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Thomasen

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[54] **TWO-WAY LOUDSPEAKER SYSTEM WITH TWO TANDEM-CONNECTED HIGH-RANGE SPEAKERS**

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[21] Appl. No.: **149,572**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 873,861, Nov. 4, 1969, abandoned.

[52] **U.S. Cl.** ..... **179/1 D**

[51] **Int. Cl.** **H04r 3/04**

[58] **Field of Search** ..... 179/1 D, 1 E, 1 GA, 1 G, 179/115.5 R, 181; 181/31.1, 32 A

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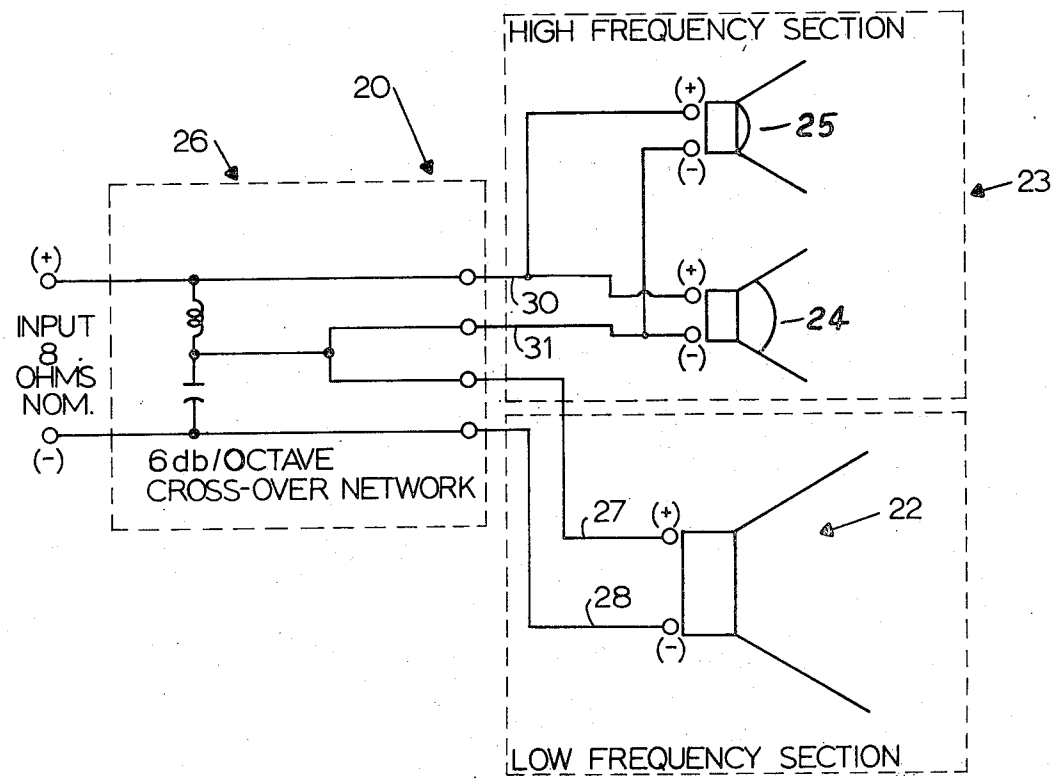
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[57] **ABSTRACT**

The high-frequency response and directional characteristics of a two-way loudspeaker system are improved by use of two specially differentiated nearly identical high-frequency speakers both identically connected in parallel to the crossover network. These two high frequency speakers are equally efficient in the region of their common high frequency assignment where their equal output is due to their equally constructed and exposed cone surfaces. However, they are unequal in efficiency in the higher region of the same common assignment where their unequallity in efficiency is due to a difference in the construction of the apex area of the speakers. The differences in efficiency of the two loudspeakers are such that their individual outputs are complementary and hence their combined output produces a substantially uniform level of acoustic output throughout their commonly assigned frequency range.

