April 17, 1945. P. W. KLIPSCH 2,373,692

LOUD SPEAKER

Filed Oct. 3, 1942 2 Sheets-Sheet 1

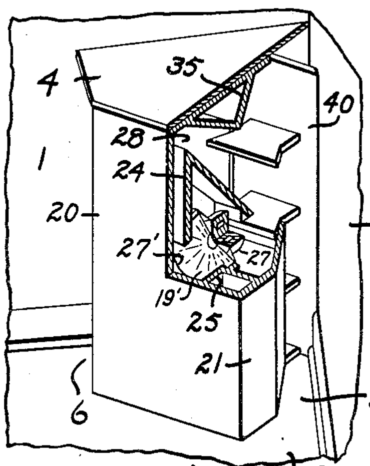

Fig. 1.

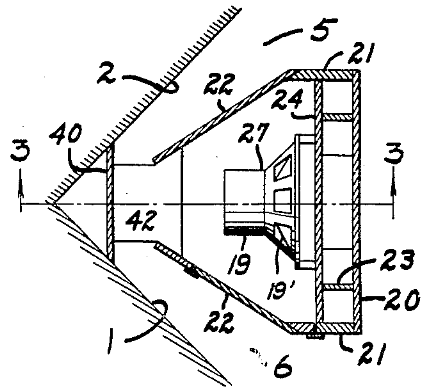

Fig. 2.

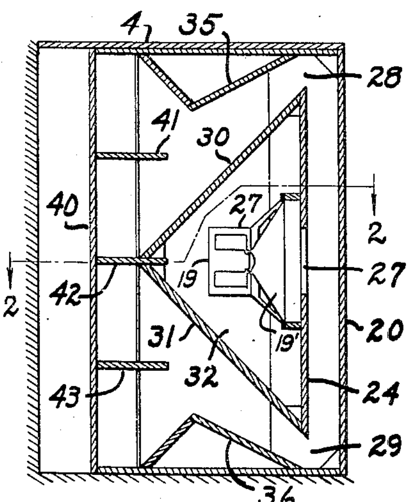

Fig. 3.

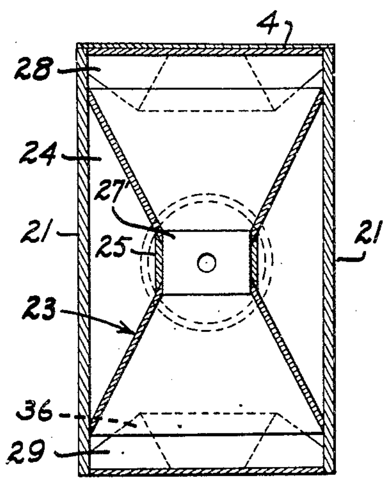

Fig. 4.

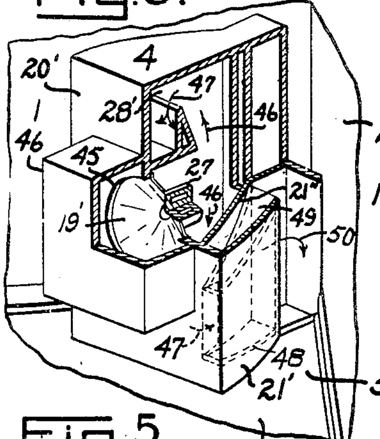

Fig. 5.

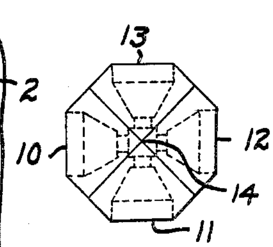

Fig. 6.

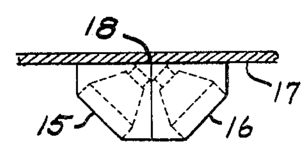

Fig. 7.

PAUL W. KLIPSCH

INVENTOR.

BY Ray L. Smith

ATTORNEY.

