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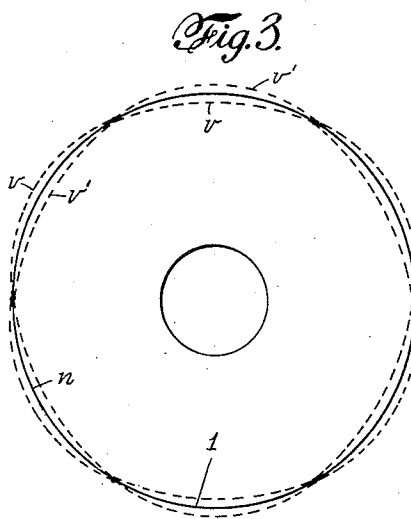
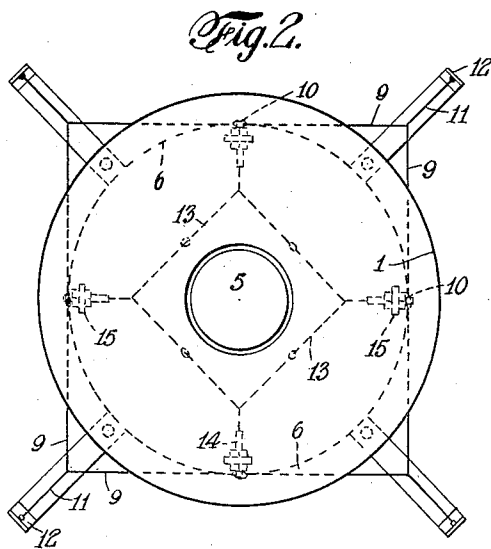
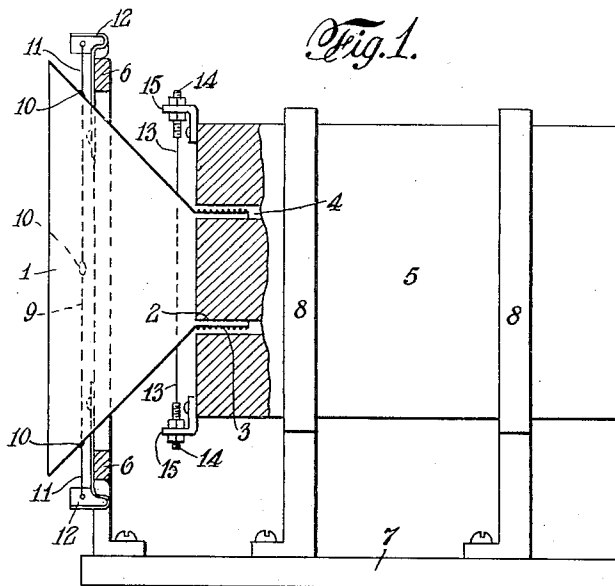
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1,778,671

SUSPENSION MEANS FOR SOUND REPRODUCING DEVICES

Filed Sept. 24, 1928

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

Fig. 4.

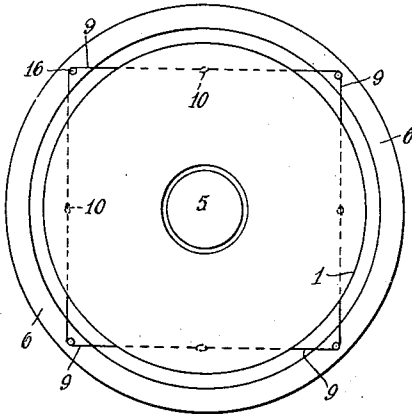


Fig. 5.

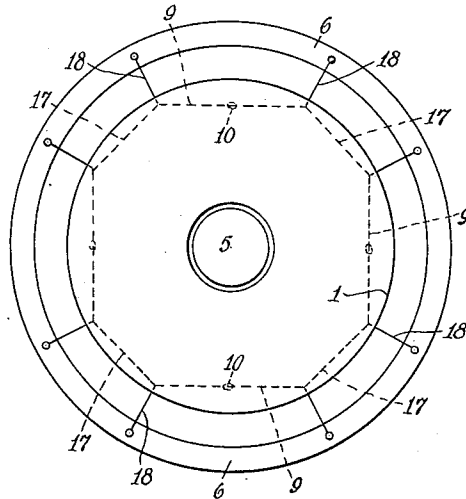


Fig. 6.

