in the range from 0.5 to 1.0 times the cross-sectional area of tube **20** while the cross-sectional area of space **22** should be in the range from 0.5 to 2.0 times the cross-sectional area of tube **20**. It is desirable to have the cross-section of tube **20** as large as the diameter of diaphragm **20** at the inner boundary of compliant edge **12***a*. While an appropriate range of relative sizes between window **23**, space **22** and tube **20** has been given, it is desirable to have window **23** and the cross-sectional area of space **22** each approximately equal to the cross-sectional area of tube **20**. In a typical practical construction the key dimensions are: tube **10**, 24½ inches long with an inner diameter of 12 inches; tube **20**, 20 inches long with an inner diameter of 8 inches and a wall thickness of ¼ inch; and window **23**, 1¾ inches high.

In the embodiment of FIGURE 3 the back wave generated by diaphragm **31** of woofer **32** is directed upwardly through center tube **33**, through annular window **34** to space **35** between cylinders **33**, **36**, through annular window **37**, upwardly in the space **38** between middle tube **36** and outer tube **39** and is radiated into space through the series of apertures **40** circularly arranged about the tubular axis and positioned just below the top closure **41** for cylinder **39**. Partition **42** extends outwardly from the lower end of tube **33** to the inner surface of tube **39** thereby directing the entire back wave generated by diaphragm **31** upwardly through inner tube **33**. Annular window **34** is formed by the space between the upper end of tube **33** and the bottom surface of cover **41**. The upper edge of middle tube **36** abuts the inner surface of top cover **41** while the lower edge **36***a* of tube **36** is spaced from partition **42** to form annular window **37**.

It should be apparent to those skilled in the art that even though the outer dimensions in the speaker enclosures of FIGURES 2 and 3 are shown as being equal, this has been done only for simplicity of illustration. Naturally, the structure of FIGURE 3 will enable the acoustic benefits of the structure of FIGURE 2 to be achieved in a shorter housing having greater transverse dimensions. In addition, different frequency ranges of sound reinforcement by the back wave may be achieved by constructing the transmission line cavity of appropriate length and diameter.

In the embodiment of FIGURES 4 and 4A cylindrical enclosure **51** is provided with internal partitions **52**, **53** which direct the back wave of woofer diaphragm **54** through an elongated path to apertures **55**. More particularly, partition **52** is a plate-like member positioned in a vertical plane extending across the diameter of cylinder **51** and dividing the interior thereof into cavity sections **56**, **57**. The upper end of partition **52** is spaced from top closure **58** for cylinder **51** so as to form window **59** connecting cavity sections **56**, **57**.

The other partition **53** is a semicircular plate abutting the lower edge of partition **52** and extending therefrom to engage half of the interior surface of cylinder **51**, thereby preventing the back wave generated by diaphragm **54** from moving upwardly in cavity section **57**. Thus, it is seen that the back wave generated by diaphragm **54** is directed upwardly in cavity section **56**, to the side through window **59** and downwardly in cavity section **57** to apertures **55**. The latter are positioned just above partition **53** extending through cylinder **51** to directly connect cavity section **57** externally of cylinder **51**.

The embodiment of FIGURE 5 is a so-called book shelf type of speaker unit and includes rectangular enclosure **61** having speaker **62** secured to front wall **63** with speaker diaphragm **64** sealing aperture **65**. L-shaped partition **66** divides enclosure **61** into parallel cavity sections **67**, **68** connected by window **69** located at the side of enclosure **61** remote from apertures **70** in a vertical row through front wall **63** of enclosure **61**. Thus, the back wave generated by diaphragm **64** travels in cavity section **67**, through window **69** and cavity section **68** to apertures **70**. Since apertures **70** are a constriction at the end of a transmission line cavity, apertures **70** act as a low pass filter so that a portion of the back wave from diaphragm **64** will radiate through apertures **70** into space in phase with the front wave generated by diaphragm **64**. In the embodiment of FIGURE 5 midrange speaker **17** and tweeter **18** are positioned between woofer **62** and apertures **70**.