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LOUD SPEAKER

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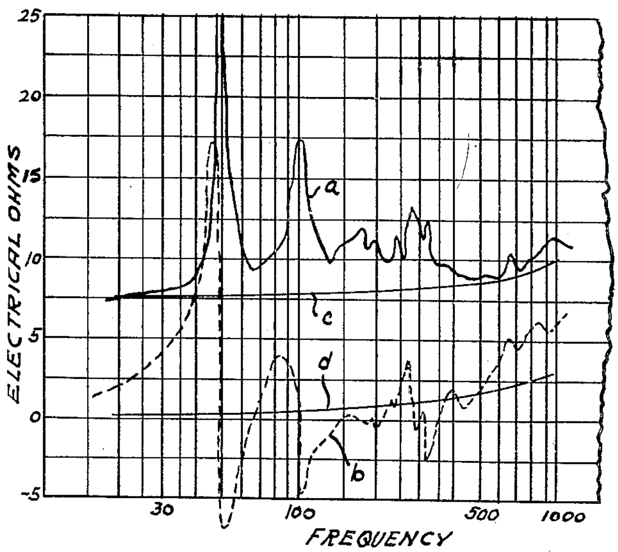

Fig. 9.

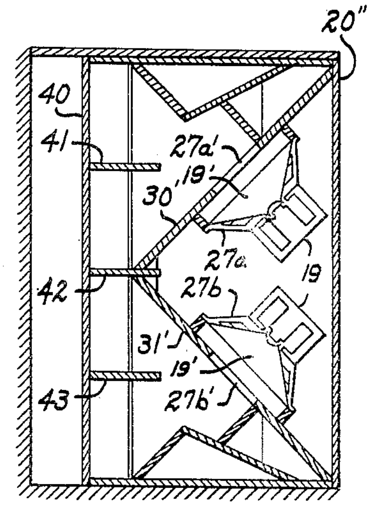

Fig. 8

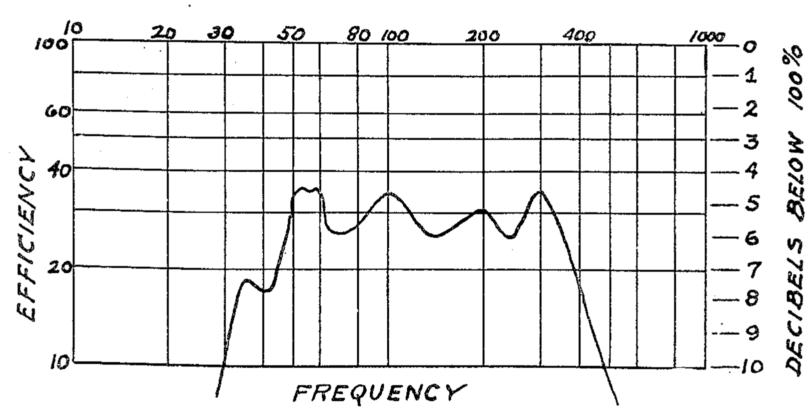

Fig. 10.

PAUL W. KLIPSCH.
INVENTOR.

BY Ray L. Smith

ATTORNEY

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UNITED STATES PATENT OFFICE

2,373,692

LOUD-SPEAKER

Paul W. Klipsch, Hope, Ark., assignor of twenty per cent to Ray L. Smith, Houston, Tex.

Application October 3, 1942, Serial No. 460,596

22 Claims. (Cl. 179—1)

This invention relates to an acoustical device and more particularly to a sound reproducing device, or loud speaker, for reproducing low frequency sound vibrations with high fidelity.

The invention relates to and broadly comprehends the subject matter of my copending application, Serial No. 317,260 filed February 5, 1940, and also my disclosures of "A low frequency horn of small dimensions," Journal of the Acoustical Society of America, Vol. 13, No. 2, pp. 137–144, October, 1941, and "Improved low frequency horn," Journal of the Acoustical Society of America, vol. 14, No. 3, pp. 179–182, January, 1943.

In order to attain fidelity in sound reproduction, and in particular the inclusion of low audible frequencies, large horns have been constructed. For example, theater speakers are commonly as large or larger than eight feet in length and four feet by four feet in transverse dimensions in order to attain desirable conditions that low audible frequencies are desirably reproduced.

It is imperative for satisfactory reproduction of the entire audible range that low frequencies be included and with high fidelity. At the same time it is desirable that the reproducing unit or speaker be of such physical dimensions that the unit may be available for residential use, or for use in other environments where space is relatively liimited.