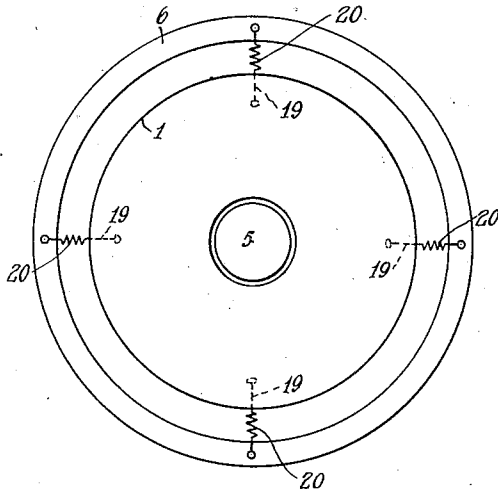
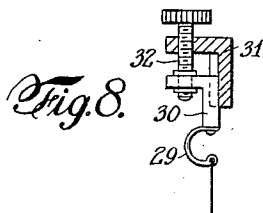
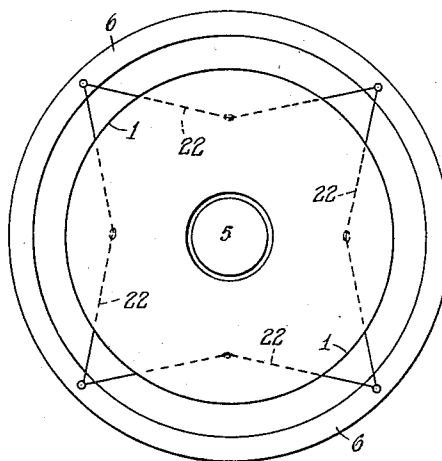


Fig. 7.



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## SUSPENSION MEANS FOR SOUND-REPRODUCING DEVICES

Application filed September 24, 1928, Serial No. 308,047, and in Great Britain March 15, 1928.

The invention relates to acoustic devices adapted to be vibrated to reproduce sounds and more particularly to the supporting means for these devices.

5 It is essential that the natural movements of a sound reproducing device in response to the impulses transmitted to it from a driving element be not substantially distorted, retarded or absorbed by the supporting means, otherwise the sound emitted is either  
10 damped or distorted at all or certain frequencies, particularly the lower frequencies.

The object of this invention, broadly stated, is to provide improved means for supporting a sound reproducing device which  
15 will permit substantially perfect freedom of motion of the device, i. e. its natural deviation from its normal shape or position, in exact response to the true vibrations imparted to the device by the driving element and which will substantially relieve the device from strain and consequent deviation from its normal shape or position other than by  
20 said true vibrations.

25 I have determined that, when impulses are transmitted to a cone by a driving element, there are produced vibrations in the cone itself normal to the surface of the cone. The latter vibrations cause the cone to deviate from its  
30 normally circular shape and to affect wave shaped deformations in planes at right angles to the axis of the cone, the peripheral elements of the cone at certain portions thereof alternately deviating for given frequencies away from and toward the respective mean  
35 centers of these elements. Evidently for a free edge or substantially free edge cone, the amplitudes of the vibrations just described are greatest at the free edge of the cone, i. e. at its larger diameter and these vibrations  
40 may be less, equal to or greater than the longitudinal vibrations of the cone in an axial direction. Obviously the free formation of these wave shaped deformations (which the  
45 suspension made according to the invention permits) is due to the tendency of the impulses transmitted to the cone by the driving element to create vibrations in the cone itself longitudinally of its side walls, the tendency  
50 of production of the latter vibrations ac-

tually giving rise to the formation of the wave shaped deformations in planes at right angles to the axis of the cone. Logically, the total or substantial elimination of the latter vibrations, in view of the supporting means  
55 which necessarily have to be provided for the cone, impairs the natural tendency of the cone to vibrate within itself, thereby impairing the quality and the volume of the reproduced sound.

