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SOUND REPRODUCING DEVICES

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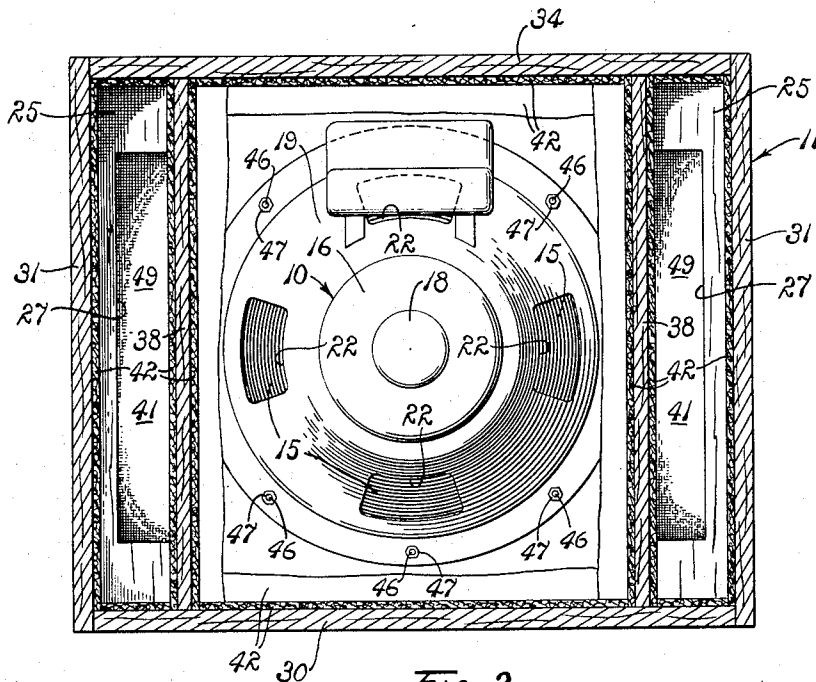


FIG. 3.

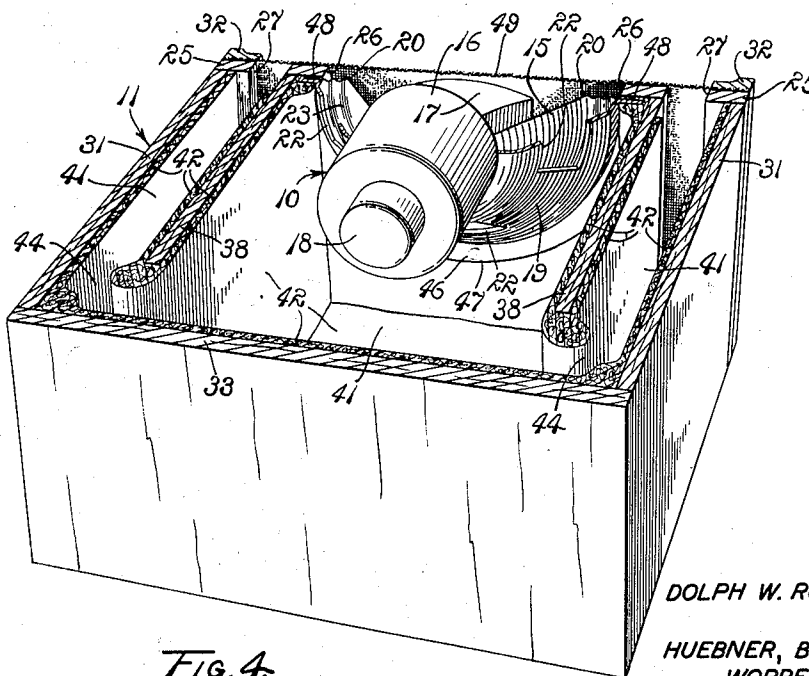


FIG. 4.

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SOUND REPRODUCING DEVICES

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9 Claims. (Cl. 181—31)

The present invention relates to sound reproducing devices and more particularly to a speaker and enclosure therefor having improved sound reproducing characteristics.

