July 30, 1929.

C. E. LANE

1,722,805

SOUND RADIATOR

Filed July 31, 1926

Fig. 1

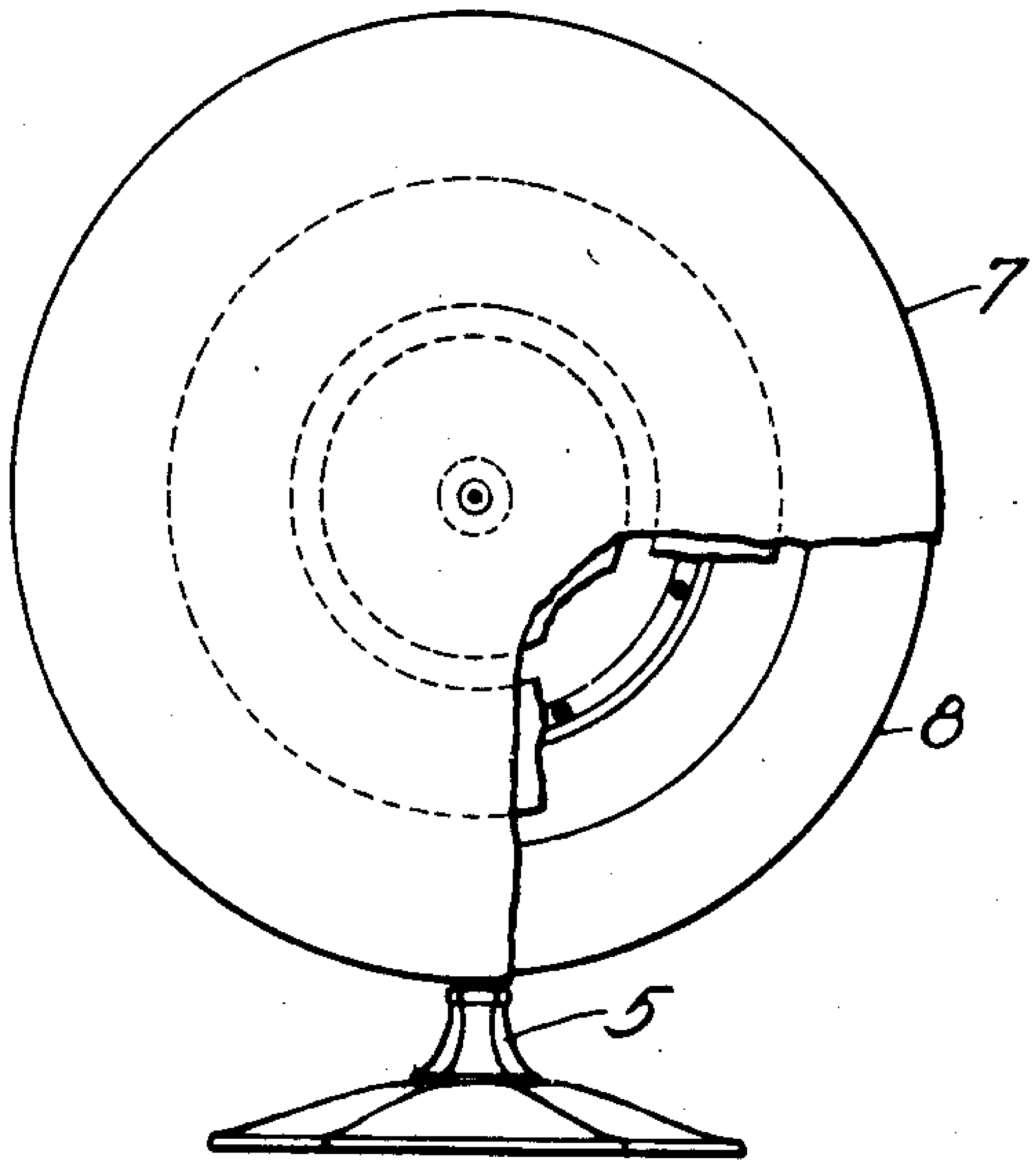


Fig. 2

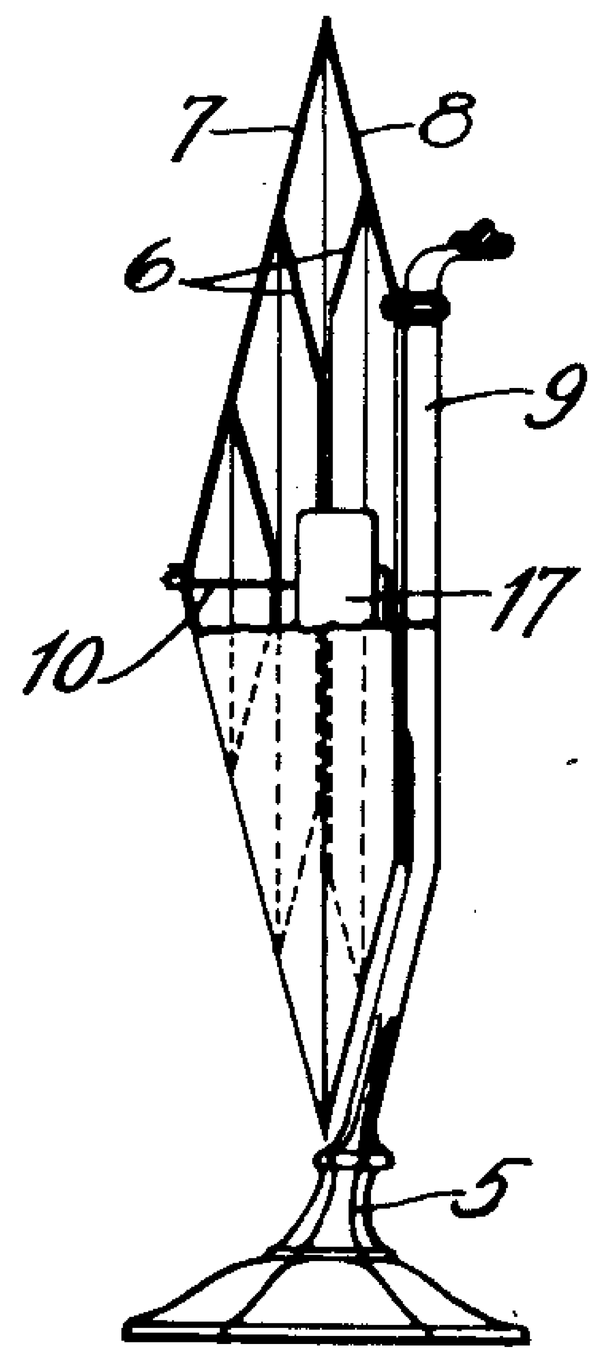