Hence, in accordance with the invention, a cone or conical shaped body is supported in such a manner that the natural movement of the cone when responding to the impulses transmitted to it by a moving coil or reed,  
60 are substantially preserved. The improved supporting means not only permit essentially free axial movements of the cone but also free vibrations of the cone within itself, i. e. the formation of the vibrations normal to the surface of the cone is not impaired; the improved supporting means effectively prevent movement of the cone as a whole transverse to its axis and are also such as not to distort, damp or absorb the natural move-  
65 ments of the cone. In this way, the cone excites directly in the surrounding air, sound waves of an intensity and pitch substantially corresponding to the original electrical waves transmitted from the moving coil or reed  
70 and as a result the reproduced sound is truer, clearer and of greater volume than would otherwise be the case if the tendency of the natural movements of the cone, described above, was in any way impaired by the sup-  
75 porting means.

The invention in its broad aspects consists in the provision of supporting cords or their equivalents which are secured to the wall of a cone. These cords may be secured to the cone  
80 either at or near its outer edge, preferably at a predetermined distance therefrom, or near its inner edge or at both of these locations. The ends of the cords may conveniently be so secured that their intermediate  
85 stretches lie tangentially to the surface of the cone. The ends of the cords may also be flexibly supported from the frame or casing surrounding the cone.

It is seen that with the improved support- 100

ing means broadly described above the cone has substantially perfect free axial movement and is permitted to freely deviate from its normal shape. This system of suspension is perfectly oscillatory and provides for an almost complete freedom or floating movement of the cone.

The invention is illustrated in the accompanying drawings in which:

Fig. 1 is a profile view, partly in section, of an electrodynamic speaker provided with a preferred form of improved suspension means;

Fig. 2 is a full view of the cone and suspension means shown in Fig. 1;

Fig. 3 is an illustration of the vibrations of the cone, normal to its surface;

Figs. 4 to 6 illustrate modified forms of cord suspension constructions;

Fig. 7 illustrates the preferred form of connecting the main suspension cords to the cone;

Fig. 8 is a detail view showing adjustable means of attaching the ends of the suspension cords.

Referring to Figure 3, the circle  $n$  represents a face view of a cone or it may be considered as a section on a plane transverse to its axis, when the cone is in its normal shape, i. e. when no impulses are being transmitted to the cone. The dotted lines  $v$  and  $v'$  represent the maximum alternate deviations of the cone from its normal circular form at that particular section of the cone when a certain frequency note is being transmitted to the cone by the driving element. Deformations of the cone, similar to those illustrated, are actually the resultant vibrations of the cone within itself. As will be seen, the suspension systems, hereinafter fully described, not only allow free axial movement of the cone but free formation of these resultant vibrations, normal to the surface of the cone.

Referring more particularly to Figures 1 and 2, 1 is a cone comprising a cylindrical portion 2 which is provided with a coil 3 located within an annular space 4 formed between the pole pieces of a magnet 5. 6 is a ring which is mounted upon a base plate 7 upon which also are mounted rings 8 supporting the magnet 5.

Four cords indicated by 9 are fixedly secured tangentially to the surface of the cone near its base or outer end, as indicated at 10 and form a square; suspension cords 11 are attached at one end to the junction points of the cords 9 or at the corners of the rectangle. These cords 11 extend outwardly as prolongations of diagonals of the rectangle and at their outer extremities are held by the ring 3 to which they are preferably connected by supporting members 12 of springy material extending outwardly from the ring 6.

The system of suspension cords just described may be attached to the outer edge of the cone, but since the amplitude of the vibra-

tions of the cone within itself, normal to its surface, are greatest at the outer edge of the cone, it is preferable to attach the suspension cords, as shown in the figures, at a predetermined distance away from the outer edge of the cone.

In the modification shown in Figure 4, the cords 9 are attached at the corners of the rectangle directly to pins 16 carried by the ring 6.