The desirability of high fidelity sound reproduction has long been recognized and much effort has been expended in improving the performance characteristics of radios, phonographs, audio portions of television sets, amplifiers and the like. While marked progress has been made in improving the electrical systems involved so as to deliver current to speakers with a minimum of distortion and interference, it has now been discovered that the speakers and their enclosures themselves are sources of considerable distortion and interference precluding the attainment of high fidelity no matter how perfected the associated electrical systems.

The final step in sound reproduction usually involves the vibration at controlled frequencies and amplitudes, of a sound producing member, such as a diaphragm, speaker cone, or the like. Whether the associated electrical systems are amplitude or frequency modulated in response to intelligence impressed upon a carrier wave, the sound producing member is vibrated by electromagnetic actuation, with the volume regulated by controlling the extent of vibration of the sound producing member, and the pitch of the reproduced sound regulated by control of the frequency of vibration. The actual movement of the sound producing member is thus a complex, continually changing composite of periodic and aperiodic waves of individually varied magnitude dependent upon the sound to be reproduced.

The vibrated sound producing members are frequently frusto-conical in form to give direction to the reproduced sound projected from within the frusto-conical member and incidentally to disperse sound from the opposite side thereof. The two projected sounds, the desired from the front of the member and the undesired from the rear thereof, interfere to such an extent that high fidelity has heretofore been difficult or impossible to achieve.

Previous efforts to correct the described sound interferences and distortion have generally involved either of two approaches to the problem. Effort has been made to create substantially equal and opposite sound waves and to utilize such waves to destroy the undesirable sound waves emanating from the rearward side of sound members. Devices of this type are intricate and complex and have not succeeded in minimizing to any major extent interference and distortion of the character described. Additionally, in the infrequently encountered environments in which abundant space is available, enclosures have been made for speakers having vibrated sound reproducing members, which completely enclosed the speakers except for the forward side thereof. Such enclosures have been air tight and provided with baffles or sound absorbing materials so as to reduce to substantial inaudibility sound coming from the back of the speakers.

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Such devices have been somewhat successful but are limited to use where space is abundant. It is generally considered that to be fully effective a chamber containing approximately 1,000 cubic feet of dead air space is required. Obviously, there are very few operational environments in which a cubical chamber ten feet long on each side can be tolerated. If the closed chambers are much smaller than that described, the associated speakers have very poor transient response, being unable to accommodate sudden large excursions of the vibratory member of the speaker. The pressure or vacuum created by the vibrating member of the speaker dampens or restricts the free actuation thereof.

Sound deadening chambers capable of absorbing substantially all rearwardly directed sound waves emanating from speakers have been referred to as infinite baffles and as noted above under known practices require great size in order to absorb the undesirable sounds from speakers of sizes popular for household use. When such chambers have heretofore been employed, but of a size practical for household use, they have been unsatisfactory. For example, they usually are subject to one or more points of resonance, have inadequate low frequency response, impede transient response by back pressure on the speaker, induce severe phase distortion, are subject to serious harmonic distortion, lack smooth frequency response, and/or generate spurious frequencies which are neither odd nor even harmonics of frequencies whose reproduction is desired.

The essence of the present invention resides in the discovery that a relatively small compact enclosure can be provided which does not interfere with speaker operation but which effectively reduces to inaudibility the undesirable sounds projected from the rear of the speaker and in this manner avoids interference incident thereto.

An object of the present invention is to make possible the improved fidelity of sound reproduction in amplifiers, radios, television sets and the like.

Another object is to provide an improved speaker and enclosure combination.

Another object is to reduce to inaudibility sound projected from one side of a vibrated sound producing member without interfering with sound produced by the opposite side thereof.

Another object is to attain the approximate operational characteristics of an infinite baffle in a speaker enclosure which is compact, simple, economical, and fully effective in performing its intended function.

Further objects and advantages will become apparent in the subsequent description in the specification.

In the drawings:

Fig. 1 is a perspective of a speaker and enclosure embodying the principles of the present invention.

Fig. 2 is a horizontal section of the structure shown in Fig. 1 taken on a plane represented by the intersecting line 2—2 therein.

Fig. 3 is a transverse section of the structure taken at the position represented by line 3—3 in Fig. 2.