7 Claims, 9 Drawing Figures



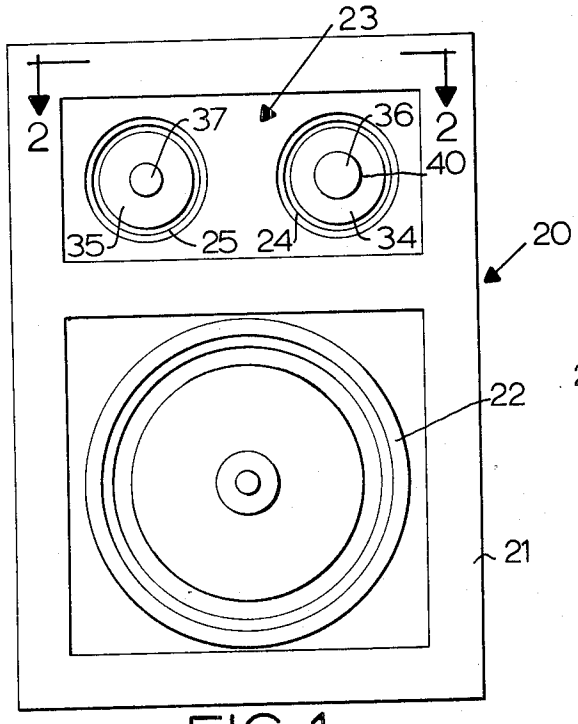


FIG. 1

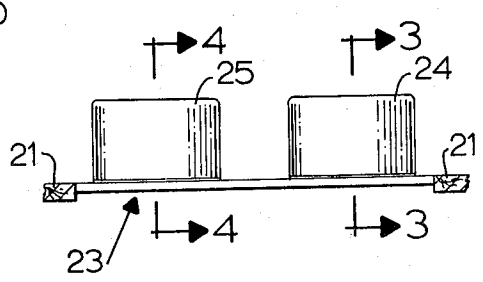


FIG. 2

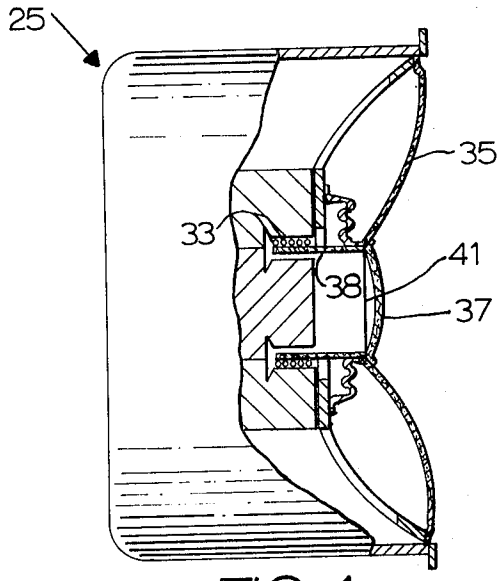


FIG. 4

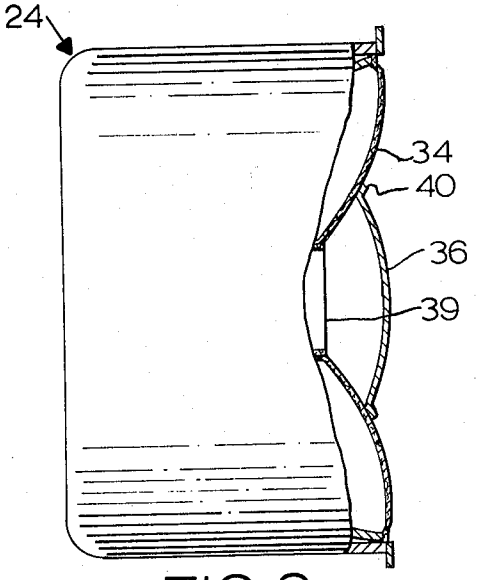


FIG. 3

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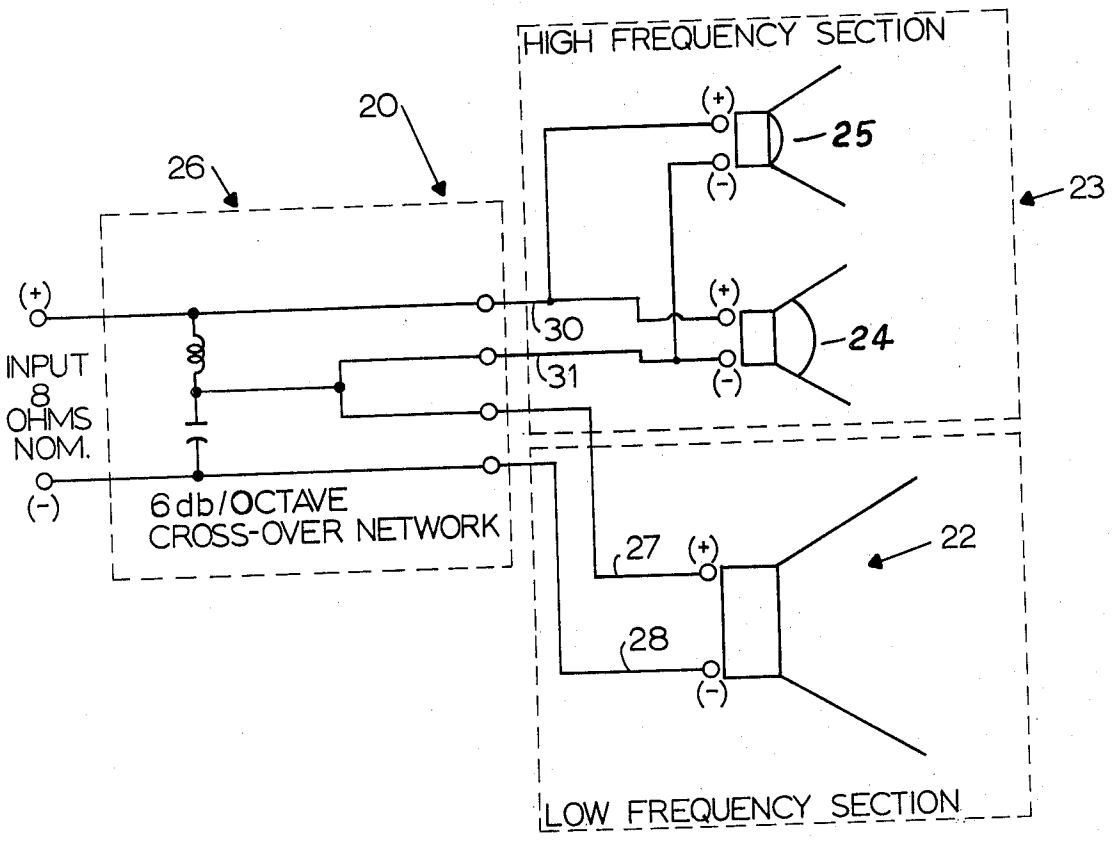


