Oct. 17, 1933. E. C. WENTE 1,930,915

ACOUSTIC DEVICE

Filed July 13, 1932 2 Sheets-Sheet 1

FIG. 1

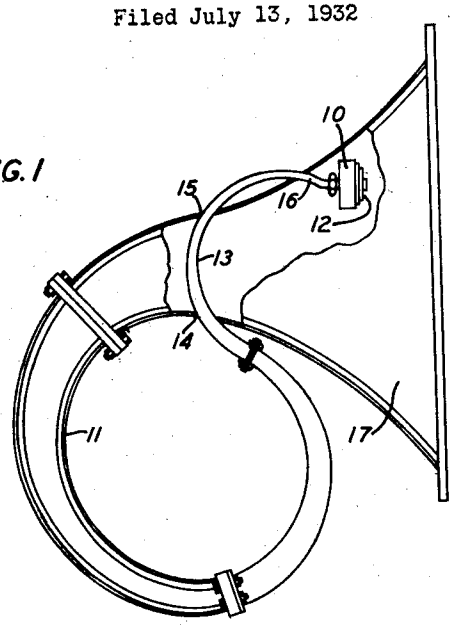


FIG. 2

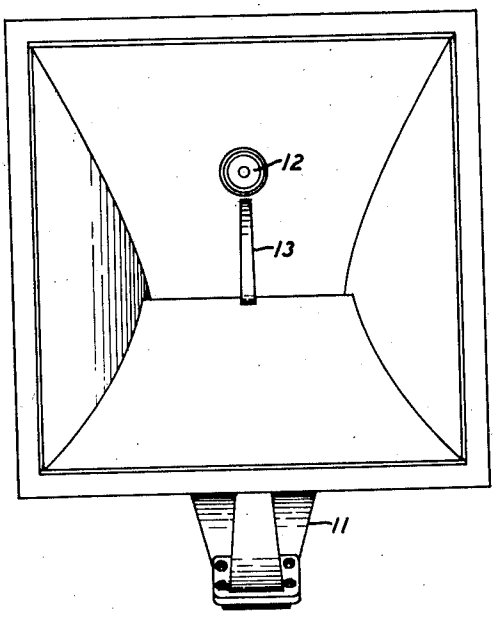
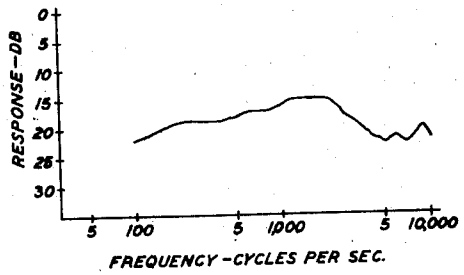