Fig. 4 is a sectional perspective of the structure divided in a plane of reference corresponding to the sectioning plane of Fig. 1 and viewed obliquely from the rear.

Referring in greater particularity to the drawings:

A speaker of well-known form is indicated generally at 10 mounted in an enclosure 11 embodying the principles of the present invention.

Considering first the elements of the speaker 10, it will be noted that a frusto-conical sound producing member, or cone, 15 is employed. The cone is vibrated axially in the well-known manner by a low frequency speaker unit 16 containing actuating electromagnetic

means, not shown, responsive to comparatively low frequency pulses of electrical current. A tweeter or high frequency horn 17 is optionally provided concentrically of the cone 15 and vibrated axially of the cone by a high frequency actuating unit 18. The present invention is not concerned with the high frequency horn, its actuating unit, nor other specific detailed speaker construction, these elements being shown as optional auxiliary equipment usually utilized where high fidelity is desired. In rearwardly spaced relation to the cone 15, a frusto-conical bracket 19 is provided having an end 20 of major diameter concentric to the end of major diameter of the cone 15 and an end 21 of minor diameter connected in supporting relation to the low frequency speaker unit 16 also in concentric relation to the cone. It will be noted that air passages 22 are provided through the bracket 19 which have an aggregate area substantially one-third of the cross-sectional area of the end of major diameter of the cone 15. While the described speaker and relationship of the air passages 22 to the end of major diameter of the cone 15 are well known and detailed consideration of speaker design beyond the province of this description, the existence of the bracket 19 and of the air passages 22 is of such significance to the subsequent description as to warrant comment.

If no passages are provided through the bracket 19, an air pocket 23 is formed which so cushions the cone that movement thereof is impeded and smooth frequency response and realistic transient response are precluded. Conversely, if no such bracket is employed and the rearward side of the cone entirely exposed, a desirable minor dampening effect of the air cushion 23 is avoided and distortion incurred usually of harmonic nature although oftentimes including spurious frequencies. At any rate, the total area of the air passages 22 usually approximates one-third the cross-sectional area of the end of major diameter of the cone 15 and it is sufficient at this point to observe that the present invention bears a significant relationship to the column or columns of air set in motion rearwardly of the cone 15, which columns are of cross-sectional area corresponding to the aggregate cross-sectional areas of the passages, whatever they may be.

The enclosure 11 takes the form of a housing for the speaker of any desired external form or dimensions consistent with the following description of the parts employed. The enclosure has a forward panel or wall 25 providing a circular opening 26 therein of substantially the same diameter as the end of major diameter of the speaker cone 15. On opposite sides of the opening 26 are provided venting slots 27. For reasons subsequently described, the slots have a total area substantially equal to the total area of the air passages 22.

The forward panel 25 is rigidly mounted on a base panel 30 which conveniently takes the form of a support for the enclosure 11, a shelf in a cabinet, or the like. A pair of side panels 31 are rigidly mounted on the base panel 30 outwardly adjacent to the slots 27 and upwardly extended in substantially parallel relation adjacent to the slots. The side panels abut and are secured to the forward panel. A molding 32 is preferably mounted about the marginal edge of the forward panel for decorative effect and for a functional purpose subsequently described. A substantially impervious rearward panel 33 is rigidly mounted on the base panel and upwardly extended therefrom along rearward edges of the side panels 31 to which the rearward panel is securely affixed. A top panel 34 is fitted between upper edges of the forward panel 25, side panels 31 and rearward panel 33. In the form of the enclosure shown, the base panel 30, side panels 31, and top panel 34 are in rectangular relation in a reference plane parallel to the forward panel 25. Somewhat similarly, the base panel 30, forward panel 25, top panel 34, and rearward panel 33 are in rectangular relation in a reference plane parallel to the side panels 31. Also, the forward panel 25, side panels 31, and rear-

ward panel 33 are in rectangular relation in a reference plane parallel to the base panel 30. While such rectangular relationship is generally preferred for ease of construction and convenience of embodiment in a console or other article of furniture, it will readily occur to those skilled in the art that the enclosure may take innumerable other forms without departing from the spirit or the scope of the present invention.