Fig. 4

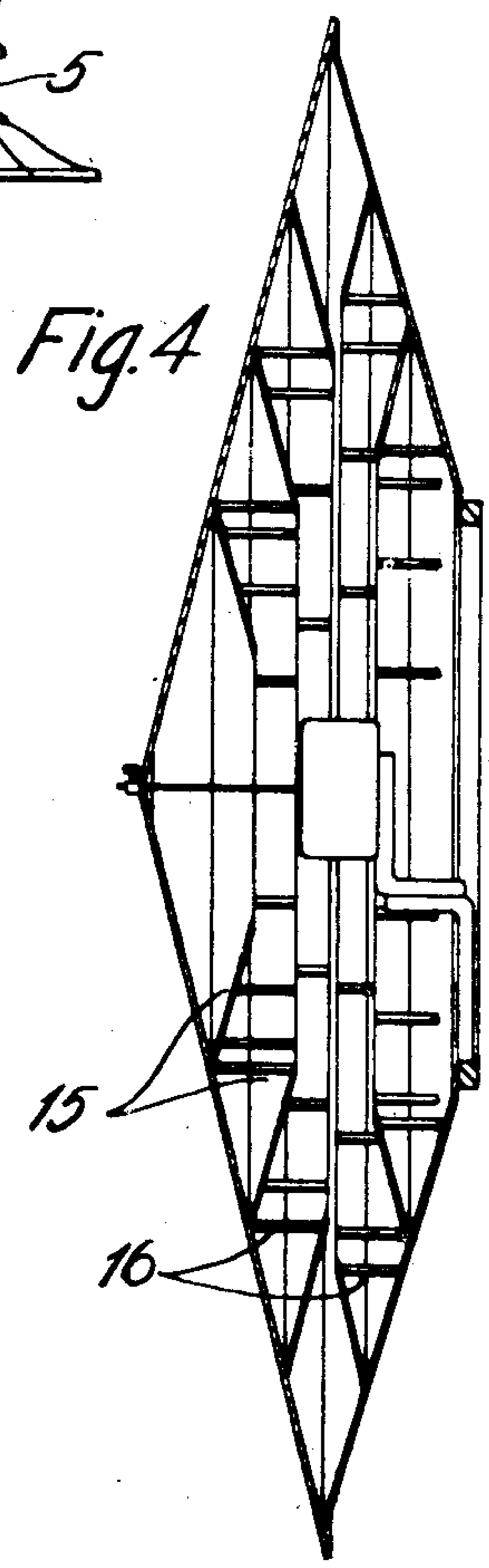
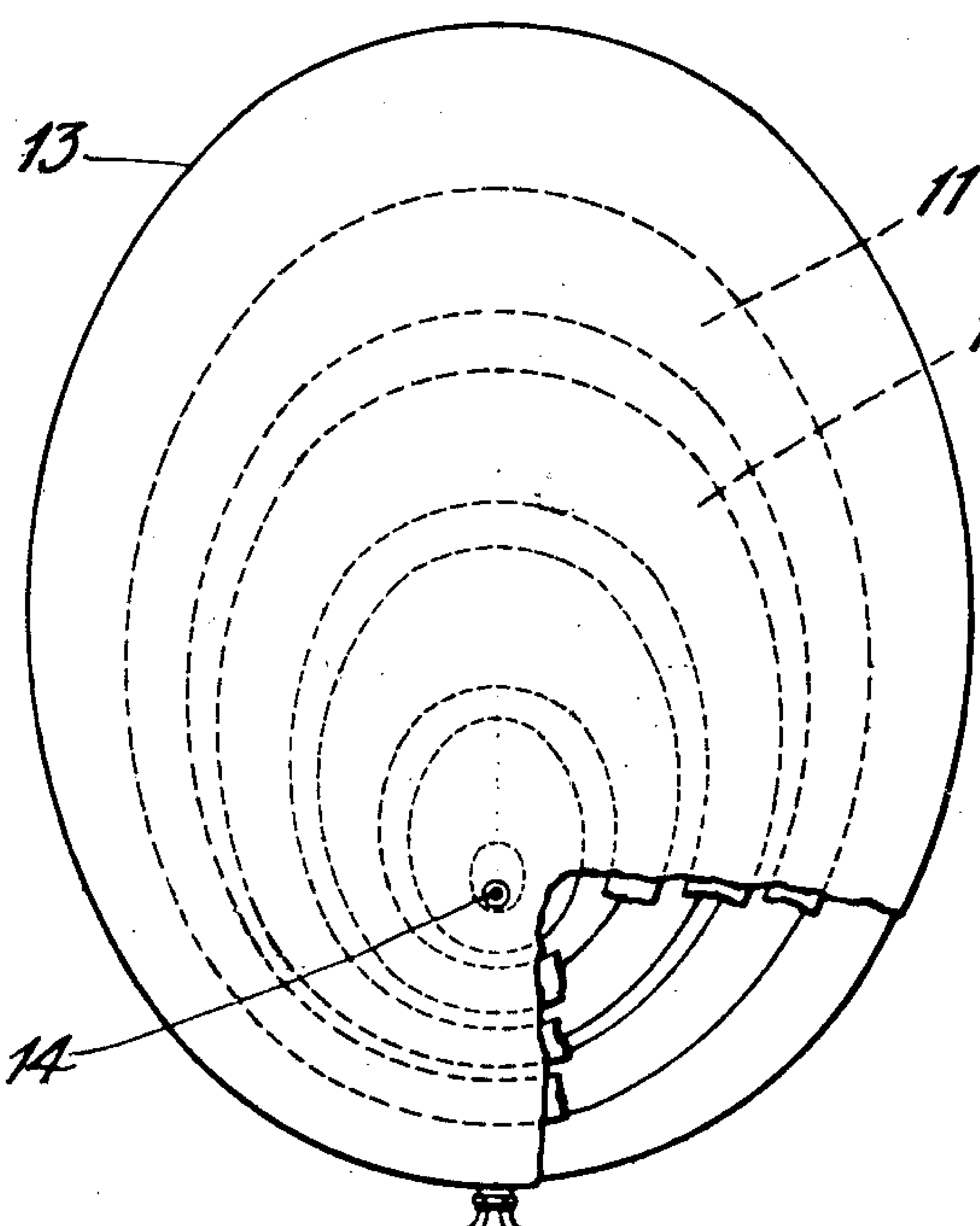


