

June 14, 1932.

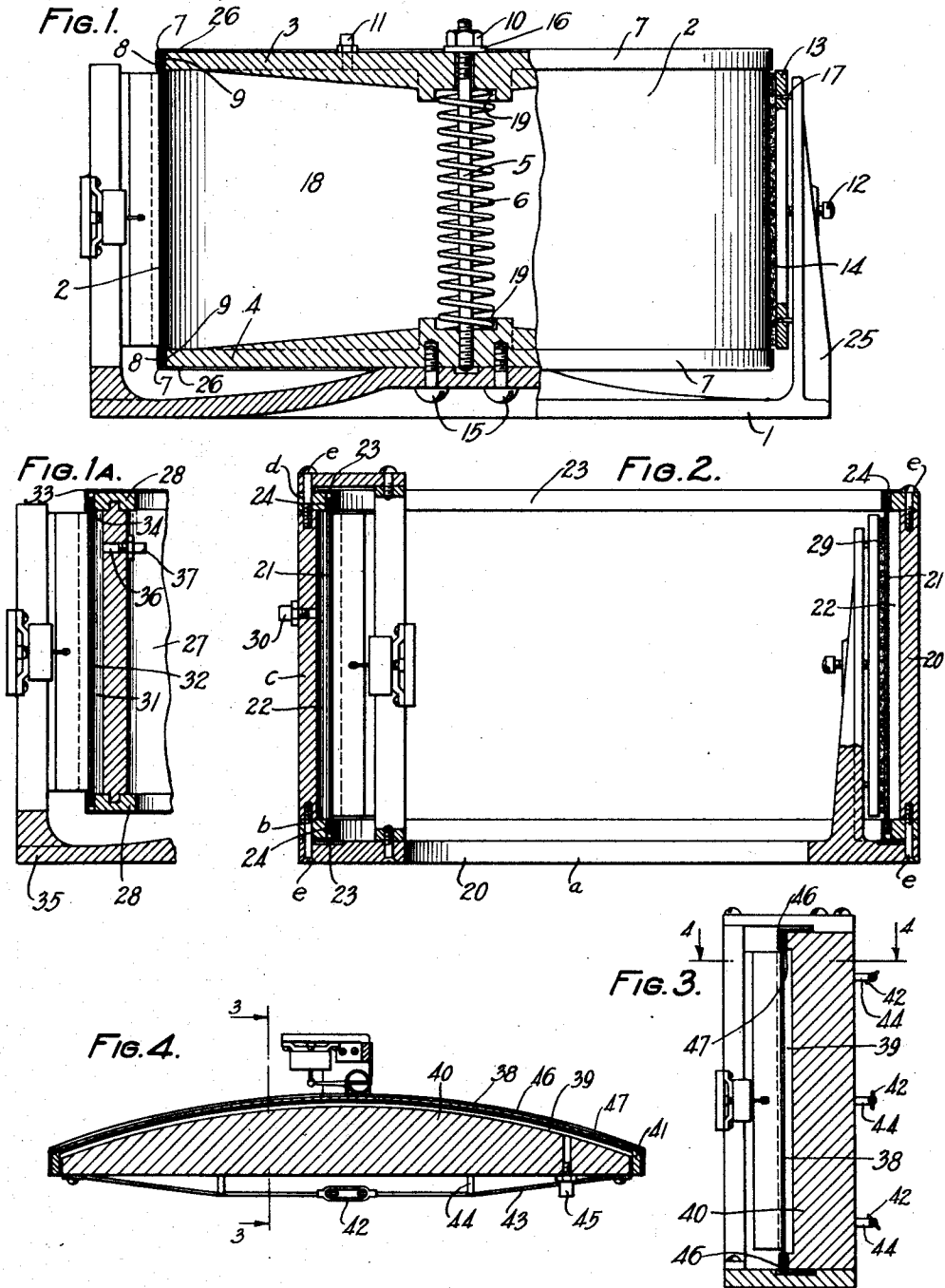
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1,862,554