A pair of substantially parallel partitions 38 interconnect the base panel 30 and the top panel 34 inwardly adjacent to the slots 27, have forward edges 39 connected to the forward panel, and rearward edges 40 in spaced parallel relation to the rearward panel 33. It will be noted that the partitions define a divided air duct 41 extended rearwardly from the speaker 10 to form a first chamber of the duct as defined by the partitions 38, base panel 30, and top panel 34, and which is return bent about the rearward edges 40 of the partitions and forwardly extended to form second chambers of the duct as defined by each partition, its adjacent side panel 31, base panel 30, and top panel 34, to the venting slots 27. As shown, the surfaces of the partitions and panels defining the air duct 41 disposed inwardly of said duct are coated with any suitable sound absorbing material 42 such as rock wool, Fiberglas, cellulose, padding, or other suitable material, many forms of which are well known for sound absorbing purposes. The sound absorbing material is adhesively affixed or otherwise secured to the surfaces coated.

It will be noted that the sound absorbing material 42 is provided in increased thickness at the rearward edges of the partitions and in the corners defined between the rearward panel 33 and the side panels 31. Such location of the material provides a constriction, indicated at 44, oriented so that the cross section thereof is oblique to both the rearwardly and forwardly extended portions of the air duct 41. The constrictions are of substantially the same height as the slots 27 and approximately the same width thereof. Thus, at no point in the duct 41 is the total cross-sectional area of the duct, whether in its unitary rearwardly extended portion or in its divided forwardly extended portion, appreciably less than the area of the air passages 22 in the bracket 19. The cross-sectional area of each constriction 44 is, of course, less than the cross-sectional area of the first duct chamber while each second duct chamber is greater in cross-sectional area than its associated slot. In effect, therefore, the first chamber and constriction and each second chamber and associated slot constitute a pair of inverted, series connected megaphones which provide a continuous unimpeded path through which the rearward side of the speaker 10 exhausts.

The speaker 10 is mounted in the enclosure 11 in the usual manner, as by bolts 46 extended through the forward panel 25 and the forward portion of the bracket 19. Nuts 47 screw-threadably mounted on the bolts serve dependably to hold the bracket and speaker in place. As is the usual custom, an annular resilient cushion 48 is provided between the end of major diameter of the cone 15 and the forward panel to accommodate axial vibration of the cone. The cone is juxtapositioned to the opening 26 and for purposes of appearance, the opening overlaid with a porous screening cloth 49 or the like. The molding 32 overlies the screening cloth and holds the same in position.

Operation

The operation of the device of the present invention is believed to be clearly apparent and is briefly summarized at this point. As the cone 15 and the high frequency horn 17 are actuated in the well-known manner, desired sound waves are projected through the opening 26. The undesirable and interfering sound waves which are projected rearwardly from the cone are to a minor extent dampened by the bracket 19 but in major extent result in the vibration of columns of air extended through

the passages 22. These are the sound waves previously referred to as normally precluding high fidelity sound reproduction. The instant invention makes possible the reduction of these sound waves to inaudibility without the concomitant disadvantage of subjecting the cone to back pressure and resultant distortion.

As the sound waves passing rearwardly through the passages 22 move through the duct 41 they are progressively reduced in magnitude by sound energy absorption by the side walls and upon striking the sound absorbing material 42 on the rearward panel 33, absorbed to a major extent. Further, the material precludes the reflection of the sound forwardly to interfere with the desired tones resulting from cone or horn vibration. The undesired sound waves passing obliquely from the rearward panel 33 through the constrictions 44 are further reduced in magnitude and effectively rendered inaudible as they pass to the venting slots 27. In addition to absorbing substantially all of the undesired sound waves, no appreciable back pressure is imposed upon the cone and even air displaced by major excursions of the cone moves with unimpeded freedom to or from the venting slots 27. In this manner, undesired dampening of the movement of the cone is avoided.

In actual practice, the device of the present invention has made possible the reduction to inaudibility, and thus the obviation of interference from, rearwardly projected sound waves emanating from the speaker. For example, enclosures of popular household size in which the length of the rearward panel is approximately 24 inches, the height of the side panels 20 inches, and the width of the base panel 20 inches, the excellence of sound reproduction has equaled or surpassed the employment of the same speaker in sound deadening chambers of cubical form 10 feet in height. Thus, high fidelity sound reproduction has been made possible in practical household sizes of speaker enclosures as good as the best results previously attainable where no space limitations were encountered.