Fig. 3



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Patented July 30, 1929. **1,722,805**

UNITED STATES PATENT OFFICE.

CLARENCE E. LANE, OF MONTCLAIR, NEW JERSEY, ASSIGNOR TO BELL TELEPHONE LABORATORIES, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

SOUND RADIATOR.

Application filed July 31, 1926. Serial No. 126,160.

This invention relates to acoustic diaphragms and particularly to large diaphragms radiating directly into the air.

An object of the invention is to decrease distortion from the introduction or generation of harmonics or other undesired frequencies by a vibrating diaphragm when operating to translate electrical or mechanical energy into sound waves in a surrounding medium, or vice versa.

A further object is to increase the mechanical ruggedness of large acoustic diaphragms without deleteriously affecting their acoustic properties.

The invention is applicable to sound emitters of the so-called "hornless" type of loud speakers which employ a large vibrating surface to radiate directly into the air and particularly to sound emitters of the conical type.

Difficulty has been experienced in this type of sound emitter and similar structures due, it appears, to unsymmetrical vibration of the diaphragm which could result from slight departures from symmetry in the structure. The introduction of vibrations of frequencies not present in the actuating source considerably impairs the faithfulness of reproduction of speech or music and is particularly objectionable where the sound radiator is employed in quantative sound studies to reproduce single frequency tones or narrow bands of frequencies from which the harmonics or frequencies without the band have been reduced below audibility by means of band pass filters of the well-known mechanical or electrical types.

According to the present invention this distortion of a conical diaphragm is greatly reduced by attaching circular reinforcing members or ribs to the diaphragm, spaced apart and concentric with the apex, so as to divide the diaphragm into portions of relatively small area. The reinforcing members also serve to increase the mechanical ruggedness of the structure and at the same time facilitate the design of the sound radiator by making its frequency-response characteristic more readily predictable. Bracing means may be provided, particularly on very large diaphragms, to lend additional stiffness and to prevent the reinforcing members from vibrating independently of the diaphragm.

While the theory as to the cause of this distortion of the radiated sound is not definitely established, and while the invention is independent of the theory, the cause of this distortion is believed to be unsymmetrical vibration. Experiments show that the large diaphragm does not vibrate in circularly symmetrical portions about the driven portion but in sectors or "patches" which are more or less unsymmetrically distributed and which vary in size and location with respect to frequency. Experiments also show that the relation existing between driving forces applied to the apex of the cone-type diaphragm and the resulting displacements is nearly linear, while the displacement resulting from a force applied to a patch has a marked departure from linearity with respect to the applied force. The effect of such a characteristic is to introduce harmonics of the frequency of the force wave. It therefore follows that, as a result of this difference in the characteristics, the amplitude of the harmonics introduced by the patch vibrations will be greater than the amplitude of the harmonics introduced by vibration of the diaphragm as a whole, thus giving a greater distortion.