ACOUSTIC DEVICE

Filed April 13, 1929

2 Sheets-Sheet 1



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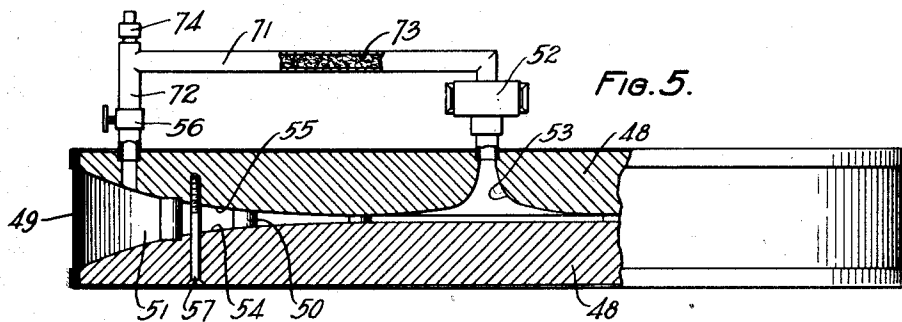


FIG. 5.

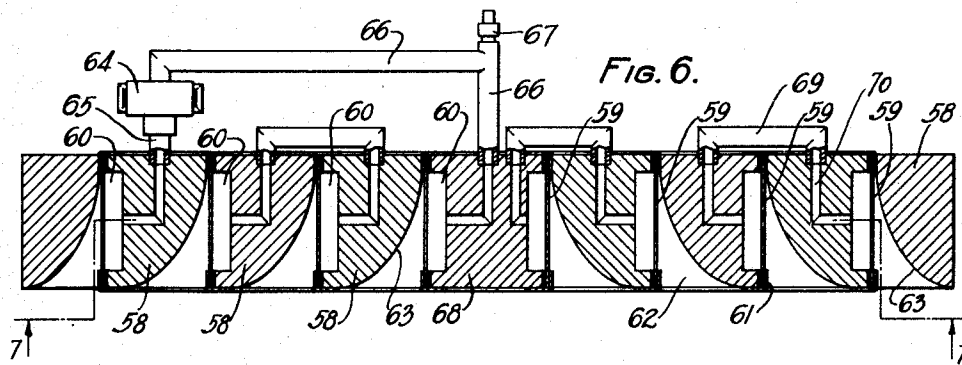


FIG. 6.

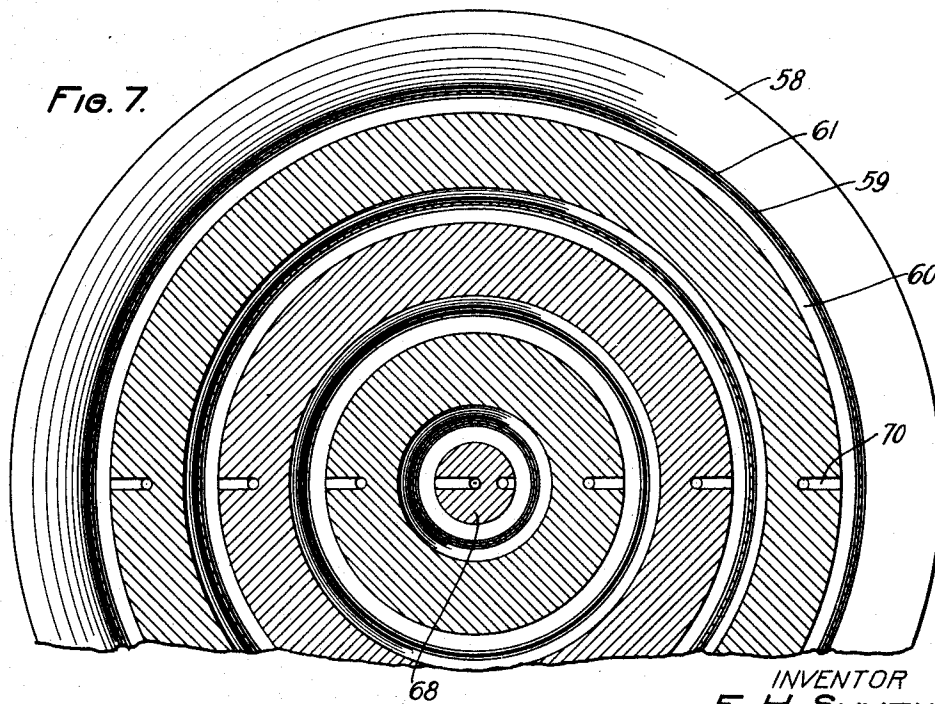


FIG. 7.

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ACOUSTIC DEVICE

Application filed April 13, 1929. Serial No. 354,801.

This invention relates to acoustic devices and particularly to sound radiators which act directly on the surrounding air and in which the propagation of the sound vibrations is through the material of the radiating means.

