Sept. 12, 1967 G. E. OWEN, JR 3,340,956

SOUND REPRODUCTION APPARATUS

Original Filed June 15, 1964 2 Sheets-Sheet 1

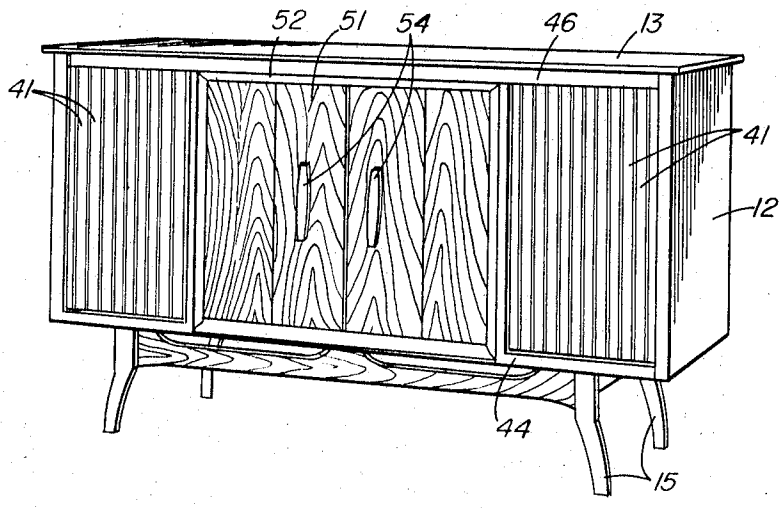
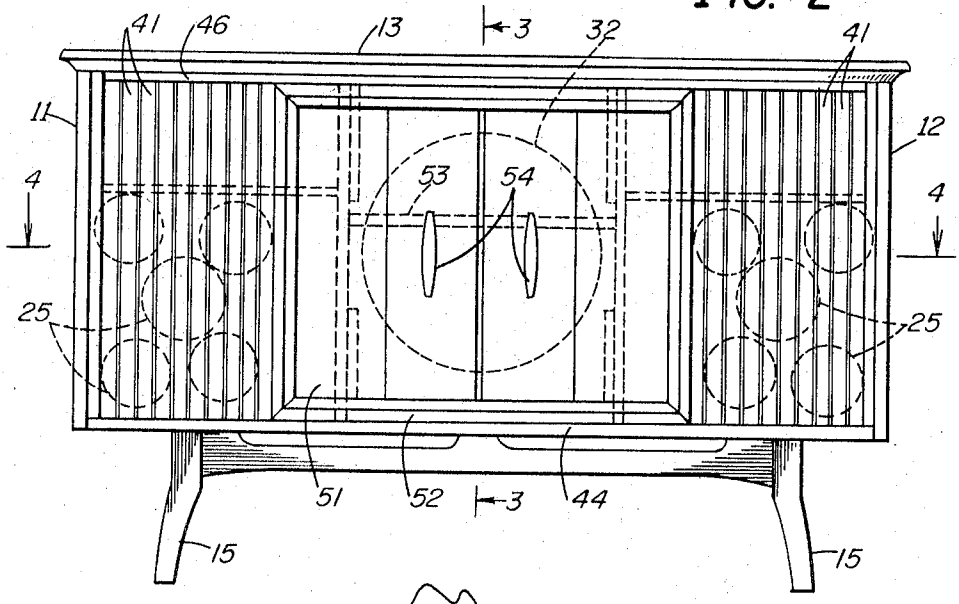


FIG. 1

FIG. 2



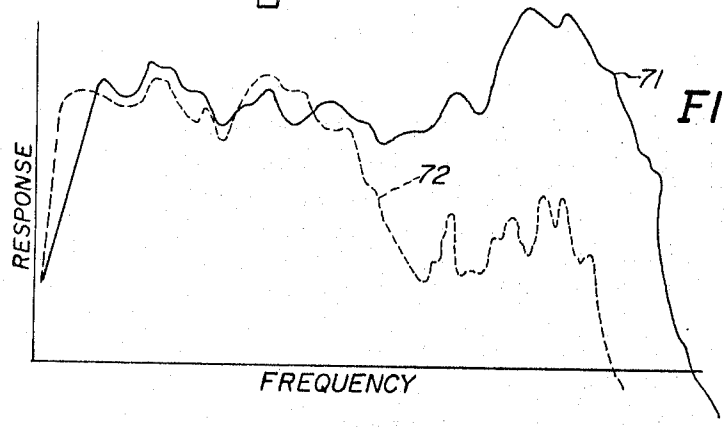


FIG. 6

Inventor
GEORGE E. OWEN Jr.
By Mueller & Nichols
Attys.

