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Gosswiller

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[54] **LOUDSPEAKER WITH SHALLOW RE-ENTRANT GRILLE-LIKE HORN**

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[52] **U.S. Cl.** ..... **179/1 E;** 181/159; 181/175; 181/190; 181/194

[51] **Int. Cl.²** **H04R 1/02**

[58] **Field of Search** ..... 179/1 E, 115.5 H; 181/143, 181/148, 152, 155, 156, 159, 175, 176, 177, 185, 186, 187, 188, 189, 190, 191, 192, 194, 195, 198, 199

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[57] **ABSTRACT**

A re-entrant type horn loudspeaker having a pair of shallow baffle members arranged in closely-spaced parallel relation in front of a diaphragm, the baffle members having complementary staggered openings and deflector or baffle elements causing sound waves projected from the diaphragm to traverse a re-entry path so as to function as a very short rapidly flaring re-entry horn.

6 Claims, 8 Drawing Figures

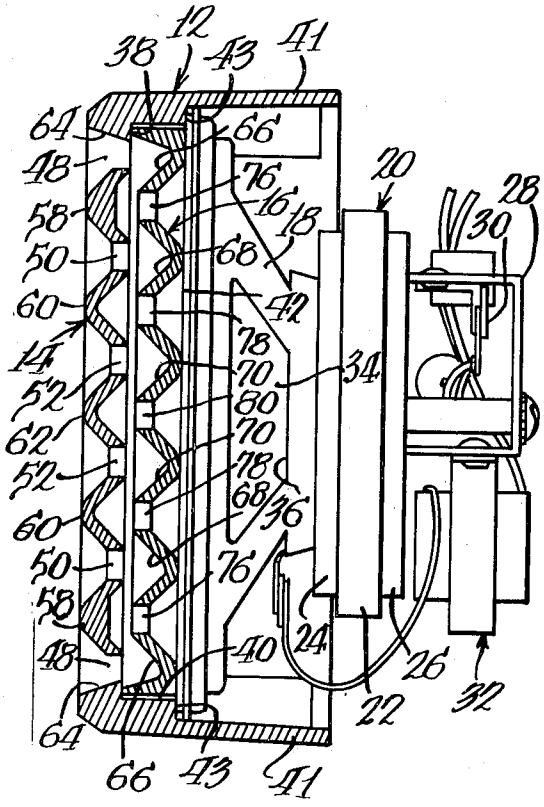


Fig. 1.

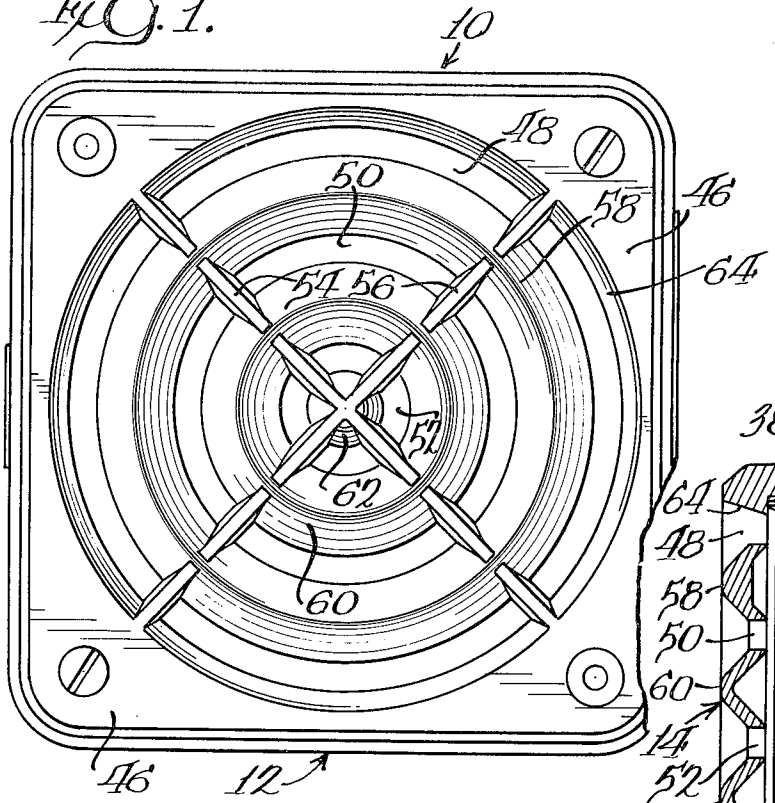


Fig. 2.