In the case of one form of conical shaped diaphragm now much used in so-called loud speakers, the vibrations of which have been investigated, and which is typical of this class of diaphragms, fundamental resonance occurs at a frequency of about 100 cycles and vibration results in the generation of harmonics of this frequency to some extent. The patches, however, would be resonant at higher frequencies, probably covering a range of about 200 to 500 cycles, and apparently, therefore, distortion due to the patch vibration would introduce harmonics of these frequencies. The harmonics generated by the vibration of the patches would, therefore, as compared with the harmonics due to the vibration of the diaphragm when moving as a whole, be of greater amplitude, due to the marked departure from linearity in the relation between the driving force and displacement in the patches, as pointed out above, and also of higher frequency. Since the ear is most sensitive at about 1000 cycles and does not vary appreciably in sensitivity over an approximate frequency range of 500 to 3000 cycles, it follows that the harmonics introduced by the patches would cause a greater response in the ear than the harmonics introduced by the diaphragm moving as a unit, not only because of their relatively large amplitude but also because their frequency range would correspond to the frequencies at which the ear is most sensitive. Upon the basis of this theory the distortion in the diaphragm could be reduced by preventing the patch vibration or by dividing the patches into several smaller patches having higher natural frequencies. Because of their higher frequency, these patches would vibrate at smaller amplitudes, thus operating over small, practically linear portions of their characteristic curves, and would produce a relatively small amount of distortion. The frequency of a large portion of these harmonics would, furthermore, be appreciably above 3000 cycles and therefore in a range at which the ear is relatively less sensitive.

The invention may be more readily understood by referring to the drawing, in which Figs. 1 and 2 are front and side views, respectively, partly in section, of a sound radiator employing a cone shaped diaphragm provided with reinforcing members in accordance with this invention; Fig. 3 is a modification of the structure shown in Fig. 1, and Fig. 4 is a sectional view of a relatively large conical diaphragm provided with a means for bracing the reinforcing members.

In the drawing, the standard 5 carries at its upper portion a bracket to which the actuating means 17 is attached. The diaphragm 7 of light flexible sheet material such as paper, parchment, thin metal or the like, specifically shown as conical in form, is joined at its periphery to an edge of a second member 8 of sheet material, shown in this case as a truncated cone. The other edge of the frusto-conical surface is secured by screws or other means to ring 9 which is part of the standard 5. Rod 10 suitably attached to the surface 7 at its apex connects the surface to the actuating means 17. This actuating means may be of any desired form, for example, any well known type telephone receiver. A suitable form of electromagnetic driving means is described in Patent No. 1,365,898 of January 18, 1921 to H. C. Egerton. In Fig. 2 the reinforcing means 6 are shown in the form of hollow truncated cones, preferably of light flexible material, which are suitably attached to the diaphragms 7 and 8.

Fig. 3 shows the invention applied to a sound radiator in which the conical diaphragms are truncated obliquely with respect to the axis, thus making the periphery elliptical. The reinforcing members 11, 12, etc., are positioned symmetrically with respect to the peripheral portion of the diaphragm 13 about the driving point 14.

In very large sound radiators, it may be necessary to provide bracing means to prevent the reinforcing members from vibrating independently of the diaphragm. As shown in Fig. 4, braces 16 which may be of wood or other light material are provided for this purpose and are attached at one end to the edge of the reinforcing members 15 which project from the diaphragm and at the other end to the diaphragm. These braces also lend additional stiffness to the structure as a whole.

It is to be understood that the invention in certain aspects, as is evidenced by the claims, is not limited to diaphragms of conical shape or large size or those acting directly into the air. While it seems preferable to employ reinforcing members which are similar in shape to the periphery of the diaphragm and positioned symmetrically about the driving point, the scope of the invention includes reinforcing members of other shapes and having various positions on the diaphragm.

What is claimed is:

1. A large acoustic diaphragm for radiating directly into the air, in combination with means attached to said diaphragm at a distance from the periphery for driving it, and means for stiffening said diaphragm, said means dividing said diaphragm into concentric symmetrical areas about its driven portion.

2. A diaphragm in accordance with claim 1 in which the stiffening is produced by reenforcing ribs attached to the diaphragm.

