

March 17, 1953

J. E. PARKER
LOUD SPEAKER SYSTEM

2,632,055

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2 SHEETS—SHEET 1

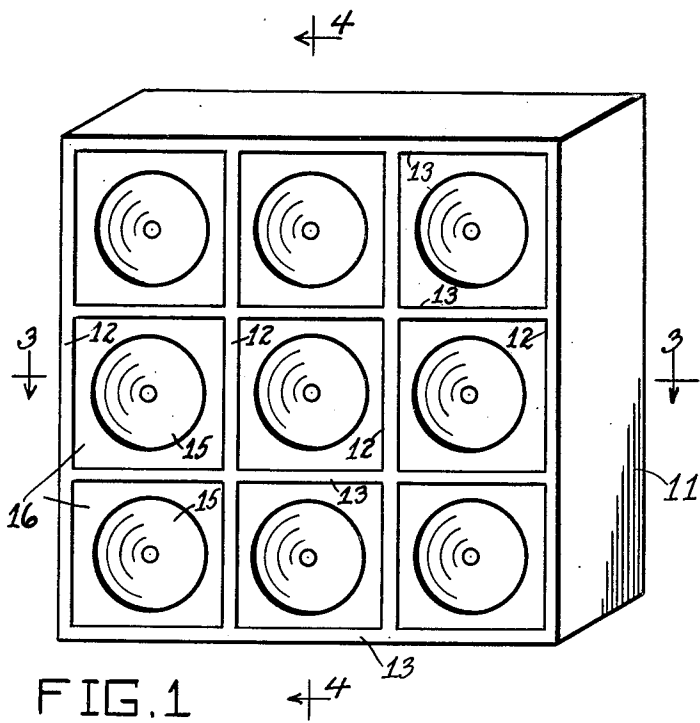


FIG. 1

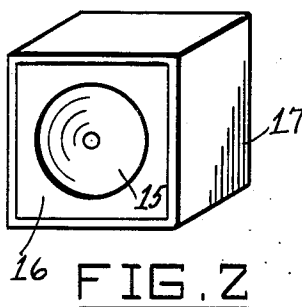


FIG. 2

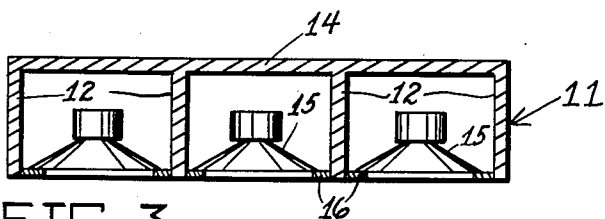


FIG. 3

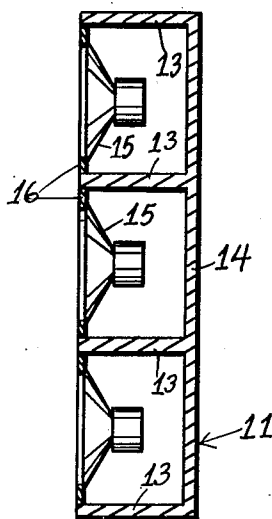


FIG. 4

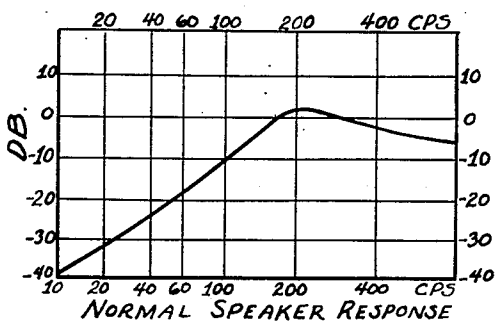


FIG. 5

Inventor

JOHN E. PARKER

By / Herman L. Gordon

ATTORNEY

March 17, 1953

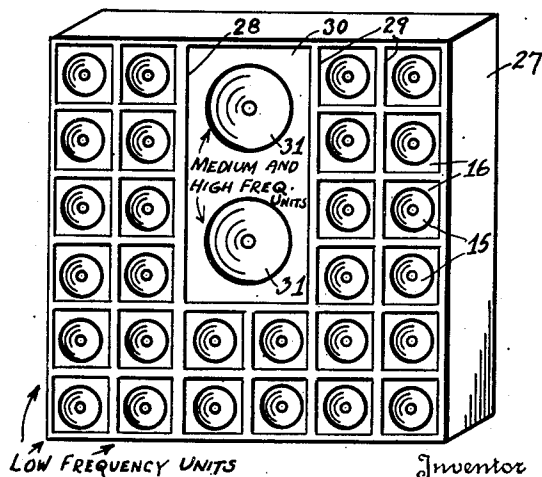
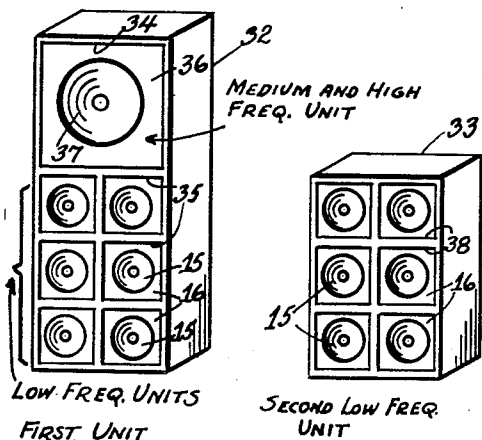
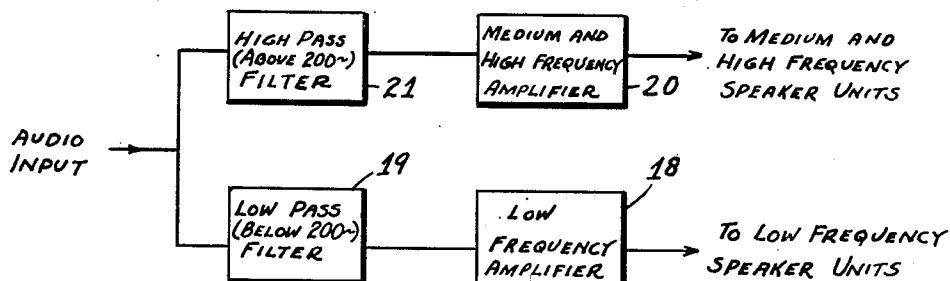
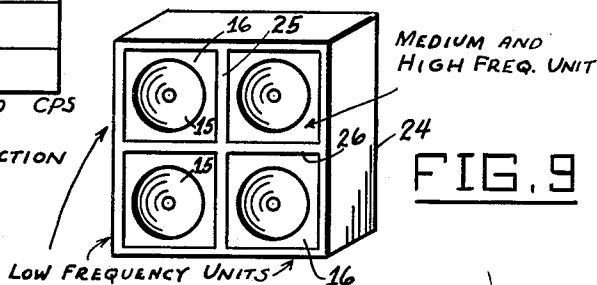
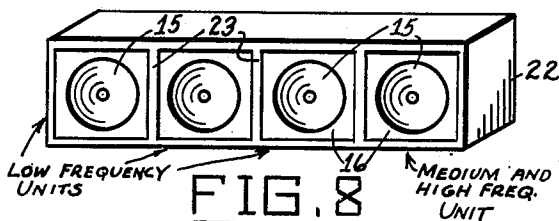
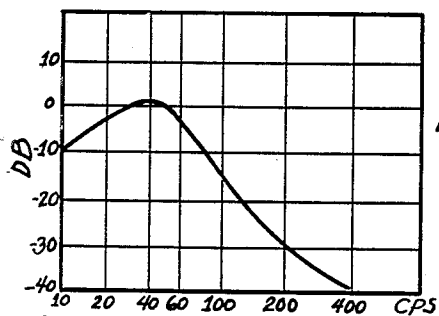
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LOUD SPEAKER SYSTEM

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2 SHEETS—SHEET 2



JOHN E. PARKER

Herman L. Gordon
ATTORNEY

UNITED STATES PATENT OFFICE

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LOUD SPEAKER SYSTEM

John E. Parker, Great Falls, Mont.

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10 Claims. (Cl. 179—1)

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This invention relates to loud speaker systems, and more particularly to systems employing multiple loud speaker units.

A main object of the invention is to provide a novel and improved loud speaker system which involves very simple components, provides accurate response, especially of low frequency tones, and which has very low intermodulation distortion.