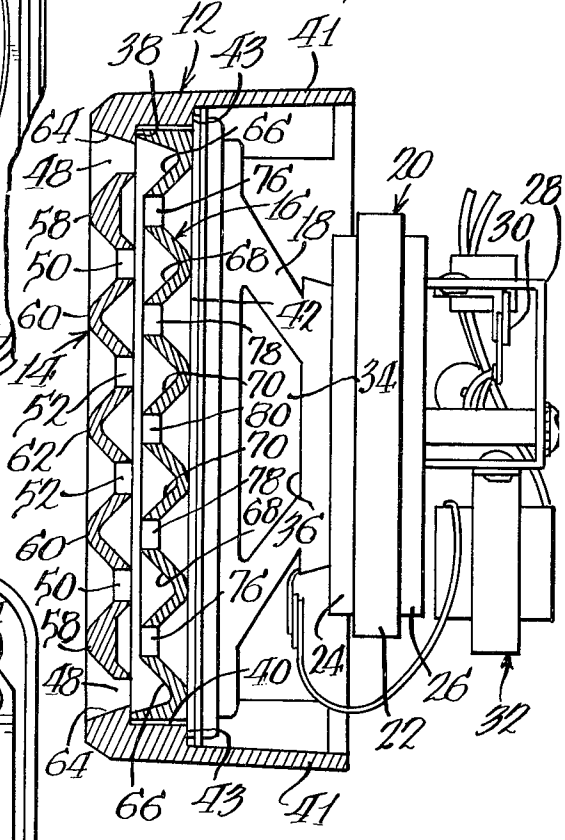


Fig. 3.

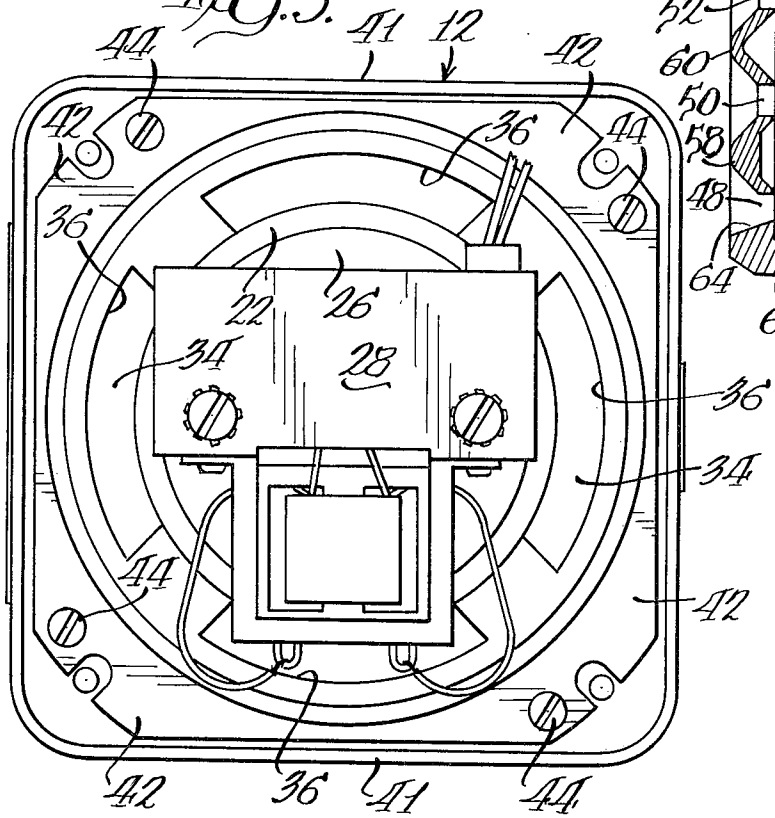


Fig. 4.