In acoustic radiators of the stretched diaphragm type the propagation of the waves may be either through the material of the diaphragm, through the air in an enclosed space of which the diaphragm forms a wall, or through both of the above means. Where the propagation is to be by way of the material of the diaphragm, the diaphragm must be placed under tension in order that the wave length in the material may be long enough in relation to the wave length in air of the frequencies to be transmitted to transfer effectively the motion from the diaphragm material to the air.

When the diaphragm is under tension, this tension may be either longitudinal, transverse, or both. If the diaphragm is in the form of a long and relatively narrow strip and the propagation of the vibratory disturbance is to take place entirely or primarily by way of the diaphragm material, and not by way of the confined body of air or fluid in contact with the diaphragm, the tension should be along the long dimension of the diaphragm. Preferably the tension should be to such a degree that the velocity of propagation in the diaphragm is substantially comparable with that in the surrounding air so that there may be minimum phase cancellation effect or none at all. Under these circumstances, the longitudinal tension in the diaphragm may be accompanied by a transverse tension if desired. However, as such transverse tension is in effect a series stiffness and acts to introduce a low cut-off in the frequency band, a better frequency response characteristic should be obtained by leaving the diaphragm untensioned, or substantially untensioned, in a transverse direction. It would be preferable, then, to omit transverse tensioning and provide acoustic damping along the longitudinal edges of the diaphragm.

Obviously, the introduction of tension in

the diaphragm involves the provision of means for supporting the force necessary to hold the diaphragm under tension. One way is to attach the diaphragm at its ends to a sufficiently strong supporting frame to serve the purpose. Another way is to connect the two ends of the diaphragm with each other to form an annulus, associate the annulus with an enclosed space of which the annulus forms one wall and subject the inner surface of the annular diaphragm to a sufficient degree of fluid pressure to put the diaphragm under tension, this tension being entirely supported by the diaphragm itself as the result of the two ends being connected together to form a closed annulus. The differential pressure between the two surfaces of the annular diaphragm may be produced either by a partial vacuum in an annular chamber of which the diaphragm constitutes in inner peripheral wall, or by pressure in an annular chamber of which the diaphragm constitutes an outer peripheral wall. The latter form seems preferable from the standpoint of construction. Both forms, however, are embodied in the invention disclosed in this application. The degree of longitudinal or circumferential tension may be easily controlled by variation in fluid pressure; the absence, presence or degree of transverse tension can also be controlled by suitable means.

The longitudinal or circumferential tension in the annular diaphragm when under fluid pressure varies directly with the diameter of the diaphragm annulus. For example, with one pound distending pressure or pressure differential, the longitudinal or circumferential tension on each inch of breadth of an annulus one inch in diameter is one-half pound. If the diameter of the annulus is 12" one pound pressure differential produces a tension of 6 pounds on each inch of breadth. If 48" is the diameter, the tension produced by one pound pressure differential within the annulus is 24 pounds, and so on.

If the diaphragm constitutes only an arc of a circle or of a cylindrical annulus the longitudinal tension varies directly with the radius of curvature of the arc.

In accordance with this invention, one embodiment takes the form of a suitable supporting means comprising two circular plates, or heads, spaced apart by a stud bolt encircled by a balancing spring, and having a diaphragm disposed circularly thereabouts enclosing the space between the plates or heads. The diaphragm is damped on one side on each circumferential edge and on the other side is sealed to a membrane which is in turn sealed to the heads. This latter acts to prevent the escape of confined fluid. The chamber enclosed by the end plates and cylindrical sheet diaphragm contains fluid at a pressure sufficient to tension said diaphragm to the desired degree. Additional fluid may be forced into the cylinder through a suitable valve. The spacing means is adjustable by means of the nut upon the threaded end portion of the stud bolt and acts as a means to control the degree of transverse tension existing in the diaphragm. Forcing the end plates or heads together tends to remove the transverse tension present whereas permitting the heads to be forced apart increases the transverse tension resulting from the presence of a particular distending fluid pressure. A driving means similar to that shown in my Patent 1,778,871, granted October 21, 1930, may be employed to impart vibrations to the diaphragm. A line damping means, preferably diametrically opposite said drive, is also provided.

In another embodiment an acoustic device has an annular space for compressed fluid, one wall being a cylindrical sheet diaphragm and the other of a suitable non-vibratory material. Suitable damping means is provided on the side of the diaphragm opposite a line drive, and also between the clamping means and the longitudinal edges of the diaphragm. It is obvious that this embodiment may have many modifications without departing from the inventive idea contained therein. For instance, the pressure of the enclosed fluid could be less than atmospheric.