FIG. 3



INVENTOR
E. C. WENTE
BY
Walter C. Kiesel
ATTORNEY

Oct. 17, 1933. E. C. WENTE 1,930,915

ACOUSTIC DEVICE

Filed July 13, 1932 2 Sheets-Sheet 2

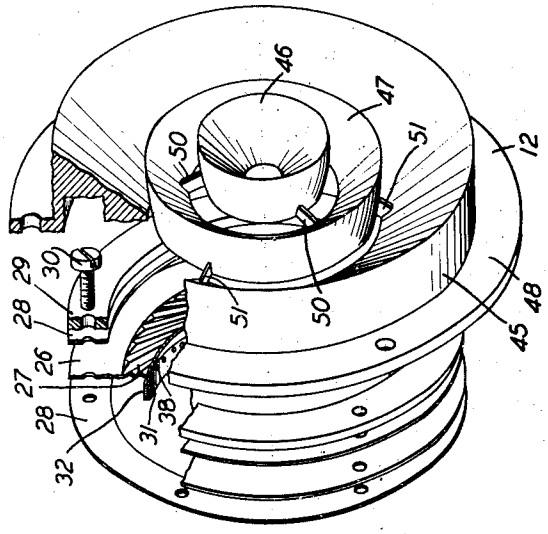


FIG. 5

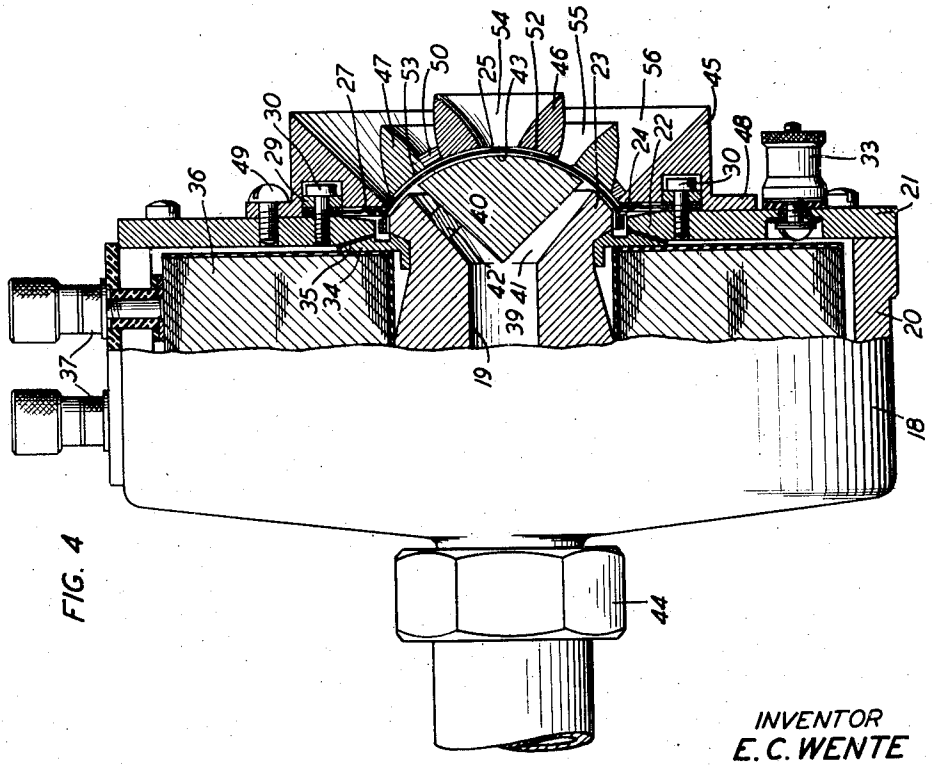


FIG. 4

INVENTOR
E. C. WENTE
BY
Walter C. Kiesel
ATTORNEY

Patented Oct. 17, 1933

1,930,915

UNITED STATES PATENT OFFICE

1,930,915

ACOUSTIC DEVICE

Edward C. Wente, New York, N. Y., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application July 13, 1932. Serial No. 622,190

18 Claims. (Cl. 181—27)

This invention relates to acoustic devices and more particularly to loud speaking telephones.

An object of this invention is to improve the response of a loud speaker over substantially the entire frequency range of speech and music.

A feature of this invention comprises loading a diaphragm on each of its sides with a horn, one horn having its lower cut-off at a frequency approximately that of the upper cut-off frequency of the other horn.

Another feature of this invention comprises loading a diaphragm on each of its sides with a horn, one of said horns comprising a plurality of nested, spaced members defining a plurality of sound wave passages.

A further feature of this invention comprises loading a diaphragm on each of its sides with a horn, one of the horns increasing the air load on said diaphragm for frequencies above the upper cut-off frequency of the other horn, said one horn also distributing the sound over a solid angle of

$$\frac{\pi}{2}.$$

This invention is embodied, preferably, in a loud speaker comprising two horns, a diaphragm, and means for actuating the diaphragm. The diaphragm is loaded on each of its sides by a horn and is positioned so that the sound waves emitted by each horn are propagated in the same direction. One horn is particularly adapted for the reproduction of the frequency range of speech and music up to approximately 5000 cycles per second and the other for the reproduction of the frequency range of speech and music above approximately 5000 cycles per second. The latter horn, comprising a plurality of nested, spaced members, preferably annular, defining a plurality of sound wave passages, increases the air load on the diaphragm for frequencies above approximately 5000 cycles per second and diminishes the directive character of the high frequency radiations by distributing the sound over a solid angle of

$$\frac{\pi}{2}.$$

A more complete understanding of this invention will be obtained from the description which follows, taken in conjunction with the appended drawings, wherein:

Fig. 1 is a side view partially broken away of the two-horn loud speaker comprising a feature of this invention;

Fig. 2 is a front view of the loud speaker of Fig. 1;

Fig. 3 illustrates the radiation characteristic of a loud speaker of the type shown in Fig. 1 embodying the features of this invention;

Fig. 4 shows the receiver unit of the loud speaker of Fig. 1 partially broken away and partly in section to show more clearly features of this invention; and

Fig. 5 is an exploded perspective view partly broken away and partly in section of portions of the receiver unit of Fig. 4 and the high frequency distributor or horn of this invention.

Referring to the drawings, Figs. 1 and 2 disclose a sound reproducer or loud speaker comprising a receiver unit 10, a horn 11, and a high frequency distributor or horn 12. The horn 11 is preferably of the exponential type and may be constructed in accordance with the disclosure of D. G. Scrantom Patent 1,852,793, granted April 5, 1932. The horn section 13 intersects the horn at 14, 15 and 16, the receiver unit being positioned preferably within the mouth or bell portion 17.

The receiver unit, as shown more clearly in Figs. 4 and 5, comprises a casing 18 of magnetic material having a central pole 19 and an outer pole 20. An annular plate pole piece 21 of magnetic material is carried by the pole 20 and its inner tapered portion 22 is spaced from the upper tapered portion 23 of the pole 19 to define an air gap 24. A diaphragm having a central stiffened, dished or dome portion 25, an outer, flat peripheral or rim portion 26, and an intermediate, corrugated, flexible annular portion 27, is mounted at its peripheral portion between washers 28 of insulating material. The diaphragm is secured to the plate pole piece 21 by the clamping ring member 29 and a plurality of fastening means 30. At the junction of the annular portion 27 and the dome 25, a coil support or form 31, of suitable material, for instance an aluminum ring, is attached to the diaphragm and has thereon an edgewound conductor or coil 32. The coil and form are disposed in and adapted for movement in the air gap 24. The coil leads are brought out in any suitable manner to the binding posts or terminals 33, one only of which is shown. A closure or ring member 34 is positioned under the air gap closing it off from the coil chamber of the casing 18. A sealing washer or gasket 35 is interposed preferably between the closure member and the pole piece 21. The closure member is preferably of a non-magnetic material, such as brass. The casing contains a ribbon-wound energizing coil 36, the ends of which terminate

at the terminals 37. So that the air under the flexible portion 27 of the diaphragm will not be unduly confined and so that the movements thereof may contribute to the output of the receiver, the coil form is provided with a plurality of perforations 38. These perforations furnish a very short path from the space under the flexible annular portion 27 to the sound wave passage 39 in the pole 19.

A conical plug member 40 is supported in the enlarged end or sound chamber 41 of the passage 39 being spaced from the wall of the passage by three equally spaced thin, flat spacer members 42, only one of which is shown, and forming a sound path, one end of which is adjacent an annular portion of the diaphragm intermediate the central and outer portions thereof. The plug has a curvature at 43 similar to that of the concave surface of the dome 25 of the diaphragm. The passage 39 expands into the horn 11 which is coupled to the receiver unit by the coupling member 44, the passage 39 therefore forming a part of the horn loading the diaphragm on its concave side.