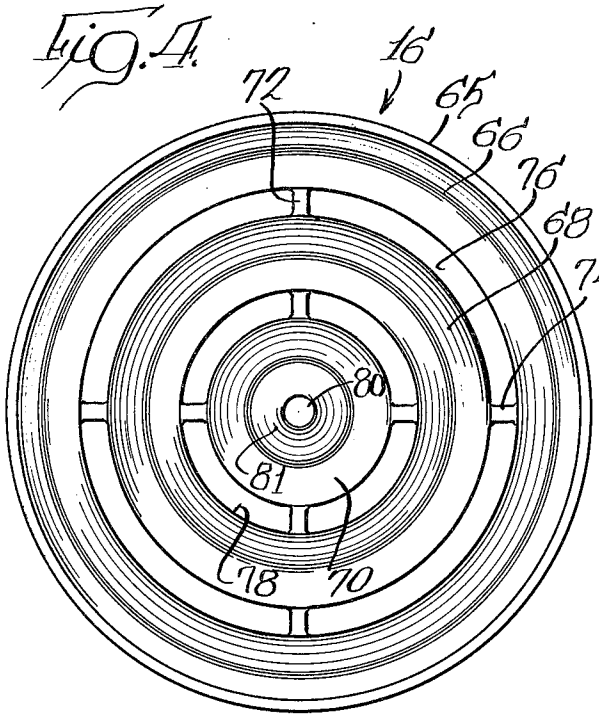


Fig. 5.

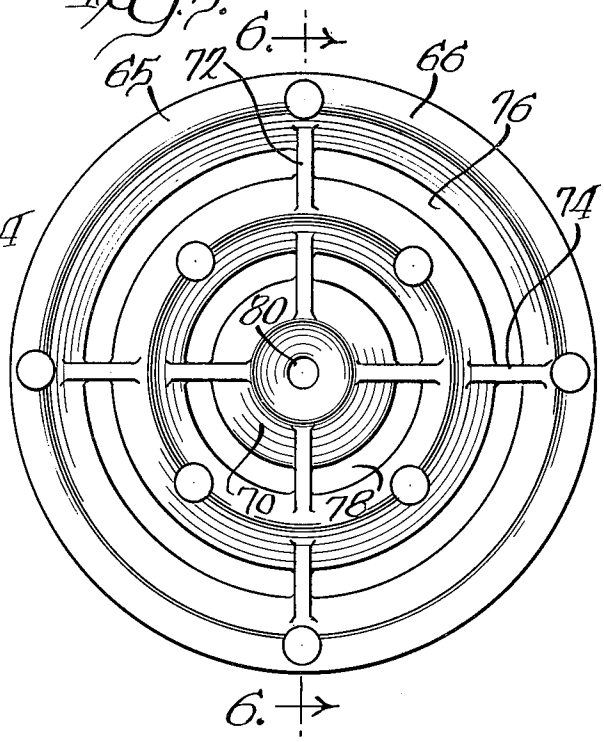


Fig. 6.

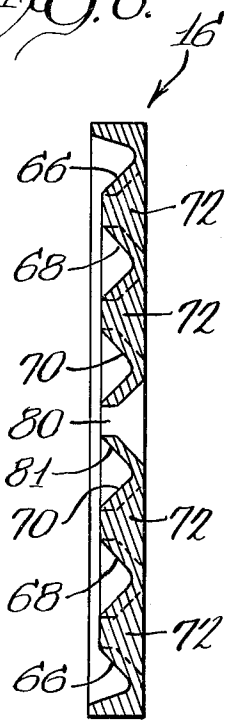


Fig. 7.

