Dec. 14, 1937. H. F. OLSON 2,102,212

SOUND REPRODUCING APPARATUS

Filed Sept. 30, 1935

Fig. 1.

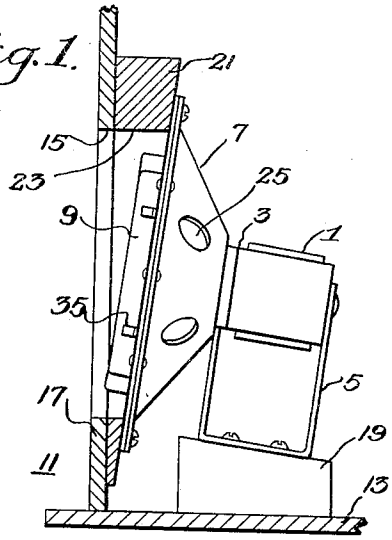


Fig. 4.

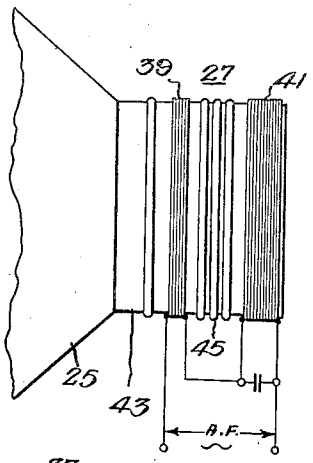


Fig. 2.

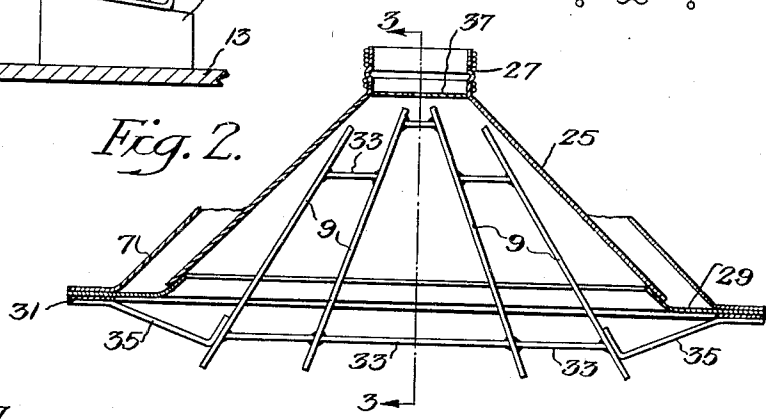
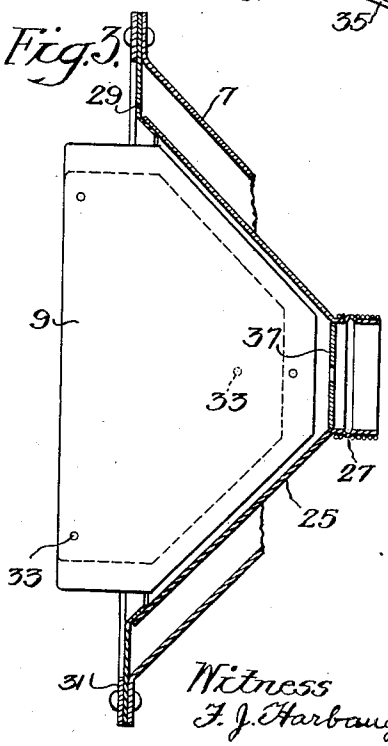


Fig. 3.



Witness
F. J. Harbaugh

Fig. 5.

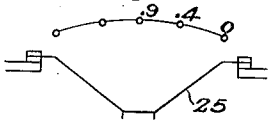


Fig. 6.

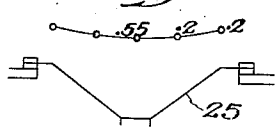


Fig. 7.