FIG. 5

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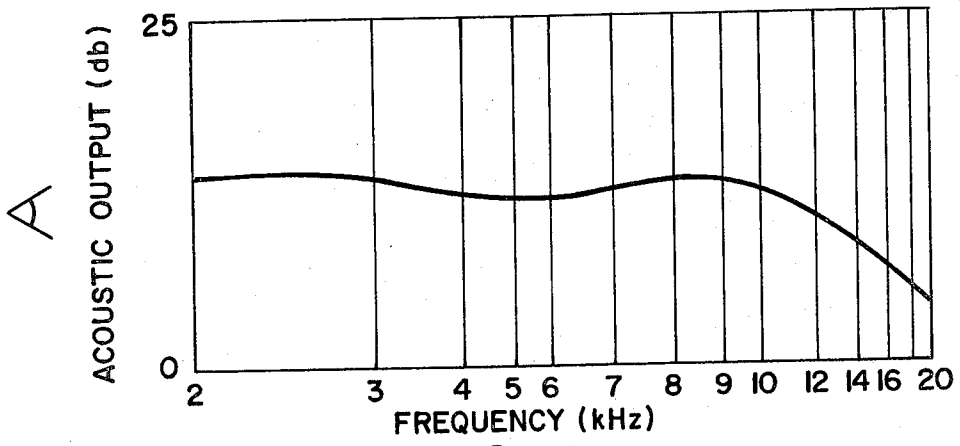


FIG_6

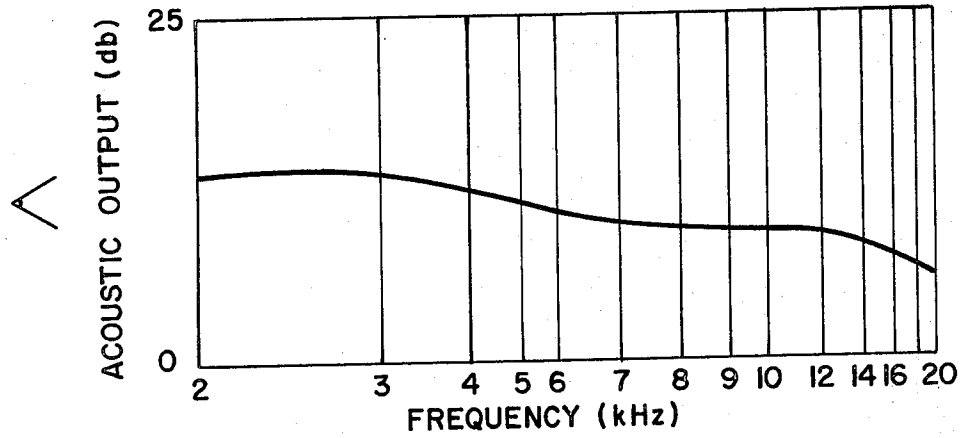


FIG_7

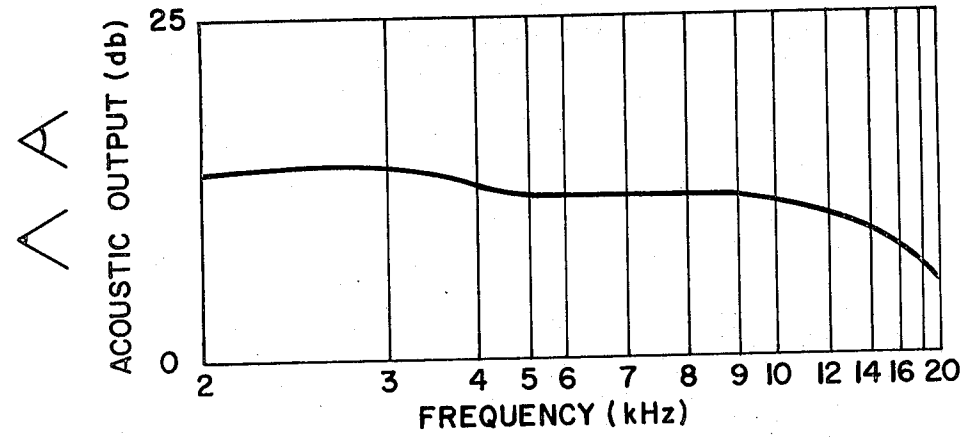


FIG_8

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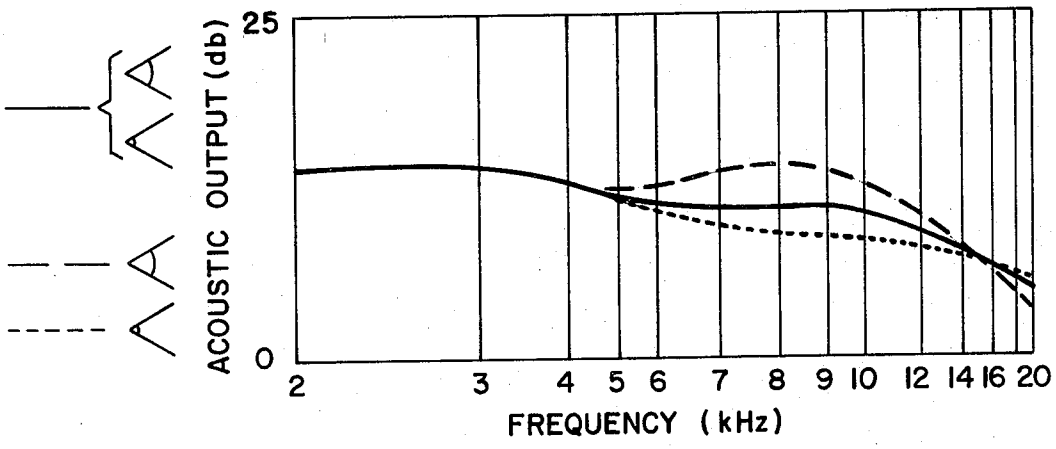