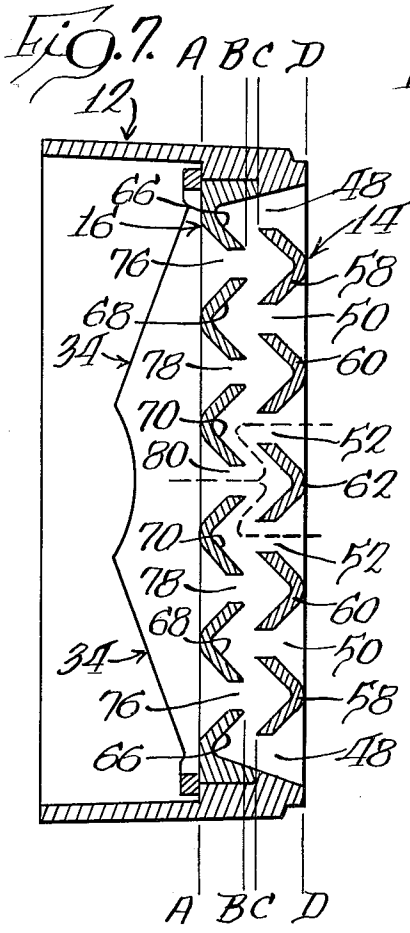
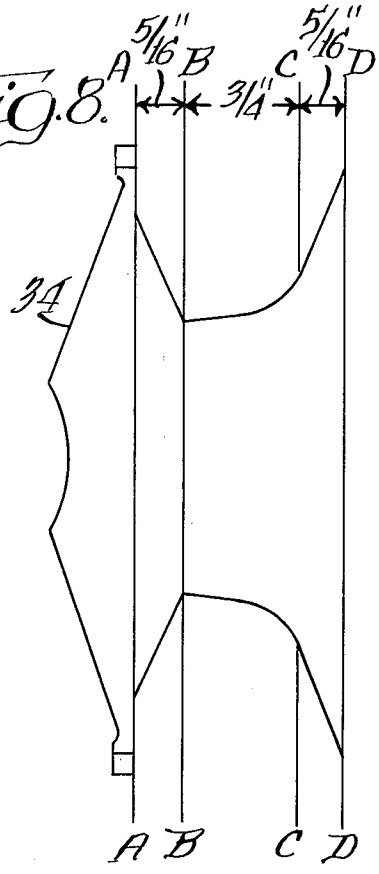


Fig. 8.



LOUDSPEAKER WITH SHALLOW RE-ENTRANT GRILLE-LIKE HORN

BRIEF SUMMARY OF THE INVENTION

Re-entrant type loudspeakers are commonly used in certain types of applications where it is important to provide high resistance to moisture, heat and deterioration due to aging. Such horns are also utilized in applications where it is important to protect the loudspeaker diaphragm against direct entrance of foreign objects such as rods or wires or the like which could cause damage to the diaphragm.

It is known to provide a loudspeaker having a phenolic diaphragm which will afford satisfactory resistance to moisture and heat, and such diaphragms are commonly used in re-entrant type horn loudspeakers. Such re-entrant type loudspeakers generally employ compression type drivers which are coupled to folded exponential horns. Due to the physical construction of a folded exponential horn, it will guard the diaphragm against damage caused by entry of foreign objects and the like.

Because of the above-mentioned advantages of known re-entrant type folded exponential horns, various fire codes and the like specify that loudspeakers must comprise high grade re-entrant horns. However, such horn loudspeakers are usually quite large for the reason that the lowest frequency the horn can transmit efficiently is a function of the expansion rate of the horn and the mouth size. Consequently, a relatively large horn is required in order to transmit low frequency signals.

Due to their size, conventional re-entrant loudspeakers with folded exponential horns are difficult to mount in a manner which is aesthetically and structurally attractive. Moreover, because of their size and high wattage, such loudspeakers are relatively expensive and thus not practical for use in fire alarm systems, particularly since their wattage and acoustic ratings are substantially beyond that required for most fire alarm applications.

It is therefore a general object of the present invention to provide an improved re-entrant type horn loudspeaker which is particularly well suited for use in fire alarm systems and affords substantially all of the advantages of a conventional re-entrant type horn loudspeaker while eliminating the usual folded exponential horn and its inherent disadvantages.

A further object of my invention is to provide an improved horn loudspeaker which is small in size, relatively inexpensive and adapted for a wide variety of architecturally and aesthetically attractive mounting arrangements.