The speaker of the present invention is designed to fulfill the foregoing requirements and is of a size comparable with radio consoles, thus making it suitable for home use. Yet, the speaker is so constructed as to possess adequate power capacity that it is suitable for use in larger rooms such as community centers, theaters, etc.

The primary object of the invention is to provide a loud speaker of small dimensions and capable of reproducing with high fidelity the lower range of frequencies of the audio spectrum.

Another object is to provide a loud speaker for reproducing the low frequencies of the audio spectrum without harmonic distortion in the reproduced sounds.

Still another object is to provide an improved loud speaker unit of small dimensions which cooperates with proximate surfaces such as of a room or with other loud speaker units so that a maximum of fidelity in reproduction is attained with a maximum of efficiency in the speaker itself and of space occupied by the speaker unit.

Another and more specific object is to provide a loud speaker unit capable of large scale sound production by superposition of a plurality of such units in a corner, arranged in side-by-side relation along a wall or grouped about a point so that sound may be radiated in all directions therefrom.

A further object is to provide a speaker of the class described which minimizes the directional effects in the reproduced sound.

Another object is to provide a low frequency loud speaker unit for large-scale sound reproduction utiliziing a plurality of driving diaphragms.

The foregoing objects, together with further and additional objects, will be more fully apparent from the following description considered in connection with the accompanying drawings in which:

Fig. 1 is an oblique view, partly in section, showing one embodiment of the invention;

Fig. 2 is a horizontal sectional view taken on the line 2—2 in Fig. 3;

Fig. 3 is a vertical sectional view taken on line 3—3 in Fig. 2;

Fig. 4 is a front elevational view in section;

Fig. 5 is an oblique view similar to that shown in Fig. 1, but illustrating a modified form of construction;

Fig. 6 is a plan view illustrating the manner of using a plurality of loud speakers of the invention for radiating the reproduced sounds throughout an angle of 360°;

Fig. 7 is a plan view similar to that shown in Fig. 6, but showing the use of two units in side-by-side relation operating in cooperation with an adjacent plane surface such as a wall;

Fig. 8 shows a vertical sectional side view similar to Fig. 3 illustrating a modified form of construction providing for two driving units;

Fig. 9 shows graphically the resistive and reactive components of impedance of a loud speaker constructed in accordance with the invention;

Fig. 10 is a graphical showing of the variation of efficiency with frequency in the device of the invention.

The device illustrated in the drawings, and as best seen in Figs. 1 and 5 thereof, is adapted to fit within a corner comprising three mutually perpendicular surfaces such as the side walls 1 and 2 and the floor 3 of a room. The winglike cover 4 has edges converging rearwardly at 90° to abut walls 1 and 2 so that the cabinet, of which the cover forms a part, cooperates with the walls to form terminal horn sections as indicated at 5 and 6 in Fig. 2.

In view of the general form of structure just described, and in accordance with the invention, a plurality of loud speaker units may be used in cooperative relation in the manner shown in Figs. 6 and 7. Fig. 6 is a plan view showing the manner of using four speakers 10, 11, 12 and 13 resting upon the floor or other surface, or suspended from the ceiling and arranged about a common point 14 so that successive units about the point cooperate to form terminal horn sections and the group functions as a unit to reproduce and to radiate the reproduced sound throughout a solid angle of 2 π or a hemisphere about the point 14. This arrangement is of particular value where a large volume of sound may be desired without distortion or wherever it is desirable that the reproduced sound be radiated in all directions regardless of volume.

In Fig. 7 is shown a plan view of an installation in which two units 15 and 16 are used in cooperation proximate a plane surface 17 such as the wall of a room or a panel that permits radiation of the reproduced sound throughout a π solid angle. In this arrangement the adjacent horns cooperate to form a portion of the outer horn sections of the units while the surface 17 at opposite sides of the point 18 cooperate with the respective units to form other portions of the outer horn sections.

It should be noted that the arrangements just described contemplate that the horns will be in proximity to a floor and/or wall or other reflecting surface. To provide for spherical radiation (4 π solid angle) in the absence of any reflecting surface, the arrangement of plan view of Fig. 6 may be used, and a second set of four units stacked on top of the first four to provide the necessary acoustical mouth impedance which would have been furnished by the mirror image of the single set of four units in proximity to the wall or floor.