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SOUND REPRODUCTION APPARATUS

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FIG. 3

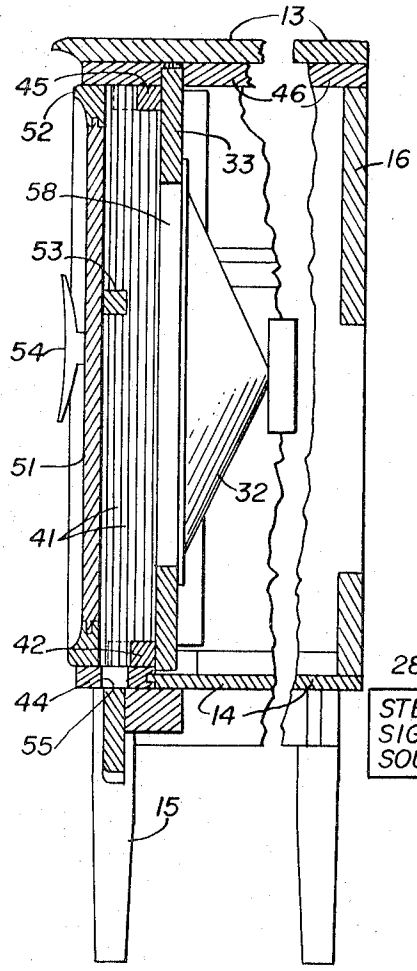


FIG. 4

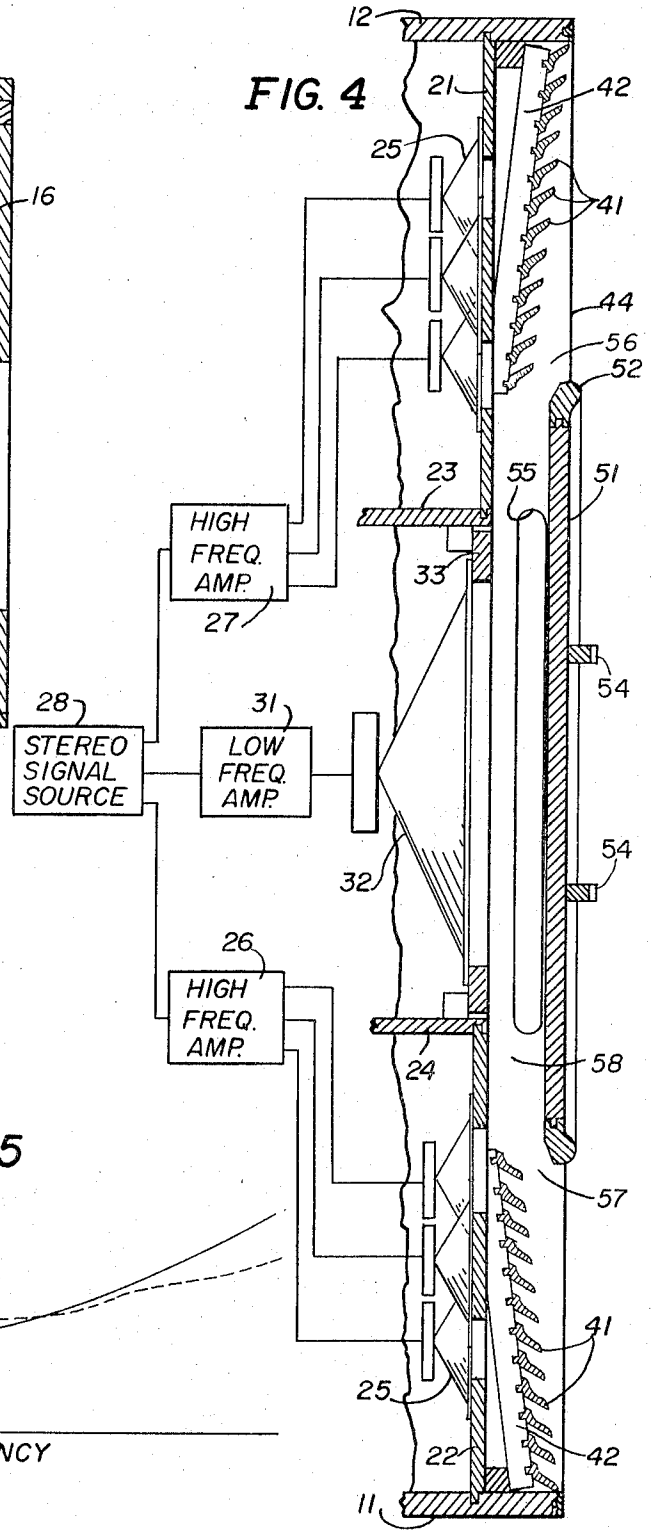
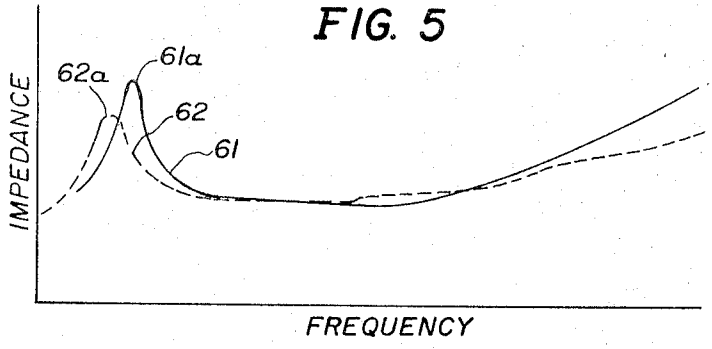