A further object of the invention is to provide an improved loud speaker system which will reproduce fundamental tones as low as 20 cycles per second and which has a substantially flat response down to this low frequency, without the usual low frequency resonant peaks which are present when all the speaker units are operated above as well as below their resonant frequencies.

A still further object of the invention is to provide an improved loud speaker system which will reproduce very low frequency tones without the use of large cabinets or baffles, the system embodying the use of separate speakers of relatively small size for reproducing low tones, said speakers being operated below their natural resonant frequencies instead of above.

A still further object of the invention is to provide an improved loud speaker system of the type employing multiple speakers, wherein separate speaker units are employed for reproducing low frequency tones, each of the low frequency speakers being, in effect operated only below its natural mechanical resonant frequency, and wherein the operating range of the low frequency speaker units is also below their electrical resonance frequencies and below the resonance frequencies of the speaker enclosures.

A still further object of the invention is to provide an improved loud speaker system of the type employing multiple speakers and wherein separate speaker units are employed for reproducing low frequency tones, the speaker units being arranged in groups or cells in honeycomb fashion, and wherein a composite speaker is provided which has a high efficiency, has smooth low frequency response, and occupies only a small amount of space.

Further objects and advantages of the invention will become apparent from the following description and claims, and from the accompanying drawings, wherein:

Figure 1 is a perspective view of a composite loud speaker assembly constructed in accordance with the present invention.

Figure 2 is a perspective view of a single cellular speaker element,

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Figure 3 is a horizontal cross-sectional view taken on line 3—3 of Figure 1.

Figure 4 is a vertical cross-sectional view taken on line 4—4 of Figure 1.

5 Figure 5 is a chart representing graphically the normal response of a composite speaker assembly comprising a group of cellular units of the type illustrated in Figure 2, when arranged in the manner shown in Figure 1.

10 Figure 6 is a chart showing the response curve of a low frequency amplifier adapted to drive the low frequency speaker elements of a speaker system constructed in accordance with the present invention.

15 Figure 7 is a block diagram illustrating the electrical relationships of the various portions of a loud speaker system constructed according to this invention.

Figure 8 is a perspective view of a modified composite speaker assembly according to the present invention.

Figure 9 is a perspective view of another composite speaker assembly according to the present invention.

25 Figure 10 is a perspective view illustrating still another composite speaker assembly in accordance with this invention.

Figure 11 is a perspective view showing a pair of composite speaker assemblies which are constructed in accordance with the present invention, said assemblies being spaced apart physically but cooperating to produce improved low frequency reproduction in a given room or auditorium.

30 Referring to the drawings, and more particularly to Figures 1 to 4, 11 designates a cabinet, which, by way of example, is shown as being rectangular, and which is divided up into individual cells or enclosures by means of vertical partition walls 12 and horizontal partition walls 13. The cabinet 11 has a rear wall 14. Each of said cells contains a small loud speaker unit 15, suitably mounted on a baffle board 16 secured to the forward margins of the walls of the cell.

35 The structure of Figures 1, 3 and 4 may be built up of individual box-like units, such as shown at 17 in Figure 2. The speaker units may be arranged in the manner shown in Figure 1 or may have other arrangements such as those to be subsequently described.

40 Figure 5 is a graph illustrating the normal response of conventional small speaker units such as shown in Figure 2, when operated in small groups arranged in the manner shown generally in Figures 1, 3, 4 and in the other figures, such

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as Figures 8 and 9. From Figure 5, it will be seen that the response has a definite peak or maximum in the neighborhood of 200 cycles per second, the response dropping off sharply below this point, and the response above this point being more or less flat. This means that where all of the speakers of the assembly carry the same range of frequencies and are driven from an ordinary amplifier having substantially flat output, the sound output of the system will have a peak or resonance point in the neighborhood of 200 cycles, thereby producing a definite low frequency distortion effect wherein tones in the neighborhood of 200 cycles per second will appear to be accentuated. The resonance point will shift downwardly or upwardly depending upon whether more or less cellular units are employed in the assembly and also depending upon the manner in which the units are distributed and on the size and type of units employed.