In still another embodiment, this invention may take the form of a composite loud speaker made up of cylindrical central and concentric annular units with sound radiating diaphragms for outer walls. These diaphragms may be held distended and under longitudinal tension by fluid pressure. The space back of the diaphragms of the different units may be interconnected and under the same fluid pressure. The diaphragms in the different units will then be placed under the same unit pressures, but different tensional forces, depending on the diameters of the annular diaphragms, and consequently under different stretch or tension. Again, the tension in the different diaphragms may be made the same by applying appropriately different fluid pressures. The drive may be in the form of a unit common to all and having

branching or series pneumatic connection with the various units, or each unit may have its individual drive, either pneumatic or mechanical, to cause transverse vibration in the diaphragm. The energy from each diaphragm is directed towards the front by an associated flaring annular trough. The outermost annular unit may have a diameter of 6' or more.

A further understanding of my invention will be obtained by reference to the accompanying drawings wherein:

Fig. 1 is a sectional view of an acoustic device embodying the features of my invention.

Fig. 1—A is a modification of the embodiment shown in Fig. 1.

Fig. 2 is a sectional view of another embodiment in which the chamber enclosed by an annular frame and an annular diaphragm contains fluid under less than atmospheric pressure.

Figs. 3 and 4 are sectional views of still another embodiment of my invention being particularly a modification of the embodiment shown in Fig. 1—A.

Fig. 5 shows still another embodiment of my invention in which pneumatic driving means is employed.

Fig. 6, showing a number of concentric sound reproducing units, is a modification of the embodiment shown in Fig. 5.

Fig. 7 is a plan view of a section of Fig. 6 along the line 7—7.

In the embodiment of my invention shown by Fig. 1, there is disclosed a cylindrical fluid enclosing body supported on a frame 1 and having a diaphragm 2 of any suitable material, but preferably of aluminum or an aluminum alloy, serving as a circumferential wall to said cylindrical body. The diaphragm 2 is supported on its circumferential edges by membranes 7 which are cemented, soldered or otherwise secured to the peripheral portions 8 of the diaphragm and are in turn sealed to the peripheral portions 26 of the end plates 3 and 4. Between the diaphragm 2 and the circular end plates 3 and 4, on the latter's circumferential surfaces, there are provided strips 9 of damping material, preferably felt, which completely encircle these surfaces. The end plates 3 and 4, are spaced apart by a stud bolt 5 engaging a threaded port on in the lower plate 4 which is secured to the frame by fastening means 15. Upon the other threaded end of the stud bolt, which extends through an opening provided for that purpose in the upper plate 3, is a nut 10 which clamps against an encircling washer 16 positioned between said nut and said end plate or head. Within the fluid chamber and encircling said bolt is a balancing spring 6, the ends of which are located in suitable depressions 19 in the inner surfaces of the end members 3 and 4. The use of this spacing

means is preferred although the purpose of the invention could be served by the use of a rigid member to hold end plates a fixed distance apart.

5 The chamber 18 contains fluid under pressure. This pressure may be varied in two ways; by introducing further fluid, or permitting the escape thereof, through the stop cock or valve 11, or by adjusting the nut 10 on the exposed portion of the stud bolt. By 10 such adjusting means it is possible to vary the degree of transverse tension present in the diaphragm.

15 The introduction of fluid under pressure within the chamber will cause substantially circumferential tension only in the diaphragm for any given value of fluid pressure. The transverse tension present will be so small as to be negligible in comparison 20 with the degree of circumferential tension. By tightening the nut 10 the heads 3 and 4 are brought together and by means of the sealing membranes 7, the transverse tension in the diaphragm may be neutralized completely. If the full effect of the transverse 25 tension possible with the given fluid pressure is desired, separation of the heads by loosening the nut 10 will cause a greater degree of transverse tension in the diaphragm. If the rigid spacing member were 30 employed this transverse tension could not be controlled but this would not seriously affect the efficiency of the device inasmuch as the degree of transverse tension due to fluid 35 pressure is small.