Although the invention has been herein shown and described in what is conceived to be the most practical and preferred embodiment, it is recognized that departures may be made therefrom within the scope of the invention, which is not to be limited to the details disclosed herein but is to be accorded the full scope of the claims so as to embrace any and all equivalent devices and apparatus.

Having described my invention, what I claim as new and desire to secure by Letters Patent is:

1. In combination with a speaker having a vibratory sound producing member providing a forward side and a rearward side; a housing having a panel providing a speaker opening therein; means mounting the speaker in the housing with the forward side of the sound producing member juxtapositioned to the speaker opening of the housing, said means being in spaced adjacent relation to the rearward side of the sound producing member and including a wall having air passages of predetermined cross-sectional area therethrough; means within the housing cooperating with the housing to form a conduit having a rearwardly extended end connected to the rearward side of the sound producing member, enclosing the speaker mounting means, and having reversely bent forwardly extended open opposite ends opening adjacent to the speaker opening, and sound absorbent material internally covering the walls of the conduit and forming constrictions therein between the rearwardly extended end and the forwardly extended ends, the conduit at the constrictions providing air passages of a total cross sectional area approximating the total cross-sectional area of the air passages of the speaker mounting means, the cross-sectional area of the forwardly extended ends of the conduit being greater than the cross-sectional area of the constrictions but less than the cross-sectional area of said rearwardly extended end.

2. The combination of a housing having a wall provid-

ing a speaker opening and vent openings therein, a speaker having a sound producing member in registry with the speaker opening mounted for vibratory movement in a rectilinear path normal to the wall of the speaker opening, the sound producing member having substantially the same area projected in a plane normal to the rectilinear path of movement thereof as said opening, means opposite to the speaker from the speaker opening mounting the speaker in the housing, said means being in spaced adjacent relation to the sound producing member and defining a vented air cushion therebetween, the mounting means having air passages therethrough of a cross-sectional area approximating one-third the area of the speaker opening, means within the housing in cooperation with the housing forming a conduit having an inner end in registry with the passages in the mounting means and extended from the passages in alignment with the rectilinear path of vibration of the sound producing member oppositely from the opening in the housing and a pair of return bent outer ends individually extended from the end in registry with the passages to the vent openings, and sound insulating material lining said conduit and forming constrictions therein between the outer ends of the conduit and the inner ends, the conduit being of such size that air paths are provided therethrough from the sound producing member to the atmosphere which are of minimum cross-sectional area at the constrictions approximating the cross-sectional area of the passages in the mounting means the return bent ends of the conduit having a cross-sectional area greater than the cross-sectional area of the respectively adjacent constrictions but substantially reduced from that of the inner end of the conduit.

3. In combination with a speaker having a vibratory sound producing member characterized by the projection of desired sound waves from one side thereof and the projection of undesired sound waves from the opposite side thereof; a housing for the speaker having a forward wall, a rearward wall, side walls interconnecting the forward wall and the rearward wall, a top wall interconnecting the forward wall, the rearward wall, and the side walls, and a bottom wall interconnecting the forward wall, the rearward wall, and the side walls, the forward wall having a speaker opening therein and vent openings on opposite sides of the speaker opening of total cross-sectional area approximately one-third of the cross-sectional area of the speaker opening; means mounting the speaker within the housing with the side of the sound producing member thereof from which desired sound waves are projected facing the opening and the opposite side thereof disposed inwardly of the housing; partitions individually connected to the forward wall between the speaker opening and the vent openings and extended therefrom toward the rearward wall in closely adjacent spaced relation to the side walls terminated in spaced relation to said rearward wall, said partitions interconnecting the top and bottom walls of the housing and in association with the housing defining a divided air duct from the rearward side of the sound producing member to the vent openings; and sound absorbing material on the rearward wall, opposite sides of the partitions, on the top and bottom walls, between the partitions and their respectively adjacent side walls of the housing and on the side walls, providing corresponding constrictions in the divided air duct from the sound producing member to the vent openings, corresponding constrictions in the divided duct being of a cross-sectional area approximately that of the cross-sectional area of the vent openings.