The above described resonance effect is ordinarily due to the natural mechanical resonance of the speakers (resulting from the combination of cone or diaphragm and associated suspension conditions) to which may be added the electrical resonance of the speakers and the resonance of the speaker enclosures. Where small speaker units (and small cells) are employed, as above described, the resonance frequencies of the assembly are relatively high. For example, employing five-inch speakers in six-inch cubical enclosures, the overall resonance frequency for a group of three or four units is found to be about 200 cycles per second, as shown in Figure 5. In comparison to this, the resonance frequency of a large speaker in a large open-backed enclosure will be about 100 cycles per second. In the case of such a large speaker, this frequently shows up by a definite "boominess" in tone quality.

I have found that in order to obtain smooth low frequency response in a multi-cellular speaker assembly it is necessary to employ a number of small speakers and to operate a substantial percentage of the speakers solely in the range below the speaker resonance frequency (approximately 200 cycles per second) while the remainder of the speakers are operated above said resonance frequency. In effect, this means building up the response in the sound spectrum in the region below the resonance frequency, attenuating the resonance frequency, and using only sufficient units to reproduce in the region above the resonant frequency to provide the desired amount of medium and high frequency response. For a multi-cellular unit using small speakers, such as five-inch speakers in cubical enclosures, arranged as in Figures 1, 3 and 4, or in Figures 8 to 11, the low frequency speaker units are driven from an amplifier having a low frequency response opposite to that of the speakers, similar to that shown in Figure 6. This latter response curve may be obtained by employing a suitable low pass filter at the input of the low frequency amplifier, said filter being designed to attenuate the input signal to a very substantial degree in the neighborhood of 200 cycles per second and providing substantially complete attenuation at a frequency not far above 200 cycles per second, as shown in Figure 6. The attenuation at 200 cycles per second will then be sufficient to compensate for the speaker resonance, whereas the gain of the amplifier below 200 cycles per second will compensate for the low speaker response in this range.

As shown in Figure 7, the low frequency units of the multi-cellular assembly are driven by an

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amplifier 18 which is provided at its input with a low pass filter 19 having the attenuation characteristics above described. The medium and high frequency speaker units, on the other hand, are driven by an amplifier 20 which is provided at its input with a high pass filter 21 which is designed to cut off at between 150 and 170 cycles per second, and has relatively low response in the neighborhood of 200 cycles per second, the speaker resonance frequency.

The response of the medium and high frequency portion of the system is therefore relatively low in the region of the resonant frequency of the multi-cellular speaker assembly and is substantially normal above said region. The response of the low frequency portion of the system is relatively high in the region below said resonant frequency and is relatively low in the region of said resonant frequency. The overall response of the system is therefore relatively flat from a very low frequency, which may be as low as 20 cycles per second, to the normal upper frequency limit of fidelity of the speakers.

In the low frequency compensation, or "base-boost" methods heretofore employed in the systems of the prior art, no provision has been made for attenuating the resonance frequency of the speaker units, particularly the low frequency speaker units, and, as a result, the prior art systems, while extending the response to very low frequency values, have exhibited strong peaks in response in the region between 30 to 200 cycles. In some cases, these systems have been characterized by very heavy "boomy" and "barrel-tone" effects.

Speakers which have a high resonant frequency, such as small commercial speakers of the five-inch type, have a natural response curve which tapers down very rapidly at the low frequency end, as in Figure 5. In order to obtain satisfactory low frequency power output from such speakers, it is necessary to employ a number of them simultaneously and to operate them from an amplifier having the opposite characteristics, as shown in Figure 6. By employing the electrical arrangement of Figure 7 and using conventional high-pass and low-pass circuits having cut-off values approximating those indicated in Figure 7 at the input of the respective amplifiers 20 and 18, it is possible to obtain extended low frequency reproduction and very smooth low frequency response, using merely a number of the small speakers. By mounting the small speakers in a relatively shallow cabinet in cellular fashion, as is shown in Figures 1, 3 and 4, the effects of cabinet resonance are minimized, since the cabinet resonance frequency will be close to and will be attenuated in the same manner as the resonance frequency of the individual speakers themselves.