Still another of my objects is to provide a loudspeaker including a very short, rapidly flaring re-entrant type horn which affords excellent efficiency and frequency response and produces an acoustic output at least equal to that of conventional fire alarm horns while providing numerous design and cost advantages over the latter.

A more specific object of my invention is to provide a re-entrant type horn loudspeaker as last above-mentioned comprising a pair of relatively shallow baffle members arranged in closely-spaced parallel relation in front of a diaphragm member, the baffles being provided with complementary staggered openings and deflector or baffle elements which afford a re-entry type sound path and provide physical protection for the diaphragm without significantly impairing the acoustic output of the loudspeaker.

The foregoing and other objects and advantages of the invention will be apparent from the following description of a preferred embodiment thereof, taken in conjunction with the accompanying drawings.

DESCRIPTION OF THE DRAWINGS

FIG. **1** is a front elevational view of a re-entrant type loudspeaker assembly constructed in accordance with the present invention;

FIG. **2** is a side elevational view of the loudspeaker of FIG. **1**, the loudspeaker housing and adjacent baffle member being shown in vertical section;

FIG. **3** is a rear elevational view of the loudspeaker of FIG. **1**;

FIG. **4** is a detail front elevational view of a baffle member which comprises a component of the loudspeaker assembly of FIG. **1**;

FIG. **5** is a rear elevational view of the baffle member of FIG. **4**;

FIG. **6** is a vertical sectional view taken substantially along the line **6—6** of FIG. **5**;

FIG. **7** is a schematic vertical sectional view of a speaker housing grille and a baffle member in combination with a diaphragm; and

FIG. **8** is a drawing comprising a developed expansion profile representative of the equivalent diameter of the opening at various section lines indicated in FIG. **7**.

Now, in order to acquaint those skilled in the art with the manner of making and using my invention, I shall describe, in conjunction with the accompanying drawings, a preferred embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to the drawings, and particularly to FIGS. **1–3,** there is shown a horn loudspeaker assembly **10** having a speaker housing **12** including a front grille member **14,** a baffle **16** positioned behind the speaker grille, a speaker frame **18** and a magnet assembly **20.** The magnet assemby **20** (see FIG. **2**) comprises a ring-shaped magnet **22** positioned between plates **24** and **26** which function as the poles of the magnet. A bracket **28** is mounted on the rear of the plate **26.** A terminal strip **30** is fixedly positioned within the U-shaped bracket **28,** and a transformer **32** is suspended from the underside of the bracket. The loudspeaker **10** further includes a diaphragm **34,** best shown in FIGS. **7** and **8.** The diaphragm **34** is preferably made of a polyamide-based phenolic material which is self-extinguishing as well as moisture and heat resistant.

In assembling the components of the loudspeaker **10,** the speaker frame or "basket" **18** and the various components which mount rearwardly thereof as shown in FIG. **2** are mounted together to form a speaker subassembly. The diaphragm **34** is mounted to the frame **18** so as to face forwardly therefrom, and it will be noted that the frame is provided with a plurality of openings **36** which render the diaphragm visible in the side elevational view of FIG. **2** and the rear elevational view of FIG. **3.**

The speaker housing **12,** which preferably comprises an aluminum die-casting, is formed with an annular ledge **38** immediately behind the front grille **14.** The housing **12** is further provided with a space behind the grille **14** defined by an annular wall **40** having a diame-

ter slightly larger than the diameter of the baffle member **16.** It will thus be understood that in assembling the loudspeaker **10,** the baffle member **16** is positioned within the recess or space defined by the annular wall **40** so as to bear against the ledge **38.** The above-described subassembly including the speaker frame **18** and diaphragm **34** is then positioned within the outer wall **41** of the housing **12** with a front face plate **42** of the speaker frame disposed against an annular ledge **43** located at the rear of the annular wall **40.** The speaker frame subassembly is then secured to the speaker housing **12** by four screws **44** (see FIG. **3**) which extend through the front face plate **42** of the speaker frame into the speaker housing **12.**