40 The strips 9 of damping material are thin and, with a pressure differential of one pound or less, would be sufficient to prevent substantial leakage of the fluid within the cylindrical chamber without the use of the membranes 7. The diaphragm 2 would of course have to be supported in some way so as not to introduce transverse tension there- 45 to. It is true that leakage would probably occur, but the area acted upon by the pressure differential of one pound or less would be so small that the damping means would remain in place and the leakage would be very slow. Further, a small compressor (not 50 shown) supplying the cylindrical chamber 18 through the stop cock or valve 11 could be used to keep the pressure differential at the correct value. It is preferable, however, to make use of the sealing membranes 7 55 which offer areas only slightly larger, in this embodiment, to the pressure differential which will also serve a number of other purposes and do away with the need for a compressor to maintain the fluid content of the cylindrical body constant in that an air- 60 tight seal is obtainable. Furthermore, the use of high values of differential pressures is possible, thus permitting the use of smaller diameter cylindrical diaphragms. The use 65 of these membranes has been found prefer-

able, also, in the other embodiments of my invention disclosed herein.

As these membranes are sealed to the heads 3 and 4 and also to the diaphragm, the force with which they are acted upon will be di- 70 vided equally between the heads and the diaphragm. In this way a slight amount of transverse tension will be produced in the diaphragm. In view of the high degree of circumferential tension present this has a 75 negligible effect on the wave energy propagated in the diaphragm. The force existing within the chamber at any given differential pressure is taken by the membranes 7, the heads 3 and 4 and the diaphragm 2. 80 Since the membranes, as supporting means, produce a minimum of transverse tension due to the force acting against the heads, the force outward on the diaphragm, as it cannot produce a transverse tension in the dia- 85 phragm, will produce a tension in a circumferential direction only to a degree depending on the force being exerted on the diaphragm.

The other functions served by the sealing membranes 7 are now pointed out. They act 90 as supports to the diaphragm 2 when the latter is in both a tensioned and an untensioned condition. They furnish air-tight seals to prevent leakage into and out of the fluid chamber 18. They provide baffling to 95 prevent interference between wave disturbance set up within and without the fluid enclosing chamber. Finally, in being sealed to the diaphragm they hold it uniformly suspended with substantially no vibratory 100 constraint and hold the diaphragm tightly against the strips 9 of damping material located between the diaphragm 2 and the heads 3 and 4.

The diaphragm 2 is preferably tensioned in 105 a circumferential direction only and to such a degree that the vibrations in said diaphragm are propagated with a velocity comparable to that of sound waves in air. By proper choice of the pressure differential 110 and the sound radiator diameter, it is possible to obtain in the diaphragm a tension approaching the elastic limit of the material comprising the diaphragm. With an alu- 115 minium diaphragm under this tension it would be possible to obtain a velocity of propagation in the diaphragm approaching that of sound waves in air. This is desirable, since, if the rate of propagation in both the dia- 120 phragm and the surrounding atmosphere are practically in unison, the phase cancellation effect will be small or none at all. In the case of an aluminum alloy, such as duralumin, it has been found that besides being 125 of greater tensile strength the velocity of vibrations therein, when tensioned to its elastic limit, is considerably greater than the velocity of sound waves in air.

The driving means may be of any suitable type capable of vibrating the diaphragm on 130

a line substantially across its width, and is preferably of the distributed drive type, such as disclosed for instance in my Patent 1,778,871, granted October 21, 1930. Line damping means are provided preferably diametrically opposite the driving means. Pins 17, secured to a suitable upright 25 forming a part of the frame 1, support a bar 13 which holds the damping material 14, preferably of felt, against the diaphragm 2 with a pressure variable by means of the thumb screw 12 disposed in the upright 25 and bearing against the bar 13.

When vibrations arising from the actuation of the driving means are set up in the diaphragm they are propagated semi-circularly in a circumferential direction and are damped, to prevent possible reflection, on a line opposite the line of drive by the damping means hereinabove described.

Referring now to Fig. 1—A, which shows a modification of this embodiment, there is employed an annular frame comprising an annular member 27 and annular rings 28 which are secured together, either as shown or in any other suitable way, in an air-tight manner. This frame may, of course, be constructed in one piece, the embodiment shown is but one of many forms in which the invention may be represented. In the annular member 27, there is provided an opening 36, to an annular fluid chamber 31 for the ingress or egress of fluid through a stop cock or valve 37. This chamber is formed by the annular frame and a circumferentially disposed diaphragm 32 which is supported, as in the embodiment shown in Fig. 1, by sealing membranes 33 and damped by strips of damping material 34 between the diaphragm and the annular rings 28. The chamber contains fluid under pressure which acts as previously outlined to produce in the diaphragm a tension which is substantially entirely circumferential and to a degree dependent on the diameter of the diaphragm and the pressure differential existing between the atmosphere and the fluid within the chamber 31. A driving means and line damping similar to that shown in Fig. 1 may also be used.