Figure 8 illustrates an arrangement of cellular speakers employed with the system of Figure 7, wherein an elongated closed rectangular cabinet 22 is employed, divided by suitable partition walls 23 into four identical cells. Each cell contains a small speaker 15, such as a conventional five-inch speaker, mounted on a baffle board 16 forming the front wall of the cell. The last speaker on the right, as viewed in Figure 8, is employed, in the system of Figure 7, to reproduce the medium and high frequencies. The remaining three speakers are employed to reproduce frequencies below the resonant frequency of the speakers, i. e., below approximately 200 cycles per second, and are driven by an amplifier such as the amplifier 18 having the low pass input filter 19.

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Figure 9 illustrates a substantially square closed cabinet 24 which is divided by the vertical and horizontal partition walls 25 and 26 into four square cells, each containing a small speaker 15 mounted on a baffle board 16. In Figure 9, the upper right hand speaker is employed to reproduce the medium and high sound frequencies, while the remaining speakers are driven only below the speaker resonant frequency, i. e., below approximately 200 cycles per second, in accordance with the arrangement of Figure 7. Except for the difference in spatial distribution of the sound output caused by the different spatial arrangement of the respective speakers, the response of the speaker assembly of Figure 9 will be generally similar to that of Figure 8.

In Figure 10, a large shallow closed rectangular cabinet 27 is employed, divided by suitable partition walls into an upper central rectangular cell, designated at 28, and a double row of small cells 29 flanking the sides and bottom of central cell 28. The central cell 28 has a baffle board 30 on which are mounted the relatively large speakers 31. Each of the small cells 29 has a baffle board 16 on which is mounted a small speaker 15. The composite speaker assembly of Figure 10 is driven by a system such as is disclosed in Figure 7, the large speakers 31 being driven from the output of the medium and high frequency amplifier 20, and the small speakers 15 being driven, solely below their resonant frequency, by the low frequency amplifier 18.

In the arrangement of Figure 11, a first unit, designated at 32, is employed together with a second unit 33. The unit 32 comprises a closed cabinet formed with a relatively large upper cell 34 and with six small lower cells 35, arranged in a double vertical bank below the upper cell. Upper cell 34 has a baffle board 36 on which is mounted a relatively large speaker 37. Each of the lower cells 35 is provided with a baffle board 16 on which is mounted a small speaker 15. The large speaker 37 is driven from the medium and high frequency amplifier 20 of Figure 7, whereas the small speakers 15 are driven, solely below their resonance frequency, by the low frequency amplifier 18. The second unit 33 comprises a closed rectangular cabinet divided into six square small cells 38, each cell 38 having a baffle board 16 on which is mounted a small speaker 15. The small speakers 15 of the second unit 33 are also driven, below their resonant frequency, from the low frequency amplifier 18.

The second unit 33 is physically spaced a few feet from the first unit 32 and acts to reinforce the low tones, providing a massive sound effect, especially desirable when the units are employed to reproduce the tones of electronic organs and the like. The sound effect thus obtained is similar to that of large pipe organs, as played in large cathedrals and theaters.

Small composite units such as shown in Figures 1, 8 and 9 are especially suitable for home use, as reproducers for radio receivers and phonographs. The larger units, as shown in Figures 10 and 11, are especially suited for use in theaters, auditoriums, churches, and other large assembly halls.

In each of the composite speaker units above described, the small low frequency speakers are operated only below their resonant frequency. Adequate sound output of the low frequencies is obtained by using a large number of low frequency speakers, as compared with the number of speakers employed for the medium and high sound frequencies. Since the effects of speaker

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resonance, as well as cabinet resonance, are substantially eliminated, the low frequency response is very smooth. At the same time, the overall response of the system can be made substantially flat from as low as 20 cycles per second to the upper normal limit of fidelity of the medium and high frequency speakers. Since the units are very shallow, the amount of floor space required therefor is very small. Furthermore, since the speakers are distributed over a large area, the spatial distribution of the sound output is more uniform than where a single speaker is employed.

While certain specific embodiments of multiple loud speaker units have been disclosed in the foregoing description, it will be understood that various modifications within the spirit of the invention may occur to those skilled in the art. Therefore it is intended that no limitations be placed on the invention except as defined by the scope of the appended claims.