Referring more specifically to Figs. 1 to 4, inclusive, the illustrated embodiment of one of the units that may be used as shown in Figs. 6 and 7 comprises a front panel 20 which extends from the cover 4 to the surface 3 and is of such width that side walls 21 connected thereto and rearwardly converging panels 22 are sufficiently spaced from surfaces 1 and 2 that the outer horn sections 5 and 6 are formed.

Spacers 23 are mounted on the rear face of the panel 20 and are attached to an inner panel 24 whose edges are also secured to the wall members 21. These spacers comprise central portions 25 and outwardly converging portions 26 so that the spacers and the inner and outer panels 20 and 24 form upwardly and downwardly diverging horn sections for initial conduction of the wave generated by the loud speaker driving unit 27 mounted upon the rear face of the inner panel 24 and comprising a driving mechanism 19 and a driven diaphragm 19' of which the peripheral portion of the latter surrounds the opening or horn throat 27' in the panel 24.

The inner panel 24 terminates at its upper and lower ends at a distance from the top and bottom of the cabinet to provide openings 28 and 29 to the succeeding horn section in which additional flare is provided.

Extending rearwardly from the upper and lower edges of the inner panel 24 are rearwardly converging baffles 30 and 31 which join at their side edges with converging side panels 22 (Fig. 2) to form an enclosure 32 for the driving unit 27. This structure serves not only to form a location for the driving unit within the speaker, but also provides an air chamber rearwardly of the diaphragm 19'. As will more fully appear, the air chamber serves to offset the mass reactance of the throat.

Desired rate of flare beyond the openings 28 and 29 is provided by inwardly extending baffles 35 and 36 secured to the top and bottom respectively of the speaker cabinet. Beyond these inwardly extending baffles the air passages extend about the rearward edge of the side baffles 22 and thence outwardly into the horn sections 5 and 6. In order that this passage shall have a relatively uniform flare, the cabinet includes a rear panel 40 extending from the top to the bottom thereof at a desired distance rearwardly from the edges of side baffles 22. To assist in providing adequate support for the baffles 22 and the rear panel 40 and hence avoid undesirable vibration thereof and, as well, to enhance distribution of the reproduced sound, horizontal baffles 41, 42 and 43 are attached to rear panel 40 and to the converging side baffles 22.

By way of illustration, but not in a limiting sense, the illustrated unit designed for frequencies from 40 to 400 cycles per second may have a throat area 27' of approximately 50 square inches with a driving unit having a moving system weighing between 14 and 18 grams. The initial taper of the horn area, between front panel 20 and inner panel 24 and above and below opening 27, doubles in a length of about eight inches, corresponding to a cut-off of approximately 100 cycles per second. The remainder of the horn, beyond the openings 28 and 29 flares at such a rate that the area doubles every 16 inches so that the nominal cutoff is 47 cycles per second.

Positive reactance imposed at frequencies between 200 and 400 cycles per second by the multiple taper is overcome by the negative reactance introduced by the air chamber between the diaphragm 19' of the driving unit 27 and the throat 27' in the panel 24.

In the modified construction shown in Fig. 5 the driving unit 27 is mounted on the rear side of the front panel 20' and the rear of the cone or diaphragm 19' faces the horn throat. The front of the cone faces opening 45 in the panel. Surrounding this opening is provided a chamber 46 of a size suitable to offset the reactive component of throat impedance.

The horn passage in this embodiment extends upwardly and downwardly from the driving unit 27 to passage 28' as indicated by the arrows 46. Thence, the passage extends sidewardly as indicated by arrow 47 and enters between spaced side walls 21' and 21''. The proper flare within this section of the horn is obtained by the relative spacing of the walls 21' and 21'' and suitable diverging spacers 48 and 49 therebetween. The portion of the air passage just described emerges at its rearmost end into the portion 5 as indicated by the arrow 50.

For sound systems requiring more power than can be delivered by a single driving diaphragm, the embodiment shown in Fig. 8 may be utilized. In this embodiment the front of the cabinet comprises a single panel 20'' with which baffles 30' and 31' join at its juncture with the top and bottom of the cabinet. Two driving units 27*a* and 27*b* reproduce vibrations which are fed to throats 27*a*' and 27*b*' and thence to two columns or horn sections in parallel. Externally the device is the same as that shown in Fig. 1.