The high frequency distributor or horn 12 which loads the diaphragm on its other side, comprises an outer member or portion 45, an inner member or portion 46, and an intermediate member or portion 47 in nested, spaced relation. The outer member, which has a peripheral flange 48, is supported by the plate pole 21 being secured thereto by suitable fastening means 49, only one of which is shown. The surface of member 45 adjacent the plate pole is recessed to receive the ring 29 and to provide clearance for free movement of the flexible annular portion 27. The inner member 46 is carried by the intermediate member 47, being spaced therefrom by thin, flat, spacer members 50. The intermediate member is, in turn, supported by the outer member 45, being spaced therefrom by thin, flat, spacer members 51. The spacer members are sufficiently thin so as not to interfere with the passage of sound waves. It will be noted that the base of the intermediate member is adjacent the portion of the diaphragm that the sound path on the other side of the diaphragm is also adjacent, and that the members are disposed adjacent concentric spaced regions of one side of the diaphragm. The base surfaces 52 and 53 of the inner and intermediate members, respectively, are of contour similar to those portions of the diaphragm to which they are adjacent. Each of these nested members is annular in shape and decreases in section away from the diaphragm, being shaped so that it provides a defining surface for sound wave passages 54, 55 and 56 which vary exponentially in area outwardly from their small ends at the diaphragm. The small ends of the passages lead from the diaphragm regions intermediate the spaced regions thereof.

Horn type loud speakers are ordinarily operated with the diaphragm of the receiver unit loaded on one side by a horn and enclosed on its other side. It has been suggested that complete enclosure of one side of the diaphragm may place undesirable restraints upon the freedom of motion of the diaphragm and hence interfere with the response of the loud speaker. It has not been suggested, however, that the response of a loud speaker could be increased and made to cover a wider range of frequencies by employing each surface of the diaphragm as an effective sound radiating surface, and loading each side of the diaphragm so that different portions of the frequency range would be effectively reproduced.

The curve of Fig. 3 is a typical total radiation curve for the loud speaker of this invention and indicates the broad band of frequencies that the horn type reproducer of this invention is capable of translating. The horn 12 has a lower cut-off at a frequency substantially that of the upper cut-off frequency of the horn 11. This is preferably, although not necessarily, at a frequency of approximately 5000 cycles per second. The horn 12 which has been referred to above as a high frequency sound distributor, increases the air load on the diaphragm for frequencies above the upper cut-off frequency of the horn 11 and has been found to distribute the sound waves issuing therefrom through a solid angle of approximately

$$\frac{\pi}{2}$$

degrees thereby diminishing the directive character of the high frequency radiations.

While the features of this invention have been disclosed with reference to a specific embodiment, it is to be understood that various modifications may be made in the details of construction without departing from the scope of the invention as defined in the appended claims.

What is claimed is:

1. An acoustic device comprising a diaphragm, a horn loading said diaphragm on one side thereof, and a horn load for the other side of said diaphragm, said second horn having a lower cut-off frequency approximately that of the upper cut-off frequency of said first mentioned horn.

2. An acoustic device comprising a diaphragm, and two horns, the diaphragm being loaded on each side by one of said horns, one of said horns increasing the air load on said diaphragm for frequencies above the upper cut-off frequency of the other horn, said one horn distributing the sound through a solid angle of approximately $\frac{\pi}{2}$.

3. An acoustic device comprising a diaphragm and a horn loading said diaphragm on one side thereof, said horn comprising a plurality of members spaced apart to define a plurality of sound wave passages, each member decreasing in cross-section away from the diaphragm.

4. A loud speaker comprising a diaphragm and a horn loading said diaphragm on one side thereof, said horn comprising a plurality of nested, spaced members defining a plurality of sound wave passages, said members being shaped so that the passages taper exponentially, said horn distributing the sound through a solid angle of approximately $\frac{\pi}{2}$.

5. An acoustic device comprising a receiver having a diaphragm and two horns, one of said horns and said receiver being positioned in the mouth portion of the other horn, each horn loading said diaphragm on one side thereof, one of said horns increasing the air load on the diaphragm for frequencies above the upper cut-off frequency of the other horn.

6. An acoustic device comprising a diaphragm, and two horns, the mouth portion of each horn opening in the same direction, one of said horns acting to increase the air load on said diaphragm for frequencies above the upper cut-off frequency of the other horn, such frequencies being reproduced with diminished directive character.

7. An acoustic device comprising a diaphragm having a central stiffened portion, an outer pe-

ripheral portion, and an intermediate flexible portion, means supporting said diaphragm at its peripheral portion, and means loading said diaphragm on one side thereof and comprising an outer member extending over and spaced from the flexible portion of the diaphragm and having a central opening defined by a frusto-conical surface, the small base of which is adjacent but spaced from the outer region of the stiffened portion of the diaphragm, an inner member having a central opening and spaced from the diaphragm about the central region of the stiffened portion, and an intermediate member having a central opening and spaced from the diaphragm in the region of the stiffened portion of the diaphragm intermediate its central and outer regions, said members defining a plurality of sound wave passages which taper outwardly from the diaphragm.