4. In combination with a speaker having a speaker cone, a housing having a wall providing a speaker opening of substantially the same size as the major transverse dimension of the speaker cone and a pair of vent openings on opposite sides of the speaker opening of total area substantially one-third that of the speaker opening; means mounting the speaker with the end of major diameter of the cone thereof juxtapositioned to the speaker opening;

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an annular resilient means interconnecting the speaker cone and the wall about the speaker opening; partitions within the housing in association therewith defining a divided return bent air passage within the housing having an enlarged central portion connected to the sound producing member and a pair of return bent portions reduced in size from the central portion connected to the vent openings; and sound absorbing material coating the walls of the air passage from the speaker cone to the vent openings, said sound absorbing material forming correspondingly positioned constrictions in the air passage in planes oblique to the passage at the return bent portions thereof; the minimum combined total cross-sectional area of the corresponding constrictions in the divided passage being approximately the cross-sectional area of the vent openings and being less than the cross-sectional area of either the central portion or the return bent portions of the conduit.

5. In combination with a speaker providing a vibratory sound producing member having a forward side from which are projected desired sound waves and a rearward side from which are projected undesired sound waves; a housing having pairs of spaced substantially parallel walls interconnected to form an enclosure of substantially rectangular cross-section, one of the walls having a speaker opening therein and one of the walls having a vent slot therein, means mounting the speaker in the housing with the forward side of the sound producing member directed toward the speaker opening and with the rearward side disposed inwardly of the housing; partitioning means connected to the wall having the speaker opening, adjacent to the speaker opening, extended toward the wall opposite to the wall with the speaker opening, defining with the walls an air duct having an end portion of maximum cross-sectional area in communication with the rearward side of the sound producing member, an opposite end portion opening outwardly of the housing through the vent slot and forming an open and unimpeded path from the rearward side of the sound producing member to the outside of the housing through the slot; and means circumscribing said path forming a constriction in the air duct between said end portions, the cross-sectional area of the end portion of the duct opening through the slot being of cross-sectional area greater than the constriction but substantially less than the cross-sectional area of the end portion communicating with the sound producing member.

6. In combination with a speaker having a speaker cone providing a forward side from which are projected desired sound waves and a rearward side from which are projected undesired sound waves; a housing for enclosing the speaker having top, bottom, side, and forward walls interconnected to form an enclosure of substantially rectangular cross-section, the forward wall having a speaker opening and elongated substantially rectangular vent openings on opposite sides of the speaker opening of a total cross-sectional area approximately one-third of the cross-sectional area of the speaker opening; a bracket mounting the speaker in the housing and being in rearwardly spaced relation to the speaker cone, the bracket having a plurality of air passages therein of an aggregate cross-sectional area substantially one-third of the cross-sectional area of the speaker opening; a pair of partitions individually connected to the forward wall between the speaker opening and the vent openings, extended rearwardly therefrom toward the rearward wall, interconnecting opposed walls of the housing, and having rearward edges in adjacent spaced relation to the rearward wall, the partitions in association with the housing defining an air duct having a rearwardly extended central portion of maximum cross-sectional area between said opposed walls of the housing and the partitions, and in circumscribing relation to the rearward side of the speaker cone and the air passages in the bracket, the

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air duct further having a pair of forwardly extended side portions between the partitions and the respectively adjacent side walls of the housing interconnecting said central portion and the vent opening; and sound absorbing material forming constrictions between the rearward edges of the partitions and the respectively adjacent corners of the housing defined by the intersection of the side and rearward walls, the constrictions being of a total cross-sectional area substantially equal to the total cross-sectional area of the vent openings, and the cross-sectional area of the side portions of the air duct being greater than the cross-sectional area of the vent openings but substantially less than the cross-sectional area of said central portion.