For theater use a speaker such as that shown in Fig. 8 has the same power handling capacity as do the 8-foot units customarily used and to which reference has been made. By grouping such units as in Fig. 7, the power handling capacity of four driving units can be achieved.

For stadium use of the embodiment shown in Fig. 8, the arrangement of Fig. 6 would quadruple the power handling ability. For aerial suspension (as over the stage in a large arena) a pair of groups shown in Fig. 6 may be stacked to give several hundred watts of power capacity. In each of the arrangements described there is a saving in space compared to existing systems. A single unit like that of Fig. 1, designed to reproduce down to 40 cycles, will occupy only about 15 cubic feet compared to 120 cubic feet for the customary theater low frequency horns.

In a loud speaker as depicted in Figs. 1 to 4 and utlizing a 12" driving unit with about 1000 cm. of voice coil conductor operating in a field of approximately 13,000 gausses, the voice coil impedance was measured with a unity-ratio impedance bridge. The impedance at various frequencies is shown in Fig. 9.

The resistive component, curve *a*, and reactive component, curve *b*, were measured with the diaphragm moving freely except for the air loading provided by the horn and air chambers. The motional impedance is the difference between this measured impedance and the impedance of the voice coil with the diaphragm blocked. The blocked impedance was found by turning off the field supply so that the diaphragm motion was reduced to an imperceptible value. The blocked impedance is shown in curves *c* and *d*; curve *c* is the resistive component and curve *d* is the reactive component. Thus the difference between curves *a* and *c* is the motional resistance which may be used to determine the efficiency. Probably the best method of computing efficiency is that offered by Bostwick (Journal of the Acoustical Society of America, vol. 2, page 243, 1930). Using the measured impedances and the Bostwick equation, the efficiency was computed and is shown in Fig. 10.

The efficiency was also computed from the horn dimensions and the constants of the driving unit, and shown in applicant's article in Journal of the Acoustical Society of America, vol. 13, No. 2, page 137 (October 1941) in Fig. 8 of that article. The differences between the efficiencies computed from the measured data and computed from the horn dimensions are of little or no practical significance. The article entitled, "Improved low frequency horn" in Journal of the Acoustical Society of America, to which reference has already been made, describes some of the theoretical aspects of the speaker unit, together with explanations of minor discrepancies between theoretical and actual performance.

For the purpose of simplicity in the specification and claims, the terms, "front" and "rearwardly" are intended to have the following meanings: "Front" is the surface as seen by an observer in the room facing the speaker housing in the corner. "Rearwardly" is the direction more remote from the observer that is toward the corner. Thus, the "front panel" is panel **20** or **20'** in Figs. 1 to 5. "Rearwardly" would mean generally to the left in Fig. 3 or 8 and obliquely to the right and upwards in Figs. 1 and 5. Also, the "working side of the diaphragm" means the side facing the horn throat and the "non-working side" means the side facing away from the throat.

By "multiple taper" is meant that the expansion rate of the horn near the throat is more rapid than the remainder of the horn. This is explained in applicant's aforementioned article in the Journal of the Acoustical Society of America. The use of such multiple taper results in an effective throat area equal to the actual area for higher frequencies, say above 200 cycles for the speaker constructed, as above indicated and an effective throat area which is larger than the actual throat area for low frequencies. Thus by "effective throat area" is meant that area which is effective in the specified frequency range.

By "taper rate" or "flare rate" is meant the length of horn within which the area doubles. For exponential expansion this "rate" is $^1/_{18}$ of the longest wave length which the horn can transmit. The "multiple taper" involves the use of a connector between a low frequency horn and its driving diaphragm as explained by Olson in a paper, "A horn consisting of manifold exponential section," Journal of the Society of Motion Picture Engineers, vol. 30, page 551 (1938). Thus, where different tapers are referred to, the "high frequency taper" refers to the rapidly flaring portion near the diaphragm, and "low frequency taper" refers to the flare rate of the subsequent larger sections of the horn.