In the arrangement shown in Figure 5, the four cords 9, secured tangentially to the surface of the cone 1, form four of the sides of an octagon, the remaining sides of which are formed by cords 17. Each angular point of the octagon is connected by cords 18 to the ring 6.

It will, of course, be understood that the number of points of attachment of cords to the cone and corresponding number of cords may be varied and that the four mentioned above is only by way of example. Still this is deemed the most practical from a commercial standpoint. It is desirable that the points of attachment be made as few as possible and that the actual attachments be made as small and light as possible to lessen the weight added to the cone and thus minimize their damping and other effects upon the vibratory surface. The cords 9 might be arranged in the form of a triangle thus reducing the points of attachment to three but a commercial disadvantage then results since the sides of the triangle are of such length that the ring 6 must be given a diameter that the whole structure becomes unwieldy.

In the modification shown in Figure 6, the cords supporting the cone 1 are arranged other than tangentially thereto. A plurality of cords, 19, four being shown in the figure by way of an example, are equally spaced from one another and arranged as prolongations of radii of a section of the cone, are connected at one end to the cone and at the other end to light springs 20 which are in turn attached to the ring 6.

The cords are preferably spaced a short distance away from the surface of the cone, by securing them to small thin paper stickers, as illustrated by the small circles at the points of attachment 10 of the cords to the cone, these stickers being in turn secured to the cone. In this way the suspension cords do not touch the cone while vibrating, particularly in view of the wave shaped deformations of the cone along peripheral elements thereof. Preferably, however, the suspension cords directly connected to the cone are not arranged exactly tangentially to the surface of the cone but at a slight angle with the tangent line on both sides of the point of attachment, as illustrated by the cords 22 in Fig. 7. This system of connection absolutely prevents any interference between the suspension cords and the natural vibrations of

the cone. If desired, spacing stickers may be additionally provided in conjunction with the system of connecting the cords shown in Fig. 7.

5 The system above described may be duplicated to form a means of support for the center or inner end of the cone, particularly if the latter is connected to a moving coil mechanism. Referring to Figures 1 and 2, for example, the cone 1 may be supported and centralized near its inner end by cords 13 arranged similarly to the cords 9 and 11 and secured to adjusting screws 14 mounted in brackets 15 secured to the face of the magnet 5. Preferably, the points of attachment of the suspension cords to the cone at its inner end are so located so as not to lie in the same planes with the points of attachment of the suspension cords at the outer portion of the cone; preferably the points of attachment at both the inner or outer edges of the cone are so located that the planes passing through each point and the axis of the cone form equal angles between one another. In this way the suspensions permit maximum freedom of vibrations of the cone.

Figure 8 shows a modified form of centralizing and supporting device, in which the suspension cords are each attached to a C spring 29 secured to a slide 30 mounted on a bracket 31. The slide is adjustable by a screw 32 engaging a screw thread formed in the bracket 31 and rotatable but not movable axially relatively to the slide 30.

35 If desired, the supports 12, shown in Figure 2 may be provided in the arrangements shown in the remaining figures. Obviously the supports 12 may be replaced by or provided with coil or spiral springs. The cords or springs not directly attached to the outer edge of the cone but leading to the supports 12 or ring 6 may be provided with an adjusting device or devices so that the tension of the main cords may be varied or the position of the cone adjusted as represented by 14 in Fig. 1 and 32 in Fig. 8. Also, in Figs. 2 and 5 the cords leading to the supports 12 or ring 6 may be replaced by light springs or their equivalent; in this way slight variations in the lengths of the main suspension cords, due, for example, to changes in humidity or temperature, do not affect the tension of the suspension system.

In order to prevent harmonics in the constructions in which the cords attached to the cone are connected to the ring 6 by separate cords, the cords are preferably of different lengths such that they are not equal nor multiple lengths of one another.