7. In combination with a speaker having a speaker cone having a forwardly disposed major diameter providing a forward side from which are projected desired sound waves and a rearward side from which are projected undesired sound waves; a housing for enclosing the speaker having a forward wall, a rearward wall in spaced relation to the forward wall, spaced parallel side walls interconnecting the forward and rearward walls, and spaced parallel top and bottom walls interconnecting the forward, rearward, and side walls, the forward wall having a speaker opening therein of substantially the same diameter as the major diameter of the cone and elongated substantially rectangular vent openings of a total cross-sectional area approximately one-third of the cross-sectional area of the speaker opening, the vent openings being substantially vertically positioned between the speaker opening and adjacent side walls of the housing; a frusto-conical bracket mounting the speaker in the housing and being in rearwardly spaced substantially concentric relation to the speaker cone, the bracket having a plurality of air passages therein of an aggregate cross-sectional area substantially one-third of the cross-sectional area of the speaker opening; a pair of substantially vertical partitions individually connected to the forward wall between the speaker opening and the vent openings, extended rearwardly therefrom toward the rearward wall, interconnecting the top and bottom walls of the housing, and having rearward edges in adjacent spaced relation to the rearward wall, the partitions in association with the housing defining an air duct having a central portion of maximum cross-sectional area between the top and bottom walls of the housing and the partitions, and in circumscribing relation to the rearward side of the speaker cone and the air passages in the bracket, the air duct further having a pair of side portions between the partitions and the respectively adjacent side walls of the housing providing rear ends connected to said central portion and forward ends opening outwardly of the housing through the vent openings; and sound absorbing material on the opposite sides of the partitions, interiorly of the housing on the top, bottom, side, and rearward walls, the sound absorbing material providing constrictions between the rearward edges of the partitions and the respectively adjacent corners of the housing defined by the intersection of the side and rearward walls, the constrictions being of a total cross-sectional area substantially equal to the total cross-sectional area of the vent openings, and the cross-sectional area of the side portions of the air duct being greater than the cross-sectional area of the vent openings but substantially less than the cross-sectional area of said central portion.

8. In combination with a speaker having a vibratory sound producing member providing a forward side and a rearward side; a housing having a panel providing a speaker opening therein; means mounting the speaker in the housing with the forward side of the sound producing member juxtapositioned to the speaker opening of the housing, said means being in spaced adjacent relation to the rearward side of the sound producing member and including a wall having air passages of predetermined

cross-sectional area therethrough; means within the housing cooperating with the housing to form a conduit having a rearwardly extended end connected to the rearward side of the sound producing member, enclosing the speaker mounting means, and having a reversely bent forwardly extended open opposite end opening adjacent to the speaker opening; and sound absorbent material internally covering the walls of the conduit and forming a constriction therein between the rearwardly extended end and the forwardly extended end, the conduit at the constriction providing an air passage of a cross-sectional area approximately one-half of the total cross-sectional area of the air passages of the speaker mounting means, the cross-sectional area of the forwardly extended end of the conduit being greater than the cross-sectional area of the constriction but less than the cross-sectional area of said rearwardly extended end.

9. In combination with a speaker providing a vibratory sound producing member having a forward side from which are projected desired sound waves and a rearward side from which are projected undesired sound waves; a housing having pairs of spaced substantially parallel walls interconnected to form an enclosure of substantially rectangular cross-section, one of the walls having a speaker opening therein and one of the walls having a vent slot therein; means mounting the speaker in the housing with the forward side of the sound producing member directed toward the speaker opening and with the rearward side disposed inwardly of the housing; partitioning means connected to the wall having the speaker opening, extended toward the wall opposite to the wall

with the speaker opening, and defining with the walls an elongated air duct circumscribing an open and unimpeded path in communication with the rearward side of the sound producing member and opening outwardly of the housing through the vent slot; and means circumscribing said path forming a constriction in the air duct and dividing the air duct into a first duct chamber of maximum cross-sectional area extended between the rearward side of the sound producing member and the constriction forming means and a second duct chamber of substantially uniform cross-sectional area with the cross-sectional area of the constriction being less than the cross-sectional area of said first chamber and with the cross-sectional area of said second chamber being greater than either the cross-sectional area of the slot or the cross-sectional area of the constriction whereby said undesired sound waves are dampened by passage through said duct and whereby back pressures on the sound producing member are minimized because of said open and unimpeded path provided by the duct.

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