As best shown in FIGS. **1** and **2,** the front grille **14** of the speaker housing **12** comprises a front face plate **46** provided with a plurality of openings **48, 50** and **52.** The openings are in the form of concentric circles interrupted by a pair of perpendicular rib members **54** and **56.** The grille **14** further includes a pair of concentric annular deflector or baffle elements **58** and **60** integral with the crossed rib members **54** and **56.** The rib member **54** extends continuously from one corner of the face plate **46** to a diagonally opposite corner thereof, and the rib **54** is integral with the face plate as well as with each of the annular deflectors **58** and **60.** The second rib member **56** extends in a similar manner between the other two corners of the face plate **46.** At the center of the grille **14** there is a third circular deflector or baffle **62** located at the intersection of the rib members **54** and **56.**

It will be understood from the foregoing that there are provided the two annular deflector members **58** and **60** interconnected to each other and the housing **12** by the ribs **54** and **56** and arranged concentrically relative to the front of the housing with the annular space **50** provided between the deflectors **58** and **60** and the annular space **48** provided between the outer annular deflector **58** and an annular wall **64** which is flared so as to be generally conical in its configuration, the wall **64** being integral with the face plate **46.** As noted above, each of the annular openings **48, 50** and **52** is divided into four segments by the crossed rib members **54** and **56,** with the small central deflector member **62** located at the intersection of the ribs.

Each of the annular deflector or baffle elements **58** and **60** is convex as viewed from the front of the grille **14.** As best shown in FIG. **2,** each such annular deflector element is generally V-shaped in cross-sectional configuration. Moreover, the central deflector **62** comprises a cup-shaped member generally conical in its configuration.

Reference is now made to FIGS. **4–6** which illustrate the baffle member **16.** The baffle **16** is a disc-shaped member having an outer wall **65** of a diameter slightly less than the diameter of the annular wall **40** in the speaker housing **12.** The baffle **16** comprises three concentrically arranged annular deflector or baffle elements **66, 68** and **70.** The three deflector elements are interconnected by a pair of crossed rib members **72** and **74.** As best shown in FIG. **5,** the rib **72** extends diametrically across the outer deflector or baffle element **66,** and the rib **74** similarly extends diametrically across the baffle element **66** perpendicular to the first rib member.

An opening **76** is provided between the annular deflector or baffle elements **66** and **68,** and a second opening **78** is provided between the baffle elements **68** and **70.** The openings **76** and **78** are each annular but are divided into four segments by the crossed rib members **72** and **74.** A small round opening **80** is also formed at the center of the central deflector member **70.**

The outer annular deflector or baffle element **66** is concave when viewed from the front as in FIG. **4.** As best shown in FIG. **6,** the annular deflector element **66** is generally V-shaped in cross-sectional configuration. The annular deflector element **68** is similarly shaped and is concentrically located within the outer deflector element **66.** The central deflector member **70** is shaped similar to the deflector elements **66** and **68** except that it is much smaller in diameter so that the radially inner wall **81** (see FIG. **6**) is generally conical in configuration and the small opening **80** is formed at the center or apex of the cone.

It is an important feature of the present invention that the grille **14** of the speaker housing **12** and the baffle member **16** are complementary to one another so that when combined in assembled relation as shown in FIG. **2** they function as a very short or shallow reentrant horn for the loudspeaker **10.** The baffle **16** is designed so that the outer annular opening **76** in the baffle is aligned with the outer annular deflector element **58** on the grille **14,** and the annular opening **78** in the baffle **16** is aligned with the annular deflector element **60** on the grille. It will of course also be noted that the central opening **80** in the baffle **16** is aligned with the central deflector member **62** of the grille **14.** The baffle member **16** is mounted within the speaker housing **12** so that the concave sides of the deflector elements **66, 68** and **70** face forwardly. Moreover, the outer annular opening **48** in the speaker housing grille **14** is aligned with the outer concave deflector element **66** of the baffle **16,** and the annular opening **50** in the grille **14** is aligned with the concave deflector element **68** of the baffle.