The volume of the air chambers is determined in the applicant's aforementioned article (October, 1941). The rear air chamber or that on the non-working side of the diaphragm, for an infinite horn, should have a volume of 2.9 times the product of the throat area and the flare rate. Where multiple flare is used, the flare rate in this product is that of the low frequency part of the horn. For practical horns of finite length this air chamber size should be smaller, of the order of half as large as the theoretical value for an infinite horn. The front air chamber, or that between the working side of the diaphragm and the throat, is used to overcome the extra mass reactance due to the multiple taper. The short, rapidly flaring, initial horn section introduces a mass reactance in the higher frequency range. This front air chamber should be about half the product of the actual throat area (effective at high frequencies) times the taper rate of the rapidly flaring connector. Thus, for the horn as constructed, the area was 50 square inches, the initial taper rate was 8 inches, and the product was 400. A volume of 250 cubic inches was used. This size air chamber is applicable to the design shown herein.

For a speaker unit with a wider range of frequencies the general requirement for a front air chamber is that its reactance should be roughly equal numerically to the throat impedance and the diaphragm mass reactance at the highest frequency which the horn must transmit. This is explained in Olson's "Elements of Acoustical Engineering," Van Nostrand 1940.

Elsewhere herein have been given certain dimensions. For the purpose of further showing the overall size of the speaker giving results shown in Figs. 9 and 10, and hence further illustrating the advantages of the invention, the following additional dimensions are given: In Fig. 1 the front panel may be 24 inches in width and 38 inches in height. The width of the top cover **4** may be 39 inches. The distance from the panel **20** to the corner formed by the intersection of side walls **1** and **2** may be 27 inches.

If 30 cycles is taken as the effective cut-off (Fig. 10), the longest wave length is about 440 inches. Hence, a speaker having the approximate dimensions just indicated has a maximum dimension that is of the order of $\frac{1}{11}$ of a wave length. This condition may be achieved by the present invention and with a minimum loss in fidelity of the low frequency tones approximate the cut-off frequency.

Naturally, the specific dimensions given are for illustration only, and should not be interpreted as limitations.

Broadly, the invention comprehends a loud speaker of small size capable of reproducing with high fidelity the lower range of the audio spectrum.

What is claimed is:

1. In a horn type loud speaker wherein proximate surfaces cooperate to form horn portions of the speaker, a cabinet comprising a front panel, said panel being of a width to provide open spaces between its side edges and the proximate surfaces, a cover, an inner panel spaced rearwardly of said front panel and having a throat opening therein, side panels extending convergingly rearwardly of said front and inner panels and spaced from the proximate surfaces to form outer horn sections therewith, means forming flaring passages between said opening and said outer horn sections, and a driving unit mounted rearwardly of said opening to reproduce and transmit sound through said opening and the horn sections therebeyond.

2. In a horn type loud speaker wherein proximate surfaces cooperate to form horn portions of the speaker, a cabinet comprising a front panel, said panel being of a width to provide open spaces between its side edges and the proximate surfaces, a cover, an inner panel spaced rearwardly of said front panel and having a throat opening therein, side panels extending convergingly rearwardly of said front and inner panels and spaced from the proximate surfaces to form outer horn sections therewith, means forming flaring passages between said opening and said outer horn sections, and a driving unit mounted rearwardly of said opening to reproduce and transmit sound through said opening and the horn sections therebeyond, said driving unit including a diaphragm spaced rearwardly from said opening to form an air chamber therebetween.

3. In a horn type loud speaker wherein proximate surfaces cooperate to form horn portions of the speaker, a cabinet comprising a front panel, said panel being of a width to provide open spaces between its side edges and the proximate surfaces, a cover, an inner panel spaced rearwardly of said front panel and having a throat opening therein, side panels extending convergingly rearwardly of said front and inner panels and spaced from the proximate surfaces to form outer horn sections therewith, means forming two flaring passages between said opening and said outer horn sections, and a driving unit mounted rearwardly of said opening to reproduce and transmit sound through said opening and the horn sections therebeyond, said driving unit including a diaphragm spaced rearwardly from said opening to form an air chamber therebetween, said means also forming a closed air chamber at the non-working side of the driving unit whereby the mass reactance of the throat impedance at low frequencies is offset.

4. In a horn type loud speaker wherein proximate surfaces cooperate to form horn portions of the speaker, a cabinet comprising a front panel of a width to provide open spaces between its side edges and the proximate surfaces, a cover, an inner panel spaced rearwardly of said front panel and having a throat opening therein, side panels extending convergingly rearwardly of said front and inner panels and spaced from the proximate surfaces to form outer horn sections, said cover extending sidewardly beyond said side panels to form one side of said outer horn section, means forming flaring passages between said opening and said outer horn sections, and a driving unit including a diaphragm extending rearwardly therefrom to form an air chamber between the diaphragm and said throat opening, said means including baffles cooperating with said diaphragm to form a closed air chamber at the side thereof opposite said throat.