Referring now to the embodiment of my invention shown in cross section in Fig. 2, there is provided an annular frame 20 which supports suitable actuating and damping means for a diaphragm 21 which forms the inner circumferential wall of an annular fluid enclosing chamber 22. The diaphragm 21 is of any suitable light weight material, preferably of aluminum or an aluminum alloy, and is held supported with substantially no transverse tension by sealing membranes 23 soldered or cemented as shown to the upper and lower peripheral edges of the diaphragm and in turn soldered or cemented to the annular frame 20, thus forming an air-tight partition

between the outer atmosphere and the fluid contained within the annular chamber 22. This partition extends annularly with the frame and diaphragm. Between the frame 20 and the diaphragm 21 is a thin strip 24 of damping material, preferably of felt.

In its preferable form, the annular chamber 22 contains fluid, preferably air, under a pressure less than that acting on the outer surface of the diaphragm 21. This external pressure is normally that of the atmosphere. The annular chamber 22 may be evacuated to the desired degree through the stop cock or valve 30. This evacuating means permits of varying the differential pressure between the outer and inner surfaces of the diaphragm 21. By varying the diameter of the annular frame and the associated diaphragm variation in the degree of tension in the diaphragm may be obtained. This tension is substantially entirely circumferentially distributed through the diaphragm with a minimum of transverse tension which depends upon the sealing membrane areas acted upon. It is understood, of course, that by varying the fluid pressure within the annular chamber 22 it is possible to introduce a transverse tension force of considerable degree but in the same ratio to the circumferential tension as before. The drive and damping means employed in the embodiment of Fig. 1 may also be used to actuate and to damp the diaphragm. The vibrations will be propagated semi-circularly in a circumferential direction.

As can be seen, the annular frame 20 hereinabove mentioned may be built up of a base *a*, an intermediate annular member *b* to which the lower sealing member 23 is secured, and an annular member *c*, forming the wall of the fluid enclosing chamber, an upper annular member *d* to which the upper sealing membrane is secured. These parts are tightly connected together by screws *e* which may be spaced at appropriate intervals around the outer periphery of the annular members.

Another embodiment of my invention takes the form illustrated by Figs. 3 and 4 in which an arcuately disposed diaphragm 38 is held distended by fluid pressure within a fluid enclosing chamber 39 formed by the diaphragm 38 and an arcuate frame 40 of suitable non-vibratile material. The diaphragm 38 is drawn tightly over the arcuate support around the end supports 41, which serve to space the diaphragm from the arcuate frame 40 when the diaphragm is under tension, and secured by screws or similar means along its terminations. Means comprising a turn-buckle 42 and tension rods 43 together with struts 44 may be used to balance the force acting against the frame 40 when the diaphragm 38 is held distended under fluid pressure. To permit the introduction of the requisite fluid and thereafter to permit variability in said fluid pressure, a stop cock or

valve 45 is provided. As shown in Figs. 3 and 4 sealing membrane 46, damping means 47 and the vibration producing means are the same and act in the same way as in previously described embodiments.

Still another embodiment of my invention is shown in Fig. 5 wherein a diaphragm 49 is supported as in embodiments previously described by sealing membranes which are cemented, soldered or otherwise secured in an air-tight manner to the diaphragm and the frame. The frame in this embodiment consists of spaced members 48—48, circular in shape, distanced and held together by inserts 50. As a further means to hold the members 48—48 rigidly spaced when the chamber 51 contains fluid under pressure, bolts or screws 57 securing them together may also be provided although not necessary. The enclosed space 51 contains fluid under sufficient pressure to tension the diaphragm to the desired degree. Vibrations are transmitted through this fluid to the diaphragm through an inlet whose wall 53 is preferably logarithmically tapered and thence radially outward through the chamber 51 whose bounding surfaces 54 and 55 are also tapered, varying exponentially with the distance from the mouth of the inlet. In other words, the areas through which the vibrations are propagated from their source vary exponentially with the distance from said source. The vibration source 52 may be of any suitable means capable of producing pressure waves in the enclosed fluid. This means may for example, comprise a coil driven diaphragm with the coil positioned between concentric annular pole pieces. Vibrations in the diaphragm 49 are produced by the pressure variations resulting from condensations and rarefactions in the fluid caused by the movement of the diaphragm in the driving unit 52. This diaphragm must be balanced on each surface by a pressure equal to that existing in the enclosed chamber. A means for varying the pressure in chamber 51 is provided in the auxiliary stop cock or valve 56 through the connecting channel 72 and the main stop cock or valve 74. When the pressure within the acoustic device is varied, unless some means is provided to avoid it, the diaphragm in the driving means 52 will be under unbalanced pressures in its normal state. Therefore, a channel or tube 71 is provided so that when valves 56 and 74 are opened to permit of a change in the fluid pressure within the acoustic device a corresponding pressure change takes place on each side of the diaphragm in the driving means 52. When the desired change in pressure has taken place valves 56 and 74 are closed. To prevent any tube resonance effect in the channels 72 and 71, the suitable damping material 73, such as felt, fiber or the like, is provided.