8. An acoustic device comprising a diaphragm and a horn, said horn comprising a plurality of nested, spaced members disposed adjacent concentric spaced regions of one side of the diaphragm, said members defining a plurality of separate sound wave passages, each leading from a region of the diaphragm intermediate the concentric spaced regions directly to the atmosphere.

9. An acoustic device as claimed in claim 8 in which said nested members comprise an outer, an inner and an intermediate member, each member being shaped so that the passages taper exponentially.

10. An acoustic device comprising a diaphragm, means defining a sound chamber on one side of the diaphragm and a sound wave passage leading therefrom, a plug member in said chamber, forming with the chamber wall a sound path having one open end adjacent an annular portion of the diaphragm intermediate the central and outer portions thereof and its other open end expanding into the sound passage, a horn into which said passage expands, and means for loading the diaphragm on its other side, said means comprising a plurality of portions positioned adjacent regions of the diaphragm and defining a plurality of sound passages, one of said portions being adjacent said annular portion of the diaphragm.

11. An acoustic device comprising a diaphragm, and means for loading said diaphragm on one side thereof so that the upper portion of the audible frequency range will be faithfully translated, said means comprising a sound wave distributor having nested portions adjacent spaced regions of the diaphragm and defining separate sound wave passages having ends thereof adjacent the regions of the diaphragm intermediate the spaced regions thereof.

12. An acoustic device comprising a diaphragm, means loading said diaphragm on one side thereof for the translation of the lower portion of the audible frequency range, and other means loading said diaphragm on its other side for the translation of the portion of the audible frequency range above the upper cut-off frequency of the first mentioned means, said other means comprising nested portions adjacent spaced regions of the diaphragm and defining separate passages having their ends adjacent the regions of the diaphragm intermediate the spaced regions thereof, each of said means radiating sound waves in the same direction.

13. An acoustic device comprising a diaphragm, means for loading said diaphragm on one side thereof so that a portion of the audible frequency range will be more faithfully translated, said means comprising a horn having portions adjacent the spaced regions of the diaphragm and defining separate sound passages having ends thereof adjacent the regions of the diaphragm intermediate the spaced regions thereof.

14. An acoustic device comprising a diaphragm and means for loading said diaphragm on one side thereof so that a portion of the audible frequency range will be faithfully translated, said means comprising annular portions adjacent concentric spaced regions of the diaphragm and defining separate tapering sound wave passages having their small ends adjacent the regions of the diaphragm intermediate the spaced regions thereof.

15. An acoustic device comprising a diaphragm and means for loading said diaphragm on one side thereof for the translation of the upper portion of the audible frequency range, said means distributing the sound waves through a solid angle of approximately

$$\frac{\pi}{2}$$

and comprising portions adjacent spaced regions of the diaphragm and defining separate sound wave passages, each passage having one end adjacent one diaphragm region intermediate the spaced regions thereof.

16. An acoustic device of the loud speaker type comprising a diaphragm, means for driving said diaphragm, means loading said diaphragm on one side for the reproduction of one portion of the audible frequency range, and other means loading said diaphragm on its other side for the reproduction of another portion of the audible frequency range, said other means having a lower cut-off frequency approximately that of the upper cut-off frequency of the first means and distributing sound waves through a solid angle of

$$\frac{\pi}{2}.$$

17. An acoustic device comprising a diaphragm, a horn loading said diaphragm on one side thereof, and a horn loading said diaphragm on the other side thereof, said second horn increasing the air load on the diaphragm for frequencies above the upper cut-off frequency of the first horn.

18. Means for reproducing sound comprising a diaphragm, a long horn for transforming sound waves generated by one side of the diaphragm, and a plurality of nested short horns for transforming sound waves generated by the other side of the diaphragm.

EDWARD C. WENTE.