5. In a horn type loud speaker wherein proximate surfaces cooperate to form horn portions of the speaker, a cabinet comprising a front panel, a second panel spaced rearwardly therefrom and having a throat opening therein, rearwardly converging panels attached to said front and second panels adapted with the proximate surfaces to form terminal horn sections, a cover, baffles within said cabinet forming a flaring passage from said opening to the terminal horn sections, certain of said baffles forming an air chamber rearwardly of said second panel, and a driving unit within said chamber for reproducing and transmitting sound vibrations outwardly through said opening.

6. In a horn type loud speaker wherein proximate surfaces cooperate to form horn portions of the speaker, a cabinet comprising a front panel, a second panel spaced rearwardly therefrom and having a throat opening therein, rearwardly converging panels attached to said front and second panels and adapted with the proximate surfaces to form terminal horn sections, a cover in engagement with the end of said front and converging panels and extending outwardly to engage the proximate surfaces, baffles within the cabinet forming multiple taper horn sections, certain of said baffles forming an air chamber within the cabinet, and a driving unit mounted within said chamber and forming a closure for said opening.

7. In a horn loudspeaker adapted to be operated in the corner formed by three mutually perpendicular surfaces, a plurality of baffles in sealed relation to form a substantially pyramidal air chamber, an aperture in one of said baffles, said aperture being adapted to be closed by a vibratile diaphragm, a second plurality of baffles defining an air column which expands from said aperture and which folds around the said air chamber, and further baffles partially defining a further length of air column, the definition of said further length of air column being completed by said three surfaces when the assembly of baffles is placed in the corner formed by said surfaces.

8. A horn loudspeaker comprising a sealed air chamber defined by baffles, one of said baffles being apertured and adapted to support a loudspeaker driving unit with its diaphragm in operating relation to said aperture, additional baffles defining an expanding air column from said aperture and arranged to fold said air column over said air chamber successively in opposite directions, the baffles comprising the last fold being adapted to cooperate with three mutually perpendicular surfaces to complete the terminal section of the air column.

9. A horn loudspeaker comprising a sealed air chamber defined by baffles, one of said baffles being apertured and adapted to support a loud-

speaker driving unit with its diaphragm in operating relation to said aperture, additional baffles defining an expanding air column from said aperture and arranged to fold said air column over said air chamber successively in opposite directions, the baffles comprising the last fold being adapted to cooperate with three mutually perpendicular surfaces to complete the terminal section of the air column, the structure comprising said baffles having its largest dimension of the order of ⅛ to 1/11 the wave length of the acoustic cut-off of the expanding air column.

10. A loud speaker horn including a cabinet having baffles therein forming an air passage comprising multiple taper horn sections, said air passage having a throat at its smaller end, an enclosure within the cabinet communicating with said throat, a driving unit including a diaphragm mounted within said enclosure to form an air chamber on the non-working side of the diaphragm, said air chamber having a volume of from one to three times the product of the effective throat area at low frequencies and the low frequency taper rate.

11. A loud speaker horn including a cabinet having baffles therein forming an air passage comprising multiple taper horn sections, said air passage having a throat at its smaller end, an enclosure within the cabinet communicating with said throat, a driving unit including a diaphragm mounted within said enclosure to form an air chamber on the working side of the diaphragm, said air chamber having a volume of approximately one-half the product of the actual throat area times the taper rate of the portion of the horn proximate the throat.

12. In a horn type loud speaker wherein proximate wall surfaces cooperate to form horn portions of the speaker, a cabinet comprising a front panel, rearwardly converging side panels attached to said front panel and adapted with the proximate wall surfaces to form a terminal horn section, a cover abutting an end of said front and side panels and extending outwardly to abut the proximate surfaces, a pair of baffles diagonally located within the cabinet so that they, together with the front and side panels, define an air chamber and a pair of horn sections which horn sections communicate with said terminal horn sections, throat apertures in each of said diagonal baffles connecting the horn sections with the air chamber, and loud speaker driving units mounted so that their diaphragms close said throat apertures.