Referring now to Figs. 6 and 7 there is shown a central cylindrical unit 68 and annular concentric units 58 which have annular sound radiating diaphragms 59 as walls to annular fluid enclosing chambers 60. At the peripheral edges of said diaphragms there are sealed, as in other embodiments air-tight membranes which are in turn sealed to the frames of the various units. The frames are so shaped that the faces 63 opposite the diaphragms flare outwardly to provide annular flaring channels 62 for the path of sound waves from the diaphragms to the outer atmosphere. It is preferable to interconnect the annular chambers behind each diaphragm by channels 69 and 70 so that all the diaphragms are under the same unit pressure but tensioned by a force which varies as the diameter of the diaphragm. As in the embodiments previously described, the preferred condition is one in which the diaphragms, at least the outermost ones, are tensioned in a circumferential direction only, the sealing membranes exerting a minimum transverse tension on the diaphragm. With a given pressure differential the diaphragms of the units of greatest diameter will be tensioned to the highest degree, and the diaphragms of lesser diameter will be tensioned to a lesser degree. Vibrations are produced in the diaphragms 59 by pressure variations in the fluid behind each diaphragm. These variations take the form of condensations and rarefactions caused by the vibrations of a diaphragm in the driving unit 64, balanced on each side by a like pressure, and which causes disturbances that move circumferentially in a semi-circular manner in each unit and finally return to the opposite side of the diaphragm from that at which they originated. Inasmuch as the path taken is a long one, the energy remaining in the wave disturbance will be practically negligible.

Although the invention has been disclosed in a number of embodiments, it is to be understood that the inventive idea disclosed could be practiced in other embodiments without departing from the scope of the invention as defined in the appended claims.

What is claimed is:

1. An acoustic device comprising a circularly disposed sound radiating diaphragm in the form of a strip relatively long as compared to its breadth, means to seal one surface of said diaphragm from the atmosphere, fluid means acting on one surface for tensioning said diaphragm in the direction of its long dimension, and means for imparting vibrations thereto.

2. An acoustic device comprising a circularly disposed sound radiating surface in the form of a strip relatively long as compared to its breadth, means for tensioning said diaphragm in the direction of its long dimension, means for securing the circumferential

edges of the diaphragm without imparting substantial transverse tension thereto, and means for imparting sound vibrations to said diaphragm.

3. An acoustic device comprising a circularly disposed diaphragm forming a wall of a receptacle of relatively larger circumference than depth, means for placing said diaphragm under tension in the direction of its long dimension only, and means for imparting sound vibrations thereto.

4. An acoustic radiator comprising a diaphragm disposed in the form of an annulus, means forming with said diaphragm a closed chamber, fluid means in said chamber for tensioning said diaphragm circumferentially only, and means for imparting vibrations thereto.

5. An acoustic device comprising a circularly disposed diaphragm forming a wall of a receptacle of relatively larger circumference than depth, fluid pressure within said receptacle acting to place said diaphragm under tension in the direction of its long dimension, and means to impart vibrations to said diaphragm.

6. An acoustic device comprising a diaphragm disposed in the form of an annulus of large circumference compared with its width, means closed off from the surrounding atmosphere, for placing said annulus under tension in the direction of its long dimension only, and means for imparting vibrations thereto.

7. An acoustic device comprising a circularly disposed diaphragm, and means to place said diaphragm under tension circumferentially such that the velocity of vibrations propagated in a circumferential direction will be comparable with the velocity of sound waves in air.