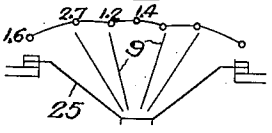
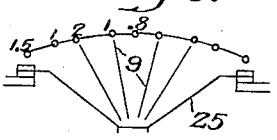


Fig. 8.



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UNITED STATES PATENT OFFICE

2,102,212

SOUND REPRODUCING APPARATUS

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Application September 30, 1935, Serial No. 42,896

9 Claims. (Cl. 181—31)

My invention relates to improvements in sound reproducing apparatus, and more particularly to a distributor for deflecting or diffusing sound waves radiated from a loud speaker.

In its broadest aspect, an important object of my invention is to provide means for obtaining a more uniform distribution of sound waves issuing into a room from a loud speaker.

More specifically, a further object of my invention is to provide means for effectively directing and spreading the high frequency sound waves radiated from a baffle connected cone type dynamic loud speaker having a substantially extended high frequency range, as constructed and operated in accordance with the teachings of my Patent No. 2,007,748 and Ringel Patent No. 2,007,747, issued July 9, 1935.

When a vibrating element, such as a diaphragm which radiates directly to the open air, is small in comparison with the wave length of the sound being radiated, the sound waves which are set up by the diaphragm are propagated spherically therefrom. On the other hand, when the radiating surface becomes comparable with or larger than the wave length of the sound waves being radiated, the wave propagation is substantially perpendicular to the effective moving surface and for a considerable distance from the surface, the propagation takes the form of a beam which does not spread or diffuse appreciably. As a result, there is a tendency toward an excess of high frequencies directly in front of the loud speaker and an insufficiency of high frequencies at the sides of the loud speaker as well as above it. This results in an uneven response throughout the room in which the loud speaker is located, with an excess of either high or low frequencies according to the position of the listener relative to the speaker.

Furthermore, because of the fact that in general the sound absorption characteristics of most boundaries used in rooms increase with frequency, the high frequency radiation from a loud speaker is more quickly absorbed and therefore does not seem as diffuse as the low frequency radiation. For this reason the sound in such rooms is localized by the ear through listening to the high frequency sound radiation. As a consequence, a beam characteristic has been attributed to cone loud speakers.

The principal factors involved in the acoustic performance of a radio receiver in a room are the response, directional and energy output characteristics of the loud speaker in the receiver and the reverberation characteristics of the room. The action and the various factors involved in this system are treated in detail in "Applied Acoustics", by Olson and Massa, published by P. Blakiston's Son, Philadelphia, Pa., page 351. The results may be summarized as follows: The ratio of reflected to direct sound (the reproduced reverberation) is proportional to the "angular spread" of the loud speaker and proportional to the reverberation time of the room. Since the room cannot be altered, the solution of the problem of increasing the high frequency reverberation is to increase the angle of high frequency sound radiation. It is the purpose of this invention to disclose a preferred system for increasing the angle of high frequency radiation from a cone loud speaker.

In the case of a horn the radiation characteristic is symmetrical about the axis of symmetry. If the cross section of the horn is comparable to a wave length, its action from the standpoint of its directional characteristics is independent of the environs. Then one means of increasing the angle of distribution is to employ several horns connected to the cone, of dimensions suitable to the range over which increased distribution is desired, the axes thereof being directed to obtain the desired angular spread. In this particular application it is desirable to increase the spread in the horizontal plane, the radiation in the vertical plane usually being sufficiently broad and satisfactory if directed upwardly from the horizontal. In accordance with my invention the horn effect can be obtained inexpensively by utilization of vanes intimately coupled acoustically to the diaphragm, resulting in an arrangement having the effectiveness of several small horns with axes inclined at different angles.

Further, in accordance with my invention, I have devised simple and inexpensive means for directing the high frequency sound beam upwardly from the horizontal or floor thereby preventing wasteful radiation at the floor level.