60 The suspensions such as above described are extremely rigid in a plane at right angles to the axis of the cone, thereby preventing motion of the cone as a whole transversely to its axis. They are, however, very flexible for axial movements of the cone and they allow

the latter to freely deviate from its normal shape in exact response to the impulses imparted to it by the driving apparatus, particularly the preferred suspension systems in which the cord is held tangentially or substantially tangentially to the surface of the cone at one point.

The suspensions described herewith are particularly favorable for the correct reproduction of the lower frequency notes, since for the perfect reproduction of a very low frequency note, a considerable amplitude of movement of the cone is required to produce sound waves of the correct amplitude. The improvement in volume of sound reproduced, made possible by these improved suspension means, is such as to make the provision of a baffle plate less necessary for the so-called free edge cone or electrodynamic speaker. Furthermore, a cone provided with these improved suspensions may have a natural period of vibration lower than 5 cycles per second and consequently the fundamental frequencies of the lowest notes can be reproduced with their correct volume and quality, and not by resonant effects. Lastly, with these suspension systems, the damping effect is so small that the cone is undistorted in shape, except by the true impulses communicated to it by the moving voice coil of the dynamic type of drive or the reed wire of the vibratory armature type of actuator and as a result the final sound is undistorted, clear and of large volume, for both the lowest and highest audible frequencies.

I claim:

1. In a sound reproducing device comprising a vibrating diaphragm formed of material capable of being distorted within itself by driving impulses corresponding to sound waves, flexible means supporting said diaphragm at a plurality of points, said flexible supporting means being arranged relative to said surface of the diaphragm to permit free movement thereof in a direction parallel with the driving force and to permit the diaphragm to be freely deviated from its normal shape when vibrating.

2. In a sound reproducing device comprising a vibrating cone formed of material capable of being distorted within itself by driving impulses corresponding to sound waves, flexible means connected to the cone and disposed relatively to the surface thereof to prevent movement of the cone as a whole transversely to its axis and to permit free movement in an axial direction and free deviation from its normal shape at the points of connection with said flexible supporting means in response to driving impulses.

3. In an acoustic device, supporting means for a vibrating diaphragm comprising cords fixedly secured to the latter at a number of points and arranged substantially tangentially to the diaphragm.

4. In an acoustic device, supporting means for a cone of vibratile material comprising cords fixedly secured to the latter at a number of points and to a support, said cords being arranged substantially tangentially to the surface of the cone and located in a plane substantially at right angles to the axis of the cone.

5. In an acoustic device, supporting means for a cone comprising a plurality of cords arranged substantially tangentially to the surface of the cone, and securing means connecting said cords to said cone and spacing them at their points of connection a short distance from the surface of the cone.

6. In an acoustic device, supporting means for a vibrating diaphragm comprising cords fixedly secured to the latter and arranged substantially tangentially to its surface, and means for resiliently supporting the cords.

7. In an acoustic device, supporting means for a cone comprising cords permanently connected to the latter and arranged substantially tangentially to its surface, and means for applying tension to the cords.

8. In an acoustic device, supporting means for a cone comprising cords permanently connected to the latter and arranged substantially tangentially to its surface, means for applying tension to the supporting cords and further means for adjusting said tension.

9. In an acoustic device, supporting means for a cone of vibratile material comprising cords fixedly secured to the latter at a number of points and arranged substantially tangentially to its surface and at a predetermined distance away from its outer edge.

10. In an acoustic device, supporting means for a vibrating cone comprising cords fixedly secured to the latter at a number of points and arranged substantially tangentially to its surface in a plurality of planes transverse to its axis.

11. In an acoustic device, supporting means for a vibrating cone comprising a plurality of cords fixedly secured to the latter at a number of points and arranged substantially tangentially to its surface in a plurality of planes transverse to its axis, said points lying in different planes passing through said axis.

12. In an acoustic device having a vibrating cone and means for imparting impulses to said cone, means for supporting said cone comprising a plurality of cords disposed relatively to said cone to freely suspend the same so that distortive movements of said cone normal to its surface in response to the driving impulses are unimpeded.

In testimony whereof, I have affixed my signature to this specification.

DOUGLAS HEATHER JOHNSON.