13. In a horn type loud speaker wherein proximate surfaces cooperate to form horn portions of the speaker, a cabinet comprising an apertured front panel, said panel being of the width to provide open spaces between its side edges and the proximate surfaces, side panels extending convergingly rearward of said front panel and spaced from the proximate surfaces to form outer horn sections therewith, means forming flaring passages between the aperture and said front panel and said outer horn sections, said flaring passages comprising a horn throat terminated by the aperture in said panel, baffles defining an air chamber in front of the aperture in said front panel and a driving unit mounted so that its diaphragm closes said aperture whereby the non-working side of said diaphragm is loaded by the air chamber and the working side of said diaphragm is loaded by the throat of the horn formed rearwardly of said aperture.

14. In a horn type loud speaker wherein proximate wall surfaces cooperate to form horn portions of the speaker, a cabinet comprising a front panel of a width to provide open spaces between its side edges and the proximate wall surfaces, side panels abutting the side edges of said front panel and extending convergingly rearward therefrom and spaced from the proximate wall surfaces to form outer horn sections therewith, means forming flaring passages between said side panels terminating in the outer sections of the horn at one end and in a horn throat at the other end, an apertured member at the throat termination of said passageways with its aperture communicating with said throat, baffles defining an air chamber attached to the apertured member opposite the throat, and a driving unit mounted with its diaphragm closing said aperture.

15. The combination comprising a pair of horn units in accordance with claim 14, arranged side by side in mutual abutting relation and in abutting relation with a proximate plane surface whereby the reproduced sound is radiated into a π solid angle.

16. The combination comprising a cluster of four horn units in accordance with claim 14, arranged in symmetrical abutting arrangement for radiation into a 2π solid angle.

17. The combination comprising a cluster of eight horn units in accordance with claim 14, one set of four units being superposed upon the other set of four units, for spherical radiation or radiation into a 4π solid angle.

18. A folded horn loudspeaker comprising an acoustic chamber coupled to one side of vibratile diaphragm and an air column coupled to the other side thereof, characterized by an arrangement of baffles defining said air chamber and air column such that the air column is divided and folded over two opposite sides of said air chamber, then folded back over the other two sides, the whole horn being so arranged that when operated in a corner formed by three mutually perpendicular wall surfaces the last fold consists of two air columns defined by the recited structure and by said surfaces.

19. A horn loudspeaker structure of insufficient size to radiate efficiently the longest wave length to be propagated but adapted to be operated in the corner formed by three mutually perpendicular surfaces whereby the reflections from said surfaces produce images which, together with the structure, form a radiator of sufficient size for efficient radiation, said structure comprising a vibrating diaphragm, coupled on one side to an air chamber and on the other side to an expanding air column, characterized by baffles defining said acoustic elements and arranged so that the air column first expands within a substantially unitary structure, and finally expands outside said structure and between said structure and said surfaces, said air column having at least one rate of expansion which is substantially continuous from the diaphragm to the region where it emerges from the mouth formed by the structure and said surfaces, the mouth size, rate of expansion and air chamber size being coordinated to enable the speaker unit to radiate a wave length of the order of six to eleven times the longest overall dimension of the structure.

20. A loudspeaker according to claim 19, further characterized by two different taper rates of the air column, the more rapid taper rate being proximate the vibratile diaphragm.

21. In a horn loudspeaker, a unitary structure comprising baffles defining an air chamber cou-

pled to an air column with a vibratile diaphragm therebetween, said baffles defining said air column being arranged to contain a part of the air column within the unitary structure and the remainder of the air column external thereto, the definition of the said air column remainder being adapted to be completed by three mutually perpendicular surfaces when the defined structure is operated in the corner formed by said surfaces.

22. A horn loudspeaker comprising a cabinet having an air chamber therein, there being an aperture in said chamber, a loudspeaker driving unit including a diaphragm mounted in obturating relation with said aperture and forming of the air chamber a sealed acoustic chamber on one side of said diaphragm, and baffle means extending from said aperture outside said chamber and cooperating with three mutually perpendicular surfaces to form an expanding air column for transmission of vibrations from said diaphragm to the exterior of the cabinet.

PAUL W. KLIPSCH.