What is claimed is:

1. A sound reproducing system comprising a relatively shallow closed housing, means dividing the housing into a plurality of cells, each cell having a baffle board as its front wall and being provided with a loud speaker located in the cell and mounted on said baffle board, certain of the speakers being similar and having natural fundamental resonant frequencies of approximately 200 cycles per second, a first amplifier, means connecting said certain speakers to the output of said first amplifier, a second amplifier, means connecting the remainder of the speakers to the output of said second amplifier, and means whereby said first amplifier passes only frequencies below 200 cycles per second.

2. A sound reproducing system comprising a relatively shallow closed housing, means dividing the housing into a plurality of identical cells, each cell having a baffle board and being provided with a relatively small loud speaker located in the cell and mounted on said baffle board, the speakers being substantially identical and having a natural fundamental resonant frequency in the neighborhood of 200 cycles per second, a first amplifier, means connecting certain of the speakers to the output of said first amplifier, a second amplifier, means connecting the remainder of the speakers to the output of the second amplifier, means whereby the first amplifier passes only frequencies below 200 cycles per second, and means whereby the second amplifier passes only frequencies above 200 cycles per second.

3. A sound reproducing system comprising a small loud speaker, a large loud speaker, audio input means, means connecting said audio input means to said loud speakers, means limiting the input to the small loud speaker to frequencies below the natural fundamental resonant frequency of said small loud speaker, and means limiting the input to the large loud speaker to frequencies above the natural fundamental resonant frequency of said small loud speaker.

4. A sound reproducing system comprising a first loud speaker, first audio input means, means connecting said audio input means to said first loud speaker, a second loud speaker, said loud speakers being substantially identical, second audio input means, means connecting said second audio input means to said second loud speaker, and means limiting said first audio input means to frequencies below the natural fundamental resonant frequency of the loud speakers.

5. A sound reproducing system comprising a

first loud speaker, first audio input means, means connecting the first audio input means to said first loud speaker, a second loud speaker, said loud speakers being substantially identical, second audio input means, means connecting said second audio input means to said second loud speaker, means limiting said first audio input means to frequencies below the natural fundamental resonant frequency of the loud speakers, and means limiting the second audio input means to frequencies above said natural fundamental resonant frequency.

6. In combination, a multicellular speaker assembly comprising a number of speakers mounted in individual cells, means driving a substantial percentage of the speakers mainly in the range below their natural resonant frequency, means driving the remainder of the speakers mainly in the range above said resonant frequency, and means attenuating said resonant frequency in the input to all of said speakers.

7. In combination, a multicellular speaker assembly comprising a number of small speakers mounted in individual cells, means driving a substantial percentage of the speakers mainly in the range below their natural resonant frequency, means driving the remainder of the speakers mainly in the range above said resonant frequency, and means attenuating said resonant frequency in the input to all of said speakers, whereby smooth extended low frequency response is obtained for the speaker assembly without emphasis of said resonant frequency.

8. In combination, a multicellular speaker assembly comprising a number of speakers mounted in individual cells, a first amplifier having a low frequency response substantially opposite to that of the speakers, means drivingly connecting said first amplifier to a substantial percentage of the speakers, means substantially confining said low frequency response to frequencies below the natural fundamental resonant frequency of said percentage of the speakers, a second amplifier, means drivingly connecting said second amplifier to the remainder of the speakers, and means whereby said second amplifier passes only frequencies above the natural

resonant fundamental frequency of the speakers driven by the first amplifier.

9. In combination, a multicellular speaker assembly comprising a number of speakers mounted in individual cells, a first amplifier, means drivingly connecting said first amplifier to a substantial percentage of the speakers, means whereby said first amplifier passes only frequencies below the fundamental resonant frequency of the speakers and attenuates said fundamental resonant frequency, a second amplifier, means drivingly connecting said second amplifier to the remainder of the speakers, and means whereby said second amplifier passes only frequencies above the fundamental resonant frequency of the speakers driven by the first amplifier.

10. In combination, a multicellular speaker assembly comprising a small speaker and a large speaker mounted in individual cells, the large speaker having a natural resonant frequency substantially below that of the small speaker, means driving the small speaker mainly in the range below the resonant frequency of the small speaker, and means driving the large speaker solely in the range above the resonant frequency of the small speaker, whereby the low frequency response of the system is provided by the small speaker, the natural resonant response of the large speaker is eliminated, and the medium and high frequency response of the system is provided by the large speaker.

JOHN E. PARKER.

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