FIG_9

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TWO-WAY LOUDSPEAKER SYSTEM WITH TWO TANDEM-CONNECTED HIGH-RANGE SPEAKERS

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part of application Ser. No. 873,861, filed Nov. 4, 1969, now abandoned.

BACKGROUND OF THE INVENTION

This invention relates to electro-dynamic loudspeakers comprising curvilinear cone diaphragms and moving voice coils, specifically where such loudspeakers are employed to cover the high frequency range in two-way loudspeaker systems.

In the present state of the art, it is found that, within the frequency range of 40 HZ to 15 KHZ, a high degree of uniformity in response can be attained in audio recordings and related amplification equipment. In the actual reproduction of recorded sound, it is desirable, therefore, to employ loudspeaker systems whose response characteristics are equally uniform throughout this same frequency range.

Musical recordings take into account both direct as well as reflected sound waves, and since they are commonly played back in reverberant conditions to be found in a typical living room, the actual performance characteristics of loudspeaker systems are measured under reverberant conditions wherein reflected sound can be taken into account. Therefore, to determine objectively the essential parameters relative to any loudspeaker which is to be employed in a speaker system, its acoustic output is ideally measured in a reverberation chamber.

In consideration of these reverberant measuring conditions, it is well known that when a wide-range, high frequency dynamic loudspeaker, comprising a curvilinear cone and moving voice coil is measured to determine its total acoustical output in a reverberation chamber, a deficiency in its output is commonly found. For example, when a loudspeaker of such wide-range type is called upon to cover the frequency range of sound between 1.5 KHZ and 15 KHZ in a reverberation chamber, its acoustic output is usually shown to diminish gradually but progressively as the frequencies rise beyond 1.5 KHZ, and as sound energy decouples toward the apex area of its curvilinear cone. Such acoustic output losses are especially noticeable when this type of loudspeaker is called upon (either by itself or in a tandem arrangement with other loudspeakers identical to it) to cover the entire high-frequency range of 1.5 KHZ to 15 KHZ in a two-way system. Here, the loudspeaker must necessarily be of such size and construction that in order for it to respond efficiently with adequate output at its lower crossover frequency of 1.5 KHZ, its performance in the higher region of its assigned range is usually compromised. When such loudspeakers are employed to handle the high frequency range of 1.5 KHZ to 15 KHZ in two-way speaker systems, a noticeable loss in acoustic output often occurs in the higher frequency region of the system's audible coverage of sound. These acoustic output losses are generally attributable to limitations in the high-frequency loudspeaker's mechanical suspension. Being called upon to cover a wide frequency range, these loudspeakers must operate efficiently down to the lower crossover region of their assignment, and must therefore embody cone diaphragms that are suspended loosely enough to resonate freely at this lower frequency. At the same time, however, this loudspeaker must be called upon to respond with equal efficiency at much higher frequencies, and therefore much higher resonances.

It is therefore common practice to impregnate only the apex area of the cone of a wide-range loudspeaker with a stiffening agent. This is done to raise the loudspeaker's resonating properties only at its apex area, which is where its cone is usually not as responsive, and therefore not as efficient, in reacting to higher frequency vibratory motion.

It might be thought that by stiffening the loudspeaker's cone, the loudspeaker can be made to respond more efficiently, due to the stiffer suspension which is thereby introduced at its apex area. The loudspeaker's output performance might then be expected to show an improvement in its overall acoustic output capability, due to the relative differences in mechanical resonances that have been introduced between the outer area of the speaker's cone and its apex area. While this practice has some merit, its benefits are usually limited by the loudspeaker itself; that is, it does not overcome losses in output that are attributable to the relatively small conical apex area left available to propagate the higher region of its assigned range. Also, it can be seen that the apex area's attachment to the lower resonating properties found inherent in the loudspeaker's spider suspension is, by itself, an impediment to its high-end output capabilities.

Despite the fact that two-way speaker systems exhibit such progressive losses in acoustic output in the higher region of their operating range, they are generally agreed to be preferable over three and four-way systems. One reason for this preference is that speaker systems by and large tend to exhibit phase-shift distortion at each crossover transition frequency, whereas a two-way system minimizes this disadvantage by requiring only a single crossover transition. In addition, three and four way systems utilize a greater number of crossover network components, along with their attendant complexities. Also their separate loudspeakers are more varied in number and complexity, due to their basic construction, since their electrical values, size and type differ considerably from each other.