FIG. **7** illustrates the relationship between the phenolic diaphragm **34,** the baffle **16** and the grille **14** of the speaker housing **12.** It will be understood that the sound waves created and propelled forwardly from the diaphram **34** will initially pass through the openings **76,** 78 and **80** in the baffle **16.** Such sound waves will then be deflected rearwardly by the concave deflector members **58, 60** and **62.** The rearwardly deflected sound waves will impinge against the concave baffle elements **66, 68** and **70** of the baffle member **16,** and the latter baffle elements will then deflect the sound waves forwardly through the openings **48, 50** and **52** in the grille **14** of the speaker housing **12.**

FIG. **8** is a drawing representing the equivalent diameter of the opening at each of the section lines A, B, C and D in FIG. **7** based upon a loudspeaker having a diaphragm **34** which is 4 inches in diameter. In accordance with the design of the present invention, used in conjunction with a four-inch diameter diaphragm, the following approximate data represents the open area at each of the indicated section lines:

SECTION	AREA (SQ. IN.)	EQUIVALENT DIA. (IN.)
A—A	7.66	3.125
B—B	2.45	1.76
C—C	4.01	2.26
D—D	11.4	3.81

The developed expansion profile in FIG. **8** is based upon the foregoing data identified as "Equivalent Diameter" and thus represents in effect an example of a developed sound profile for a re-entrant horn loudspeaker constructed in accordance with the present invention.

It will now be understood that the loudspeaker described herein is well suited to accomplishing the previously stated objects of the present invention. The re-entrant horn comprised of the grille **14** and baffle **16** provide protection against damage from radiation heating effects of fire and render the loudspeaker virtually damage- and tamper-proof by inhibiting foreign objects from being thrust into the loudspeaker mechanism. The foregoing re-entrant horn is quite different from a conventional folder exponential horn because it is very compact in size and architecturally and aesthetically practical for a variety of mounts such as flush wall, surface or gasketed back-box through the use of conventional accessory plates and boxes.

The horn loudspeaker of the present invention is particularly well suited for use in conjunction with a combination alarm and emergency communication system of the type described in my copending application Ser. No. 359,987, filed May 14, 1973, and assigned to the assignee of the present invention. By utilizing the short, rapidly flared, re-entrant horn loudspeaker of the present invention, it is possible to achieve excellent efficiency and frequency response. Such a loudspeaker has been found well suited to reproduce distinctive, loud, penetrating, electronically generated tones which command instant recognition as fire alarm and other emergency alerting signals, including the "slow whoop" signal which is highly desirable as a fire alarm alerting signal. The loudspeaker of the present invention is also well-adapted for reproducing voice communications as provided for in the system described in the foregoing copending application. Moreover, such a horn loudspeaker will meet various fire codes which require use of a re-entrant type horn and yet it dispenses with the disadvantages inherent with use of a conventional re-entrant folded exponential horn.

It should be noted that the diaphragm **34** disclosed herein is essentially a cone-type or conically-shaped diaphragm member, even though there is a small central bulbar member which functions primarily as a cover for a coil (not shown) disposed behind the central portion of the diaphragm. Conventional re-entrant loudspeakers employ compression-type drivers in conjunction with a generally bulbar diaphragm as contrasted with a cone-type diaphragm, and as described hereinabove the drivers are coupled to folded exponential horns. However, in the re-entrant loudspeaker of the present invention, which eliminates the need for the usual large folded exponential horn, I have found it is more advantageous to employ a cone-type diaphragm in conjunction with the very shallow, rapidly-flared re-entrant horn comprised of the grille **14** and baffle **16.** Moreover, I have found that by using a cone-type diaphragm in conjunction with the grille member **14** and baffle **16,** the latter two components will impair the output of the loudspeaker only to a very small degree if at all, and as previously noted the loudspeaker of the present invention provides excellent efficiency and frequency response and produces wattage and acoustic ratings far in excess of that required for most fire alarm and other emergency alarm applications.