FIG. 5



United States Patent Office 3,340,956
Patented Sept. 12, 1967

3,340,956

SOUND REPRODUCTION APPARATUS

George Edwin Owen, Jr., Melrose Park, Ill., assignor to Motorola, Inc., Franklin Park, Ill., a corporation of Illinois

Continuation of application Ser. No. 374,922, June 15, 1964. This application Nov. 1, 1965, Ser. No. 513,625

2 Claims. (Cl. 181—31)

This invention relates to sound reproduction apparatus, and more particularly to an improved speaker system. This application is a continuation of application Ser. No. 374,922, filed June 15, 1964, now abandoned.

Enclosures for audio signal speakers generally provide grill cloth or louvers to conceal the speakers and yet permit passage of sound freely therethrough. Such grill cloth or louvers may undesirably limit the cabinet designer in achieving an attractive overall cabinet design. This can be a particular problem in multi-speaker console record players wherein substantially the entire front of the cabinet may enclose speakers which radiate outwardly of the cabinet, thus generally requiring sound passage construction across the entire front wall of the cabinet.

With reference to more technical problems in speaker systems, it is noted that a combined speaker and enclosure will generally have a resonant frequency at the lower end of the audio frequency spectrum and may contribute to "booming" bass note sounds. Another problem with regard to low frequency speakers, or woofers, is that their response may extend well upwards into the higher frequencies. When used in a multi-channel system, irregular cross-over may result from this, and when used in a three channel stereophonic system, poor channel separation may result. Various other problems exist in connection with low frequency speaker systems such as Doppler effects created by the moving speaker cone, and distortion due to excessive speaker cone excursion.

It is an object of this invention to provide a speaker system having an enclosure which presents an attractive appearance while at the same time reducing or eliminating some of the foregoing technical problems.

Another object of the invention is to provide an improved multi-channel speaker system.

Still another object of the invention is to provide a three-channel stereophonic sound reproduction system with superior channel separation and improved low frequency response.

A feature of the invention is the provision of a cabinet construction which mass loads a low frequency speaker to lower the natural resonance of the system.

Another feature of the invention is the provision, in a speaker system, of a solid panel over the front of a low frequency speaker with the top and bottom of the panel closed with the speaker enclosure so that the volume of air between the panel and the front of the speaker mass loads the speaker and the solid panel enhances the appearance of the assembly.

Still another feature of the invention is the provision of a compression enclosure over the front of a low frequency speaker in a stereo reproducing system, which enclosure is constructed to suppress high frequency signals from the speaker in order that only associated further speakers can produce these signals which contribute to stereo information.

In the drawings:

FIG. 1 is a perspective view of the front of a stereophonic phonograph cabinet constructed in accordance with the invention;

FIG. 2 is a front elevational view of the cabinet of FIG. 1;

FIG. 3 is an enlarged sectional view taken along the line 3—3 of FIG. 2;

FIG. 4 is an enlarged sectional view taken along the line 4—4 of FIG. 2, with circuitry shown schematically;

FIG. 5 is a graph exhibiting the impedance characteristics of the system as compared to conventional systems; and

FIG. 6 is a graph exhibiting the response characteristics of the system as compared with conventional systems.