SUMMARY OF THE INVENTION

Accordingly, one of the objects of the present invention is to overcome, to a large extent, the acoustic output losses in two-way speaker systems. It provides improvements which make it possible for these systems to produce a smoother and more uniform level of acoustic output over their entire range. This is accomplished by utilizing two nearly identical wide-range high-frequency dynamic loudspeakers of the same basic type and size. These two speakers are operated in tandem with each other to cover the same high-frequency range in two-way systems. The improvement is made through a combination of differences in the mechanical construction, and therefore in the combined resonance properties of these two loudspeakers; but this improvement is made only where it is required — at the apex areas of their curvilinear cone diaphragms, so that a corresponding improvement in their combined acoustic output characteristics is obtained only where it is re-

quired — in the higher region of their common high-frequency assignment.

In one speaker only of this two-speaker high-frequency array, there is the usual dust cap positioned directly over the voice coil bobbin at the apex of its curvilinear cone. In the other one of these two speakers, however, there is no such usual dust cap over its voice coil, but instead there is located, axially onto and substantially covering its apex, a thin, light-weight dome, relatively larger, therefore, in diameter than the usual dust cap. This large dome is preferably made of aluminum.

The effect of this special two-speaker combination is that there are no changes made between them in their acoustic output in the lower region of their common frequency assignment — where their equal output is due to their cone surfaces being identically constructed and identically exposed. At their apex areas, however, the changes that are made between them in their construction and therefore in their acoustic output have a cooperative effect in overcoming, to a large extent, the lack of uniformity in acoustic output found common to such wide-range loudspeakers in the higher frequency region of their assigned range. Thus, through the combination of these two speakers, a more uniform level of acoustic output is obtained throughout their assigned range than would be possible from either of these two speakers operating alone over the same assigned range. Still other important effects are discussed below at a point where they can be better understood. In this manner, many benefits are obtained. They in fact serve to enhance the inherent advantages for which two-way systems are otherwise preferred.

A better understanding of the benefits to be obtained from this invention may be had from further descriptions and from references to the drawings.

In the drawings:

FIG. 1 is a view in front elevation of a two-way loudspeaker system embodying the principles of the present invention, the grille cloth being removed.

FIG. 2 is a view in section taken along the line 2—2 in FIG. 1.

FIG. 3 is an enlarged view mostly taken in side elevation and partly in section, along the line 3—3 in FIG. 2.

FIG. 4 is a view partly in side elevation and partly in section taken along the line 4—4 in FIG. 2.

FIG. 5 is a simplified circuit diagram of the relationship between the speakers of FIG. 1.

FIG. 6 is a representative description of a frequency-response curve plotted against decibels of acoustic output showing the output characteristics of the speaker of FIG. 3 as measured in a reverberation chamber.

FIG. 7 is another representative description of a frequency-response curve showing the output characteristics of the speaker of FIG. 4 as measured under the same reverberation chamber conditions.

FIG. 8 is another representative description of a frequency-response curve plotted against decibels of acoustic output of the two-speaker combination shown in FIG. 2 measured under the same conditions as for FIGS. 6 and 7.

FIG. 9 is a composite diagram of the frequency-response characteristics of the speakers in FIGS. 3 and 4 compared to the frequency-response characteristics of the two-speaker array in FIG. 2, where measurements for all of these curves are made under the same conditions in a reverberation chamber.

DESCRIPTION OF A PREFERRED EMBODIMENT

The loudspeaker assembly **20** shown in FIG. 1 comprises a suitable enclosure **21** in which is supported a two-way loudspeaker system, comprising a low-frequency speaker **22** and a two-speaker high-frequency array **23**. The low-frequency speaker **22** in this instance is a single loudspeaker of suitable low-frequency characteristics, while the high-frequency array **23** comprises a pair of speakers **24** and **25** which are identical except for the important differences which this invention introduces at their apex areas. The two speakers **24** and **25** are otherwise identical in size and construction throughout, including their voice coils **33.**

In FIG. **5** a crossover network **26** of the usual type for a two-way system is shown, its low-frequency range being transmitted by leads **27** and **28** to the low-frequency speaker **22** and its high-frequency range transmitted by leads **30** and **31** to the dual-speaker high-frequency array **23.**

The speakers **24** and **25** of FIG. **2** are connected in parallel to the crossover network **26** in FIG. **5.** These two speakers **24** and **25** are thereby driven together in the array in FIGS. **2** and **5** to cover the high-frequency range of the two-way loudspeaker system **20** in FIG. **1,** wherein a typical high-frequency range of 1.5 KHZ to 15 KHZ is to be handled.

Both speakers **24** and **25** embody identical curvilinear cones **34** and **35** and are equal to each other in size and construction throughout, with the exception that important differences in construction exist between them only at their apex areas. Therefore, the speakers **24** and **25** are equally efficient in that region of their common assignment where their acoustic output is affected by their equally constructed and equally disposed cone surfaces **34** and **35.**

The two speakers **24** and **25** have different efficiency only in that region of their common assignment where their acoustic output is affected by differences that are made to exist between them at their apex areas. The differences between the speakers **24** and **25** are confined to their apex areas. Thus, the two-speaker array **23** in FIG. **2** achieves a desirable two-speaker combination, wherein both speakers **24** and **25** are equally efficient in their lower frequency region, where no improvement in output uniformity is called for, but they are unequal in efficiency in their higher frequency region where an improvement in output uniformity is substantially required. By operating together in combination in the array **23,** these two speakers **24** and **25** provide a confluence of two different sound radiating sources. This two-speaker confluence in sound radiation is made so that the two speakers resonate differently only over that frequency region of their common high-frequency assignment where their acoustic output is affected by the differences in mechanical construction, and therefore by the resonance properties of their apex areas. These differences in construction and acoustic output between speakers **24** and **25** will be observed as follows:

In FIG. **2** the speaker **24** embodies a thin lightweight dome **36** (e.g., aluminum) positioned so that its circular line of contact **40** with the cone **34** (to which the

dome 36 is preferably connected) approximates the perimeter of the cone's apex area. A relative difference in resonant behavior, and therefore in acoustic output is thereby introduced between this speaker 24 which embodies a dome at its apex, and the other speaker 25, which does not embody a dome at its apex, but instead has only a typical paper dust cover 37. The positioning or contact line 40 for the dome 36 on the speaker 24 is suitable when the line 40 approximates the perimeter of the cone's apex; however the preferred positioning line 40 is, in this instance, determined objectively with the aid of plotted output measurements made independently for both speakers 24 and 25 in a reverberation chamber environment under equal conditions. The relative and appropriate difference in acoustic output between the speakers 24 and 25 is measured, and therefore determined under equal conditions. The sum of the difference in output between speakers 24 and 25 has a decided and favorable effect upon the total acoustic output which is simultaneously produced by both speakers 24 and 25, i.e., by the array 23. A pronounced increase in acoustic output is produced by one speaker 24 within the same frequency region where a pronounced and characteristic loss in output in exhibited by the other speaker 25. Then, since they are driven together in parallel in the dual-speaker array 23, their combined output characteristics are resolved as a level of output that is more uniform than that which can be produced independently by either speaker 24 or 25, under equal conditions.

FIG. 3 shows the speaker 24. The paper dust cap 37 of the speaker 25 (see FIG. 4) covering the voice coil bobbin 39 of the speaker 24 is replaced by a larger, yet lightweight dome 36. This lightweight dome 36 may be of thin aluminum or fiber material. In this instance, the position of contact between the aluminum done 36 and the speaker's cone 34 is made at a preferred circular line 40 at the cone's apex — which also describes the perimeter of the dome 36. Then, for this speaker 24, as the frequencies rise, sound energy decouples gradually and progressively toward the curvilinear cone's apex area. Sound energy approaches the circular line 40 describing the line of contact between the dome 36 with the cone 34. When this occurs, sound energy in that restricted frequency region which would normally respond to mechanical resonances found at this circular line 40 on the curvilinear cone's apex area, is now abruptly transferred onto a relatively larger radiating surface formed by the dome 36. By shifting sound energy in this manner from a small circular area on the cone 34 at the line 40 to a relatively larger radiating surface, the performance of the speaker 24 is characterized by an abrupt increase in its acoustic output. Accordingly, a peak in response is shown to occur in its independently plotted curve in FIG. 6, commencing at the same frequency where further losses in output would continue to occur if not arrested by the dome 36. Since both speakers 24 and 25 embody identical curvilinear cones, it is further seen that, as the frequencies rise, any difference in acoustic output between speakers 24 and 25 which first occurs will occur simultaneously. The actual frequency at which such differences in output are first made to occur depends upon preference for any given loudspeaker. Since loudspeakers vary as to the frequency at which their output losses become undesirable, the dome's contact line 40 should ultimately correspond to the frequency at which it is found desirable to arrest further continuance of high frequency losses.

It will be noted in FIG. 6 that the peak, or increase in output of the speaker 24, covers a wide and important region of audible sound, wherein a substantially uniform level of acoustic output is essential in the reverberation environment for adequate definition of a musical reproduction.

It will also be noted that this peak or increase in output produced by the dome 36 is naturally abrupt, and therefore the output of speaker 24 when operated by itself deviates from a substantially uniform level of output. However, when both the speakers 24 and 25 are driven together in the array 23, this abrupt peak in output is resolved as a smoother and more uniform curve by the nature of their combined differences in output, wherein a characteristic loss in output is exhibited by the speaker 25 over the same frequency region where an increase in output is produced by the speaker 24.

FIG. 4 shows the speaker 25 with its dust cap 37 covering its voice coil bobbin 41. No modifications are made on the speaker 25. Its curvilinear cone 35 is also retained conventionally exposed.

The overall acoustic output of this speaker 25 is measured in the reverberation chamber under the same conditions as for the speaker 24. Thus, its comparative efficiency at its apex area, as shown in FIG. 7, is plotted as a dip or loss in acoustic output. In FIG. 7, it is seen by comparison to FIG. 6 that this loss in output from the speaker 24 naturally occurs over the same frequency range where a peak or increase in output would otherwise be exhibited by it if a dome (such as the dome 36 on the speaker 24) were positioned at any preferred line of contact approximately describing the perimeter of the cone's apex area.

In accord with this invention, both speakers 24 and 25 are therefore connected in parallel to the high-frequency leads 30 and 31 so that together they cover the high-frequency range of the two-way system in FIG. 1. These two high-frequency speakers are mounted in a plane onto a flat baffle in the array 23 in FIG. 2. Their combined acoustic output, measured under the same conditions as for their independent measurements in FIG. 6 and FIG. 7, can be seen in FIG. 8 as their resultant response curve. Neither the abrupt peak of the speaker 24, shown in FIG. 6, nor the characteristic dip of the speaker 25, shown in FIG. 7 is evident.