For a more complete disclosure of the invention, reference should be made to the following specification which should be read in connection with the accompanying drawing, in which

Fig. 1 is a side elevation view, partly in section, and reduced in size, of acoustic apparatus embodying my invention,

Fig. 2 is a plan view, in relatively enlarged form and partly in section, of a loud speaker and sound directing elements of the acoustic apparatus of Fig. 1,

Fig. 3 is a side elevation view in section of the elements shown in Fig. 2, taken on lines 3—3,

Fig. 4 is a side view, in enlarged form relative to Fig. 1, and with portions broken away, of driving means employed in the device shown in Fig. 1,

Figs. 5 and 6 are graphs illustrating response characteristics of acoustic apparatus without the features of my invention, and

Figs. 7 and 8 are graphs illustrating response characteristics of the acoustic apparatus made in accordance with my invention.

Referring to Fig. 1 of the drawing, a loud speaker, preferably of the electrodynamic direct acting type, comprising a field winding 1, a field yoke 3 of magnetic material, a metallic support base 5 and a diaphragm support or housing 7, is provided with diverging vanes 9 and is supported preferably in the bottom portion of a radio cabinet 11. It is mounted in a suitable manner as on a shelf or bottom wall 13 of the cabinet, and adjacent an opening 15 in a baffle or front wall 17 of the cabinet. The speaker is supported in an inclined position, as by means of wedge-shaped blocks 19 and 21, block 21 having an opening 23 in alignment with the baffle opening and effectively forming an acoustic seal between the baffle and the bases of the cone diaphragm and housing. The baffle is preferably vertical, principally for manufacturing reasons, but I do not wish to be limited to such a structure. The angle of inclination of the speaker, between the cone diaphragm axis and the horizontal, is preferably around seven to ten degrees. This effectively gives a total spread of the high frequency beam of the order of 30 to 35 degrees in the vertical plane and minimizes the possibility of frequency discrimination for points removed from the axis of the loud speaker.

Referring to Figs. 2 and 3, the high frequency sound distributor 9, with its mounting structure, is shown in its relation to a speaker diaphragm 25 of conical or equivalent form, which I will refer to as a cone type diaphragm structure. The diaphragm is provided at its small end with a double voice coil driving structure 27, shown in detail in Fig. 4 and disclosed in my patent above referred to, and at its large end is supported by the usual annular flexible means 29 from the diaphragm housing. The flexible ring is clamped to a flange on the housing 5 by a metal ring 31. The distributor 9 consists of a plurality of vanes, four being shown by way of illustration in the apparatus built and used in accordance with my invention, which divide the space in front of the concave side of the cone diaphragm effectively into five horns with horizontal axes inclined at different angles. The vanes are disposed, respectively, in different vertical, non-parallel or divergent planes, although the vane surfaces may be curved, if desired. The vanes are held together in spaced relation by means of small metal rods 33 spot-welded thereto and the assembly is supported, by metallic strips 35, from the cone ring 31. The inner ends of the vanes are spaced closely to the small end of the cone diaphragm and centering disc 37, respectively, by an amount to allow for free vibration of the cone, of the order of $\frac{3}{16}$ inch. Such closeness of spacing is desirable for effective operation of the vanes as horns in the radiation of high frequency sound waves, for the purpose of minimizing leakage between horn sections at the edges of the vanes near the diaphragm. I prefer to use sheet metal for the vanes about $\frac{1}{32}$ inch thick. I have found that paper or wood is not satisfactory because of the high degree of absorption of these materials of the higher frequencies, particularly when used in areas of high pressure. In other cases, where vanes have been distantly spaced in front of the cone, where the action is that of a reflector, it is not advantageous to use metal.

Referring to the graphs of characteristic performance, shown in Figs. 5–8, I have shown the result of tests of a speaker, without and with the vanes. The speaker employed, designated by Serial No. PL–77, had an eight inch cone of light paper and a double voice coil, a small coil 39 and a large coil 41, shown in detail in Fig. 4. The coils were wound on a form 43 of light weight metal, provided with compliances 45 between coils. The tests were made with the speaker mounted behind a flat baffle instead of in a cabinet, the action at the high frequencies being the same with a baffle as with a large cabinet.