8. An acoustic device comprising a circularly disposed diaphragm, and means for tensioning said diaphragm circumferentially to a high degree with substantially no transverse tension, said means comprising fluid under pressure.

9. An acoustic device comprising a circularly disposed diaphragm, and means for tensioning said diaphragm circumferentially to a degree approaching the elastic limit of the diaphragm material, said means comprising fluid under pressure.

10. An acoustic device comprising a diaphragm forming a circumferential wall for a receptacle, means for tensioning said diaphragm circumferentially with a minimum of transverse tension, and means for varying the degree of transverse tension present therein.

11. An acoustic radiator comprising a receptacle and a relatively long, narrow membrane constituting one wall of said receptacle, means for forming a substantially airtight seal between longitudinal edges of said

membrane without exercising substantial vibratory constraint upon said edges, fluid under pressure within said receptacle to place said membrane under tension in the direction of its length only, and means to impart acoustic vibrations to said membrane.

12. An acoustic device comprising an annular frame, an annularly disposed membrane forming a circumferential wall, fluid means under pressure acting on one surface of said diaphragm for tensioning said diaphragm circumferentially, and means for imparting acoustic vibrations thereto.

13. An acoustic device comprising a circularly disposed diaphragm forming the outer wall of a receptacle of relatively greater circumference than depth, means for placing said diaphragm under tension in a circumferential direction, means for imparting acoustic vibrations thereto, and means for damping vibrations therein.

14. An acoustic device comprising a circularly disposed diaphragm forming the wall of a receptacle of relatively greater circumference than depth, fluid under pressure within the receptacle acting to place said diaphragm under tension in the direction of its long dimension, means to vary said fluid pressure, means to impart acoustic vibrations to said diaphragm, and means for damping vibrations therein.

15. An acoustic device comprising a circularly disposed diaphragm forming the outer wall of a receptacle of relatively larger circumference than depth, means for tensioning said diaphragm circumferentially, means to vary the tension in said diaphragm, means for securing said diaphragm on its circumferential edges, and means for imparting vibrations to said diaphragm, said means comprising a line drive transverse to the propagation of vibrations in the diaphragm.

16. An acoustic device comprising cylindrical units having diaphragms for circumferential walls, means for tensioning each of said diaphragms to a different degree, and means for imparting vibrations to said diaphragms.

17. An acoustic device comprising cylindrical and concentric units having sound radiating diaphragms for circumferential walls, fluid pressure against one surface of each diaphragm for imparting tension thereto, and means for imparting vibrations to said diaphragms.

18. An acoustic device comprising an arcuate frame, an arcuately disposed diaphragm forming a wall for the space enclosed by said frame and diaphragm, means for imparting tension to said diaphragm, and means for imparting vibrations to said diaphragm.

19. An acoustic device comprising concentric units having sound radiating diaphragms as circumferential walls, means for imparting

vibrations to said diaphragms, and means for directing the sound energy directly from each diaphragm.

20. An acoustic reproducer comprising a receptacle and a vibratory diaphragm constituting one wall of said receptacle, means for forming a substantially air-tight seal between longitudinal edges of said diaphragm and the receptacle without exercising substantial vibratory constraint on said edges, fluid under pressure within said receptacle, and means to impart vibrations to said diaphragm.

21. An acoustic device comprising a strip of vibratile material disposed as an annulus, means for tensioning said strip substantially circumferentially only, and means for imparting vibrations thereto.

22. An acoustic device comprising a diaphragm, and means placing said diaphragm under a tensioning force, said tensioning force being opposed substantially entirely by the diaphragm itself only.

23. An acoustic device comprising a plurality of stretched cylindrical sound radiating diaphragms arranged in nested relation, and means to impart vibrations to said diaphragms.

24. An acoustic device comprising a plurality of diaphragms comprising strips of vibratile material closed on themselves to form annuli of different diameters and arranged one within the other, each of said diaphragms being stretched to a different degree, and means for imparting vibrations to said diaphragms.

25. An acoustic device comprising a plurality of diaphragms comprising a plurality of strips of vibratile material closed on themselves and arranged in nested relation, each of said diaphragms being stretched to a different degree.

26. An acoustic device comprising a plurality of diaphragms comprising a plurality of strips of vibratile material, and means forming a fluid chamber with one surface of each of said strips and connecting said chambers, and a vibratory member coupled to said chambers.

In witness whereof, I hereunto subscribe my name this 3rd day of April, 1929.

EDWIN H. SMYTHE.