It will be observed in FIG. 9 that the speaker 24 (embodying the dome 36) exhibits a loss at the very high limits of its range. This loss is caused by covering the innermost central area of the speaker's apex area with the dome 36. It is here where the cone 34 is most responsive to the very high-frequency limits of the speaker's useful range. This very high-frequency loss is compromised to some degree. However, this loss is accepted in favor of assuring the best performance in the more immediate and important frequency region lying below 15 KHZ, which, in turn substantially establishes the higher audible regions of the musical spectrum. Nevertheless, relative to this very high frequency loss, it is also shown in FIG. 9 that this loss is minimized by the greater contributing output of speaker 25 within the same higher limits, owing to the fact that it is driven in conjunction with speaker 24 in the two-speaker array 23 of FIG. 2. Thus, when both speakers 24 and 25 are operating together in the array 23 of FIG. 2, the dome 36, which is embodied on only one of two other-

wise identical speakers, is effectively utilized to compensate for inherent losses exhibited by the other speaker's conventionally exposed apex area. Since the dome **36** has its own independent disadvantages, the array **23** therefore obtains, simultaneously, the advantages of both speakers **24** and **25** and the drawbacks of neither. Accordingly, it is shown in FIG. **9** that the peak which is exhibited independently by the speaker **24** and the dip which is exhibited independently by the speaker **5** are resolved simultaneously in the array **23** as a substantially uniform level of acoustic output.

Through this invention, a smoother overall performance level is obtained throughout the high-frequency range of two-way loudspeaker systems, where undue non-uniformity in acoustic output is attributable to the inadequate mechanical construction at the apex area of dynamic, wide-range, high-frequency loudspeakers, embodying curvilinear cone diaphragms and moving voice coils.

Other benefits from this invention are obtained. For one thing, a single crossover transition minimizes crossover network phase-shift distortion. For another, the additional electrical components and their costs required in three and four way systems to produce an equivalent uniform performance level are eliminated. A reduction in cost is therefore realized, while actually improving, not only the frequency-response capabilities of two-way systems, but also their polar response capabilities, as follows:

Sound waves in the higher frequencies are directional and therefore have a beaming effect. It is important, therefore, to provide some means of broadening the dispersion pattern of speaker systems in the higher frequencies of sound.

Attempts are frequently made in the design of two-way systems to improve their dispersion pattern in the high-frequency range. One common practice that is used to improve their high-frequency dispersion pattern is to employ a plurality of high-frequency speakers mounted at different angles from each other. Their common high-frequency assignment is therefore radiated at varying angles throughout the listening area. However, there are many disadvantages in mounting such a plurality of speakers at different angles. One disadvantage is that it imposes the necessity of deviating from a flat baffle, which is a common and economical embodiment for direct frontal radiation of sound. Thus, since a flat baffle lends itself easily to common usage in cabinetry and speaker enclosures at minimal cost, angular mounting of loudspeakers to provide broader angular sound radiation loses the benefits obtained from a flat baffle. In addition to providing greater uniformity in acoustic output over a wider range, the two-speaker array **23** of this invention retains the benefits obtained from a flat baffle and at the same time makes it possible to broaden the dispersion pattern in the high-frequency range of two-way loudspeaker systems. The differences in construction between the speakers **24** and **25** are confined to their apex areas; therefore these two speakers **24** and **25** remain basically the same. Accordingly, their efficiency and polar response remain the same over that region of their common assignment where sound energy is not affected by their differences. However, by the nature of their differences in construction at their apex areas, the two speakers **24** and **25** radiate the higher region of their common assignment through two different, but combined angles of dispersion. This restricted region of their assignment is also the region where their differences in dispersion are attributable to their differences in construction. Since the well-known beaming effect becomes more acute as the frequencies rise, it is seen as advantageous to provide more than a single and unique angle of dispersion for that higher region of sound which is disposed by higher resonances to emanate from the apex area of a speaker's cone. Thus, the sharp conical section at the apex area of the speaker **25** is shaped like a megaphone. As such, it acts as a megaphone to hinder high-frequency dispersion by directing sound in a tightly beamed pattern. This effect is minimized in the more forward-looking dome **36** on the speaker **24.** Thus, an improvement in dispersion is accomplished without varying the basic construction of either speaker **24** or **25.** Also, the improvement in dispersion is accomplished without compromising a uniform level of acoustic output throughout their commonly assigned frequency range.

To those skilled in the art to which this invention relates, many changes in construction and widely differing embodiments and applications of the invention will suggest themselves without departing from the spirit and scope of the invention. The disclosures and the description herein are purely illustrative and are not intended to be in any sense limiting.