In accordance with the invention, a speaker system for reproducing three-channel stereophonic signals is enclosed in a cabinet. The cabinet has three aligned baffle boards across the front, and high frequency speakers are disposed in each of the outside baffle boards. A low frequency speaker is mounted in the center baffle board, and a compression enclosure is secured to the cabinet over the low frequency speaker. The compression enclosure partially encloses a volume of air in front of the low frequency speaker to mass load the low frequency speaker and limit the high frequency response thereof. The resonant frequency of the low frequency speaker system is thereby reduced to improve reproduction of lower frequency signals. Moreover, separation of the left and right stereophonic channels is improved while at the same time the overall appearance of the cabinet is enhanced.

Referring now more particularly to the drawings, FIGS. 1–4 illustrate one form of speaker system constructed in accordance with the invention. A cabinet having sides **11** and **12**, top **13** and bottom **14**, is supported on legs **15**. The configuration of the supporting legs **15** may match the overall styling of the cabinet itself. The back of the cabinet is enclosed with an apertured panel **16** forming a substantially open backed cabinet as shown in FIG. 3 for ventilation and to permit free speaker cone movement.

The front portion of the cabinet includes a pair of baffle boards **21** and **22** at either end thereof, extending from respective sides **12** and **11**, to interior supporting panels **23** and **24**. Baffle boards **21** and **22** provide support for a plurality of speakers **25** which carry the higher or directional frequencies of the right and left channels of a stereophonic signal. The respective speakers **25** are driven by amplifiers **26** and **27** connected to a stereo signal source **28**.

The lower frequencies of both the right and left channels of the stereo signal, which frequencies are non-directional in character, and therefore do not contribute to the stereophonic effect, are applied through a low frequency amplifier **31** to low frequency speaker **32**. Low frequency speaker **32** could be a single large speaker as shown or a plurality of small speakers. Speaker **32** is mounted to a center baffle board **33**, which extends between supporting panels **23** and **24** and completes the front portion of the cabinet.

From an appearance standpoint, it is desirable that some form of decorative covering be placed over the speakers **25** in order that the speaker cones are not visible. Such covering may take the form of grill cloth as is well known in the art, or may, as shown in the drawings, take the form of a plurality of vertical louvers **41**. These louvers **41** have their lower ends mounted in respective right and left support rails **42** on a bottom panel **44**, which bottom panel forms an extension of cabinet bottom **14**. The top end of louvers **41** are supported by right and left support rails **45** similar to rails **42**. Rails **45** are supported on an under panel **46** secured to the lower side of top **13**. Louvers **41** are angularly disposed to conceal the speakers **25** and yet permit passage of sound therethrough.

A compression panel **51**, which is substantially rectangular, is secured over the speaker **32**. Panel **51** is solid, having no apertures, and has an outward surface which

complements the overall cabinet design. The panel is more simple in decoration than the louvers, contributing to a pleasing and uncluttered outward appearance of the cabinet as seen in FIG. 1. Panel **51** has a surrounding frame **52** and is secured at the top edge to the under panel **46** and at the bottom edge to bottom panel **44**. A stiffener cleat **53**, for affording rigidity to panel **51**, extends across the interior surface thereof, and a pair of ornamental handles **54** extend from the outer surface of panel **51**. The side edges of the panel **51** are left unconnected with the cabinet, and a vent **55** is provided in the lower panel **44**.

Panels **51** and the top and bottom panels **46** and **44** form a compression chamber **58** to partially enclose a volume of air in front of low frequency speaker **32**. This air "mass" loads speaker **32** by providing an effective "reactance" for the cone movement (in referring to an electrical equivalent of a mechanical system). This loading has the opposite reactive effect to what can be called "stiffness" loading. If the compression chamber **58** thus formed is closed too much, stiffness loading can result with an accompanying rise in the low frequency speaker system resonant point. However, by a proper amount of venting or opening of the sound passage around panel **51**, the low frequency resonance can be established at an optimum low value. The piston action of the speaker cone forces the air out of the sides of the compression chamber **58** through the spaces between frame **52** of panel **51** and the innermost of louvers **41**. This space, it should be noted, is somewhat narrower than the distance between the outer face of the baffle board **33** and the inner face of the compression panel **51**. Air is also forced out through the vent **55**.