It has been pointed out hereinabove that the small size of the loudspeaker **10** is one of its important advantages. This advantage applies in particular to the fact that the loudspeaker **10** is extremely short or shallow in its dimensions whereas a conventional re-entrant horn is not only of a very large diameter at its outer end, but in addition is normally quite long. While the present invention is not restricted to a specific size, it has been found that for most fire alarm and the like applications a speaker having a diaphragm **4** inches in diameter will perform satisfactorily, and it will be understood from FIG. **7** that the outer diameter of the speaker housing **12** need be only slightly larger than the diameter of the diaphragm. Moreover, in a preferred embodiment, the total thickness of the re-entrant horn measured from the rear face of the baffle **16** to the front face of the grille **14** does not exceed approximately one inch. In fact, favorable results can be achieved where such dimension is only about 0.75 inch or less.

It is also important to understand that the re-entrant horn comprised of the baffle **16** and the grille **14,** in spite of its shallow dimension, does in fact function as a sound expansion chamber in a manner generally similar to large conventional horns. The foregoing is illustrated by the developed profile drawing of FIG. **8** which represents graphically the dimensional data set forth on page **9** of the specification. It will be seen from the foregoing data and from FIG. **8** that the area of the sound chamber decreases from Section A—A to Section B—B, increases from Section B—B to Section C—C, and then increases very substantially from Section C—C to Section D—D. Accordingly, the re-entrant horn comprising the baffle **16** and grille **14** does provide an expansion chamber for the sound waves as they pass through a re-entry path before emanating from the loudspeaker. It should perhaps be pointed out that the dimension of three-fourths inch indicated between Section B—B and Section C—C in FIG. **8** does not represent the distance between those planes in FIG. **7,** but rather represents the length of the mean re-entry sound path between such planes as represented by the dotted line in FIG. **7.**

I claim:

1. A loudspeaker comprising, in combination, a diaphragm, and a shallow re-entrant horn disposed adjacent the front of said diaphragm, said re-entrant horn comprising a protective grille-like baffle member arranged substantially parallel to the front of said diaphragm in proximity thereto, said grille-like baffle member having a first plurality of concentric annular baffle elements and first intermediate annular openings located approximately in a first plane adjacent to said diaphragm, and a second plurality of complementary concentric annular baffle elements and second intermediate annular openings located approximately in a second plane disposed parallel to and outwardly of said first plane, said first plurality of baffle elements comprising outwardly directed annular concave deflectors and said second plurality of baffle elements comprising inwardly directed annular concave deflectors, said first annular openings being aligned with the deflectors in said second plane, the deflectors in said first plane being aligned with the openings in said second plane, and the annular openings in said second plane being at

greater average radii compared to the annular openings in said first plane, whereby sound waves projected forwardly from said diaphragm through the annular openings in said first plane are deflected rearwardly by the deflectors in said second plane and then are deflected forwardly through the annular openings in said second plane by the deflectors in said first plane so as to traverse a re-entry type sound path which affords a sound expansion profile.

2. A loudspeaker as defined in claim **1** where the total thickness of said grille-like baffle member measured from the rear of said first plurality of baffle elements to the front of said second plurality of baffle elements does not exceed approximately 1 inch.

3. A loudspeaker as defined in claim **1** including a speaker housing having a front face, said second plurality of concentric annular baffle elements and intermediate annular openings being formed in said front face of said speaker housing, and a separate baffle member inserted into said speaker housing and mounted therein immediately behind said front face of said speaker housing, said first plurality of concentric annular baffle elements and intermediate annular openings being formed in said separate baffle member.

4. A loudspeaker as defined in claim **1** where in each of said first and second planes the plurality of concentric annular baffle elements are interconnected by at least one radial rib member.

5. A loudspeaker as defined in claim **1** where said diaphragm is conically-shaped and is made of phenolic material.

6. A loudspeaker as defined in claim **5** where said speaker housing is provided with a circular recess immediately behind said front face, and said separate baffle member comprises a discshaped baffle having a diameter slightly less than said recess whereby said separate baffle member is mounted within said circular recess in approximate abutment with the rear of said front face, and a speaker frame having said diaphragm mounted on the front thereof, said speaker frame being fixedly mounted in said housing immediately rearwardly of said separate baffle member so as to retain said separate baffle member in said recess and position said diaphragm in close proximity to said separate baffle member.

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