To show the action of the sound distributor, the shape of the wave front directly in front of the cone, with and without the distributor, was determined by means of a microphone explorer moved so that the phase of the wave was the same for each observation point. The line in front of the cone in each figure represents a line of equal phase of the sound, and the numbers along the line indicate relative sound pressures at the various points at which the pressures were determined. A comparison of the curves of Figs. 6 and 8 illustrate the effectiveness of the vanes in spreading the high frequency sound beam. While readings were taken for the range of 3000 to 8000 cycles, only those for 6000 and 8000 cycles are illustrated. Those below 6000 are not sufficiently different or significant to warrant illustration.

I am aware of the fact that certain workers in the art have proposed to spread the high frequency beam horizontally by means of reflecting vanes placed in front of the cone diaphragm. They have not, however, appreciated the fact that it is highly desirable, for effective results, to place the vanes as close to the cone as is consistent with maximum amplitude of vibration in order to reduce leakage around the edges of the vanes adjacent the cone. In effect, such vanes, as previously used, have been reflectors, the high frequency sound waves having impinged against the vanes and literally bounced off at an angle depending upon the inclination of the vanes. This has resulted in distinct beams to either side of one straight ahead of the cone, with a considerable amount of space in-between characterized by an absence of high frequency sound waves. In my arrangement the vanes constitute a plurality of short horns arranged to direct the high frequency waves from the source, close to the diaphragm surface, with the well known desirable action of a horn.

I am aware also that still others have inclined speakers with the cone axis up from the horizontal, as by inclining a baffle board and speaker, presumably for the purpose of raising the high frequency beam from the floor. Inclined baffles have had certain disadvantages; they take up more room in a cabinet and the assembly is more expensive.

However, the problem of high frequency sound wave distribution has heretofore not existed to any practical extent, since the problem arises to a substantial degree only when really high fidelity apparatus is used. The speakers in general use for several years are well known to have an upper limit of 4000 to 5000 cycles in response characteristics. The curve in Fig. 5 shows that at 6000 cycles, beyond the limit of ordinary prior

apparatus, there was no beam effect. Beyond 6000 cycles, the response in the case of prior apparatus was negligible, as may be seen by referring to Fig. 4 of my Patent No. 2,007,748, which illustrates a curve made from a standard dynamic speaker of fairly recent design and one made from a high fidelity double voice coil speaker.

It will be seen that, as a result of my invention, the response for all frequencies is appreciably more uniform than heretofore. Without the high frequency distributor the radiation was found to be attenuated 6 decibels, for example, at 25 degrees. With the distributor, however, the radiation, assuming an average of curves taken from 3000 to 8000 cycles, was attenuated 6 decibels for an angle of 45 degrees; or the total spread is increased from 50 degrees without the distributor to 90 degrees with the distributor.

While I prefer to employ my sound distributor device in combination with a double voice coil dynamic speaker for both highs and lows, it has utility when used with a speaker designed to reproduce only the high frequencies. I have employed it to good advantage with a similar arrangement, invented by me, wherein high frequencies are radiated only from the front surface of a cone type diaphragm and low frequencies are taken from the rear thereof.

It is to be understood that the apparatus set forth is for explanation and illustration only and that many changes therein can be made without departing from the spirit and substance of my invention, the scope of which is to be limited only by the appended claims.

What I claim is:

1. In a sound reproducing apparatus, a substantially vertical baffle having an opening, a loud speaker having a cone type diaphragm adapted to be driven to radiate directly low frequency sound waves and a beam of high frequency sound waves, means for mounting said speaker in operative relation to said opening and with the axis of said diaphragm inclined upwards for raising said beam from the horizontal and means positioned adjacent the concave surface of said diaphragm in intimate acoustic coupling relation therewith for diffusing said beam of high frequency sound waves horizontally.