I claim:

1. In a two-way loudspeaker system of the type having a crossover network to divide the loudspeaker systems entire frequency coverage between a low-frequency speaker and high-frequency speaker means, the improvement wherein said high-frequency speaker means comprises

a two-speaker array incorporating two basically identical wide-range dynamic loudspeakers, each having a curvilinear cone with a voice coil coaxial with the apex of the cone, said loudspeakers being equal to each other in size and construction throughout,

with the exception that in one of them a dust cap covers the voice coil at the apex area, and that in the other loudspeaker there is no dust cap there, but instead there are means for shifting sound energy from a small circular area to a relatively large radiating surface to produce an abrupt increase in acoustic output in said other loudspeaker in a restricted frequency range, said means comprising a thin lightweight dome which covers the voice coil at the apex area,

said dome being positioned so that its perimeter makes contact with the curvilinear cone at a circular line describing the approximate perimeter of its apex area to transfer onto the dome the sound energy in said restricted frequency range which would normally respond to mechanical resonances found at said circular line,

the speaker having the dust cap cover having the entire radiating surface of its curvilinear cone exposed, said dust cap being attached directly over its said voice coil,

the two speakers forming the two-speaker array being connected in parallel so that both speakers are driven together simultaneously to cover the same high-frequency range assignment in said two-way loudspeaker system,

said two speakers of said array being equally efficient in that region of their common high frequency assignment where their equal output is affected by their equally constructed and equally exposed cone surfaces, but being unequal in efficiency in the higher region of this same common assignment where their differences in output are due to the stated differences in construction at their apex areas such that the individual outputs of said high-frequency speakers are complementary and their combined output produces a substantially uniform level of acoustic output throughout their commonly assigned frequency range.

2. The loudspeaker system of claim 1 wherein said dome is thin lightweight aluminum.

3. The loudspeaker system of claim 2 wherein the perimeter of the aluminum dome is positioned at the circular line which substantially describes the perimeter of the apex area of its said speaker's curvilinear cone, whereby said domed speaker produces a relative increase in its acoustic output over the same frequency region where the other said speaker in said two-speaker array exhibits a loss in output, the circular line of contact being made between the thin lightweight dome and curvilinear cone of one of these two speakers at the locus where it simultaneously arrests any further undue losses in acoustic output and resolves any undue peak in output as may be due principally to inadequacies in the resonating properties at the apex areas of either of the two speakers, thereby establishing a total level of acoustic output from both speakers that is substantially more uniform than either of the two speakers in said two-speaker array can produce independently throughout the same high-frequency assignment.

4. An improved two-speaker high-frequency array, comprising

two wide-range dynamic loudspeakers, driven together and connected in parallel to cover the same high-frequency range assignment in a two-way loudspeaker system,

each said loudspeaker in said array having a curvilinear cone and a moving voice coil coaxial with the apex of said cone, both said loudspeakers being identical in size and construction throughout, with the exception that only one of these two speakers has a centrally located paper dust cap and the other one only utilizes a thin lightweight dome, larger in size than said centrally located dust cap, which it replaces in that speaker,

said dome being forward-looking in shape and being positioned to substantially cover the sharp conical section at the apex area of this speaker's curvilinear cone, whereas the first named said loudspeaker of said two-speaker array has no such dome and its said dust cap lies directly over its said voice coil, this loudspeaker's entire curvilinear cone being exposed,

said two loudspeakers being different in construction only at their apex areas, with the result that their polar responses differ from each other only in that higher frequency region of their common assignment where their acoustic output is affected by their differences in construction at their apex areas,

thus establishing two separate but combined angular patterns of sound radiation emanating from the combination of the dome at the apex of one said loudspeaker and the sharp angular section of the exposed apex area of the other said loudspeaker,

their dispersion pattern as well as the efficiency of said two loudspeakers remaining equal to each other in the region of their common assignment where their acoustic output is affected by their identically exposed curvilinear cone surfaces, but their dispersion patterns and their efficiency being different from each other only in the higher region of their common assignment where their acoustic output is affected by differences in construction that exist between them at their apex areas,

whereby the individual outputs of said high-frequency speakers are complementary and their combined output produces a substantially uniform level of acoustic output throughout their commonly assigned frequency range.

5. The high-frequency array of claim 4 wherein said thin lightweight dome is positioned at a circular perimeter line of contact describing within it the greater part of the apex area of its said loudspeaker's curvilinear cone, thereby causing its said loudspeaker to produce an increase in output in its independent operation resulting from the dome's position,

whereas the other speaker of said high-frequency array, having no dome at the apex of its curvilinear cone, exhibits a characteristic loss in output in its independent operation;

the increase in output caused by the dome of one said loudspeaker occurring over the same frequency range as when a loss in output is exhibited by the other speaker's exposed and less efficient conical apex area,

whereby through the combination of the independent characteristics of both said loudspeakers a confluence of two sound radiating sources produces a smoother level of acoustic output as well as a broader pattern of dispersion than either of these two loudspeakers could produce independently within the same frequency range under equal conditions.

6. The two-speaker high-frequency array of claim 4 wherein both said loudspeakers are mounted in a plane on a flat baffle, so that sound waves emanating from their identically exposed and identically constructed cone surfaces are simultaneously radiated in substantially identical angular patterns, whereas the sound waves emanating from their differently exposed and differently constructed apex areas are simultaneously radiated in substantially different angular patterns.

7. The two-speaker high-frequency array of claim 4 wherein both said loudspeakers are identically constructed except at their apex areas thereby retaining equal efficiency, equal polar response, and equal frequency response for both speakers in the lower frequency region of their common assignment, where all of these performance characteristics for both of these loudspeakers are adequate, but wherein the unique differences at their apex areas distinguish them differently from each other in their efficiency, polar response, and frequency response for the higher region of their common frequency assignment where their adequate performance is dependent only upon differences made in construction between them as are required and as are therefore confined to their apex areas.

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