The embodiment of FIGURE 6 is another so-called book shelf type speaker system having rectangular enclosure **81**. Woofer **85** is mounted to the front enclosure wall **82** with woofer diaphragm **83** providing the closure for centrally located aperture **84** in wall **82**. L-shaped partition **86** divides the interior of housing **81** into parallel cavity sections **87** and **88** connected by window **89**.

The back wave generated by diaphragm **83** is directed through cavity section **87**, window **89** and cavity section **88** to apertures **90** positioned in a vertical row in front wall **82** of enclosure **81** near the side thereof remote from window **89**. Vertical spaced slats **92** and center support **93** provide a false front for enclosure **81** in front of and spaced from wall **82**. Mid-range speaker **17** and tweeter **18** are mounted to central section **93** directly in front of diaphragm **83**.

Thus, it is seen that the instant invention provides a number of practical structures for moderate sized speaker enclosures in which improved base response is achieved. Improvement is typically over a relatively wide frequency range in the region below 50 cycles. The construction is such that antiresonances in the low frequency range are essentially eliminated.

Although there has been described a preferred embodiment of this novel invention, many variations and modifications will now be apparent to those skilled in the art. Therefore, this invention is to be limited, not by the specific disclosure here, but only by the appended claims.

I claim:

1. A speaker system including an enclosure having an opening means venting to atmosphere and a tubular side wall with its tubular axis extending vertically; said opening means including a first and a second section; a bass speaker within said enclosure; said speaker including a sound generating diaphragm which when vibrated produces a front wave and a back wave of reverse phase to said front wave; said diaphragm operatively positioned in proximity to and above said first section to direct said front wave therethrough; said speaker positioned near the bottom of said enclosure with said diaphragm facing downward; said speaker being of a diameter substantially equal to the diameter of said tubular side wall; said first section comprising an annulus positioned below said diaphragm and concentric with said tubular axis; partition means within said enclosure cooperating with the inner boundary of said tubular side wall to define a transmission line acting as an elongated path directing said back wave to said second section; said second section defined by boundary means providing a constriction at one end of said path acting as a low band pass filter; said path being of a length such that portions of said back wave emitted through said second section are reversed in phase with respect to these portions of said back wave as they are generated by said diaphragm whereby these portions of said back wave are in phase with and reinforce said front wave; said path including a first portion and a second portion connected by a window portion; said first and second portions extending generally parallel to one another.



2. A speaker system as set forth in claim 1 which said second section is formed in said side wall.

3. A speaker system as set forth in claim 2 in which said partition means divides said enclosure into a plurality of telescoped tubular sections concentric about said tubular axis with the lower end of the innermost of said tubular sections communicating directly with the rear of said diaphragm; each of said tubular sections communicating with an adjacent one of said tubular sections by means of an annular window concentric with said axis.

4. A speaker system as set forth in claim 3 in which said innermost tubular portion and the tubular portion adjacent thereto are of substantially the same cross-sectional area substantially equal to the area of the window connecting these tubular sections.

5. A speaker system as set forth in claim 3 in which the innermost tubular portion is of a cross-sectional area from one to two times the cross-sectional area of the tubular portion adjacent to said innermost tubular portion and the area of the window connecting these portions.


**References Cited**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| 2,065,367 | 12/1936 | Evans | 181—31.1 |
| 2,476,572 | 7/1949 | Wenzel | 181—31.1 |
| 2,904,123 | 9/1959 | Nigro | 181—31.1 |
| 3,122,215 | 2/1964 | Sutton | 181—31.1 |

FOREIGN PATENTS

| | | |
|---|---|---|
| 791,142 | 9/1935 | France. |
| 1,025,702 | 1/1953 | France. |
| 433,284 | 4/1948 | Italy. |


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