3. An acoustic conical diaphragm having a plurality of hoop-like stiffening ribs, one edge of each of which is secured to said diaphragm.

4. An acoustic diaphragm for radiating directly into the air and means for stiffening said diaphragm comprising a relatively rigid bracing member attached to and extending away from said diaphragm and means rigidly connecting a portion of the bracing means remote from said diaphragm with a plurality of points on said diaphragm to form a rigid trussed structure therewith.

5. An acoustic diaphragm of thin sheet material and stiffening means for said diaphragm comprising a plurality of relatively rigid stiffening members attached to and extending away from said diaphragm, and means extending from a plurality of points in said diaphragm to each of said stiffening members to form a trussed structure with said diaphragm.

6. A large acoustic diaphragm for radiating directly into the air and shaped to correspond to the curved surface of a cone

and circular stiffening ribs attached to said diaphragm, spaced apart and concentric with the apex.

7. An acoustic diaphragm having a natural frequency of less than 200 cycles, and means attached to said diaphragm to reduce the amplitude of the harmonics generated by said diaphragm.

8. An acoustic diaphragm having a natural frequency of less than 200 cycles, and means attached to said diaphragm to change the frequency of the harmonics generated by said diaphragm to frequencies at which the ear is relatively less sensitive.

9. A direct acting acoustic diaphragm, and means attached to said diaphragm to decrease the amplitude of the harmonics introduced by the unsymmetrical vibrating portions of said diaphragm.

10. A direct acting acoustic diaphragm, and means attached to said diaphragm to divide the unsymmetrical vibrating portions of said diaphragm into vibrating portions having higher natural frequencies.

11. A sound radiator comprising a diaphragm having a conical and a frusto-conical portion joined at their peripheries, means for directly driving a portion of said diaphragm, and reinforcing means comprising a plurality of annular members positioned symmetrically with respect to the driven portion of said diaphragm.

12. A sound radiator comprising a diaphragm having a conical portion and a frusto-conical portion joined at their peripheries, means for driving said diaphragm at the apex of said conical portion, means for supporting said diaphragm at the edge opposite the base of said frustro-conical portion, and reinforcing means comprising a plurality of hollow truncated cones having their bases secured to a surface of said diaphragm and positioned symmetrically about its driven portion.

13. An acoustic diaphragm reinforced by a plurality of stiffening members, one edge of each of said stiffening members being secured to the diaphragm, bracing means attached at one end to one of said stiffening members and at the other end to the diaphragm.

14. The combination with a conical diaphragm of at least one baffle located at the concave side of the cone and positioned between the apex and the base of the cone to sub-divide the resonance chamber formed by the concavity of the cone.

15. The combination with a conical diaphragm of a cone frustum secured to the inner wall of the cone between the apex and the base of the cone to sub-divide the resonance chamber formed by the concavity of the cone.

16. The combination with a conical diaphragm of at least one baffle located at the concave side of the cone and positioned between the apex and the base of the cone to sub-divide the resonance chamber formed by the concavity of the cone, said baffle extending inwardly toward the axis of the cone and being provided with at least one opening.

17. The combination with a conical diaphragm of at least two baffles located at the concave side of the cone and positioned between the apex and the base of the cone to sub-divide the resonance chamber formed by the concavity of the cone, each of said baffles extending inwardly toward the axis of the cone and being provided with at least one opening.

18. The combination with a conical diaphragm of at least one baffle located at the concave side of the cone and positioned between the apex and the base of the cone to sub-divide the resonance chamber formed by the concavity of the cone, said baffle extending inwardly toward the axis of the cone and being provided with a central opening.

19. The combination with a conical diaphragm of at least one baffle located at the concave side of the cone and positioned between the apex and the base of the cone to sub-divide the resonance chamber formed by the concavity of the cone, said baffle extending inwardly toward the axis of the cone and being provided with a central opening reinforced at its edge.

In witness whereof, I hereunto subscribe my name this 30th day of July A. D., 1926.

CLARENCE E. LANE.