2. The invention as set forth in claim 1, characterized in that said diffusing means comprise a plurality of metal vanes disposed, respectively, in different non-parallel planes.

3. In a loud speaker of the direct acting type, an acoustic diaphragm structure, means for driving said diaphragm structure as a piston over a lower range of frequencies, means for driving at least a portion of said diaphragm structure over a higher range of frequencies for radiating waves of dimensions comparable to or shorter than the radiating surface of said diaphragm, said waves being characterized by a beam effect, a baffle structure cooperating with said diaphragm structure and low frequency driving means for the effective radiation of sound waves in said lower range, and a plurality of vanes divergently disposed with edges adjacent said diaphragm structure, forming a plurality of horns coupled in close acoustic relation to said diaphragm structure for the effective radiation and diffusion of the waves throughout said higher audio range.

4. In a sound reproducing apparatus, a cone type loud speaker, a cabinet housing for said speaker adapted to be placed in a room, means for mounting said speaker in said cabinet adjacent the bottom thereof with the cone diaphragm axis inclined upwardly from the horizontal, and means forming a plurality of horns positioned closely adjacent the concave surface of the small end of said diaphragm for diffusing high frequency sound waves radiating from the surface of said diaphragm.

5. In a sound reproducing device, a cone diaphragm adapted to be driven to radiate a beam of high frequency sound waves, a housing for supporting said diaphragm, a plurality of directing vanes of sheet metal divergently disposed in the concave side of said diaphragm, the inner ends of said vanes being closely disposed to said diaphragm and forming a plurality of horns coupled in close acoustic relation thereto, and means for supporting the vanes, in spaced relation, from said housing.

6. In a sound reproducing apparatus, a loud speaker having a cone type diaphragm for direct radiation of low frequency sound waves and adapted to be driven to radiate sound waves of such a high frequency that the waves are radiated in a narrow beam, a plurality of horns having their small ends closely coupled acoustically to the concave surface of the small end of said diaphragm in a high pressure high frequency area, said horns being mounted in divergent directions to diffuse said waves.

7. In a loud speaker, a cone diaphragm, a plurality of sheet metal vanes for effectively partitioning the space enclosed by the concave side of said diaphragm into a plurality of divergent short horns, means for positioning the edges of said vanes adjacent different portions of the diaphragm as close as possible thereto consistent with vibration of said diaphragm, whereby leakage around said edges is substantially reduced.

8. In a loud speaker of the direct acting type, a cone type diaphragm adapted to radiate directly low frequency sound waves and tending to radiate a beam of high frequency sound waves of a length comparable with or shorter than the radiating surface of said diaphragm, a driving structure for said diaphragm comprising a plurality of substantially independently acting means, one of which is adapted to drive at least a portion of said diaphragm to radiate said high frequency sound waves, a plurality of horns having their small ends disposed adjacent the concave surface of said diaphragm in intimate acoustic coupled relation therewith in a high frequency high pressure area and extending in divergent directions into a low pressure area for the efficient radiation and diffusion of said beam.

9. In a loud speaker of the direct acting type, a cone type diaphragm adapted to radiate sound waves of a limited lower range of frequencies and sound waves of a limited higher range of frequencies, a compound driving structure for said diaphragm comprising a plurality of substantially independently acting means connected to the small end of said diaphragm, one of said driving means being adapted to drive at least the small end of said diaphragm to radiate said high frequency sound waves and a plurality of vanes divergently disposed on the concave side of said diaphragm for effectively subdividing the enclosed space in front of the diaphragm into a plurality of horns, the edges of said vanes being so closely disposed to different portions of said diaphragm that said horns are intimately coupled acoustically to said diaphragm for the effective radiation of sound waves over said high frequency range.

HARRY F. OLSON.