The natural resonance of the low frequency loudspeaker vibratory system is moved substantially lower because of this mass loading, as compared to no loading or stiffness loading referred to above. This lowering of the resonance frequency is also accompanied by an amplitude reduction in electrical impedance of the speaker system at and near the resonant frequency. These two factors are illustrated in FIG. 5 wherein the solid line **61** shows the impedance characteristics of the system when unloaded by the compression panel **55**. The dotted line **62** shows the characteristics of the system with panel **51** in place. It will be seen that the resonant peak **62***a*, corresponding to the resonance peak **61***a* of curve **61**, is wider and lower. Also at the high frequency end of the curves it will be noted that curve **62** increases substantially less than curve **61**. The result is an overall lessening of the variation in impedance for the full audio frequency spectrum reproduced by speaker **32**. Thus, over the useful part of this acoustic spectrum, the loudspeaker presents a more uniform electrical load upon the associated amplifier **31**. Therefore, more undistorted electrical audio power is available. The booming one note bass effect is substantially reduced, and the Doppler effect resulting from the moving cone is also reduced due to the loading of the air mass. Furthermore, there is less harmonic distortion because the excursion of the speaker cone is less for high peak outputs of the amplifier **31**. This is also because of the damping effect of the air mass.

Referring to FIG. 6, a further effect of the improved system will be noted. The dark curve **71** represents the response characteristics of speaker **32** without panel **51** in place, and the dotted curve **72** represents the response characteristics of the system with panel **51** in place. It will be seen that as a result of the lowering and spreading out of the resonant frequency band due to pnael **51**, the lower end of the response curve is shifted further to the left for improved low frequency reproduction.

It will also be noted from FIG. 6 that at higher frequencies the response curve of speaker **32**, when mass loaded due to panel **51**, takes a considerable drop. This insures that any directional frequencies reproduced by

speaker **32** (which is positioned between the stereo speakers) will be at a sufficiently low level as to not detract from the stereophonic effect. Greater improved stereophonic channel separation results. To further effect this separation, the inner surface of panel **51** may be lined with an acoustic damping material to absorb higher frequencies. This also minimizes or eliminates low frequency Doppler modulation from speakers radiating in an adjacent spectrum range. The radiation vent **55** may be positioned in such a manner relative to the vibratory system so that the acoustic phases radiated over certain parts of the spectrum are such that cancellation will be obtained, further aiding in spectrum balance adjustment.

It has been found that as a general rule, between one and four square inches of opening should be left for every twenty-five cubic inches of enclosed volume in compression chamber **58**. In a system such as is shown, with the panel **51** spaced very colse to the speaker **32**, between 25% and 50% of the peripheral area of the enclosed chamber should be left open. A satisfactory construction of the invention has been accomplished in accordance with the design shown in the drawings, wherein the distance between the inner surface of panel **51** and the outer surface of baffle board **33** was 1¾ inches, and wherein the compression panel **51**, including frame **52**, measured 18¾ inches high and 25 inches wide. The volume of air enclosed should be determined from the size of the speaker, but where a 15 inch speaker was used for speaker **32**, the volume of the compression chamber **58** enclosed was approximately 820 cubic inches. The spaces **56** and **57** between the respective side edges of frame **52** and the innermost ones of louvers **41** was approximately 1 inch. Vent **55** was approximately ⅞ inch by 16¾ inches. The total open area, therefore, was approximately 52 square inches.

It may therefore be seen that the invention provides an improved and attractive speaker systems effecting improved channel separation in stereophonic systems and improved low frequency response. Distortion is substantially reduced, and a better impedance match between the driving amplifiers and the speaker system is also accomplished.

I claim:

1. A speaker system for increasing the low frequency response and improving stereophonic sound reproduction, including in combination, a cabinet having a baffle panel at the front thereof, said baffle panel having a speaker opening therein, a low frequency speaker disposed adjacent said baffle panel to emit sound through said opening thereof, a high frequency speaker disposed at each side of said low frequency speaker for reproducing stereophonic sound, said cabinet having an apertured back panel to permit free operation of said low frequency speaker, a solid compression panel having top, bottom and side edges and disposed in spaced relation from said baffle panel and in alignment with said low frequency speaker, means extending along the entire top edge of said panel to secure the same with respect to said baffle means, further means extending along the bottom edge of said compression panel to secure the same with respect to said baffle means, a portion of said cabinet extending in spaced relation along the side edges of said compression panel and spaced therefrom a distance less than the spacing between said compression panel and said baffle panel to define sound passages, the spacing between said baffle panel and said compression panel enclosing a volume of air to define a compression chamber, the compression chamber and the sound passages providing an effective loading of said low frequency speaker to increase the low frequency response thereof and decrease the high frequency response thereof so that said low frequency speaker emits reduced sound in the range of the high frequency speakers to improve stereophonic sound reproduction from said speaker system.

2. The speaker system of claim **1** in which the area

of the sound passages provides between one and four square inches of area for every 25 cubic inches of volume enclosed in said compression chamber.

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STEPHEN J. TOMSKY, *Primary Examiner.*