

Nov. 17, 1942.

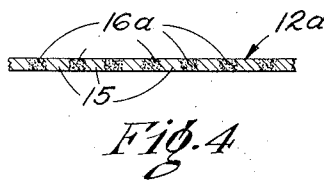
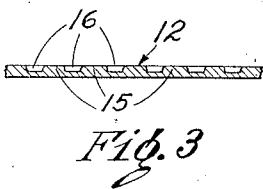
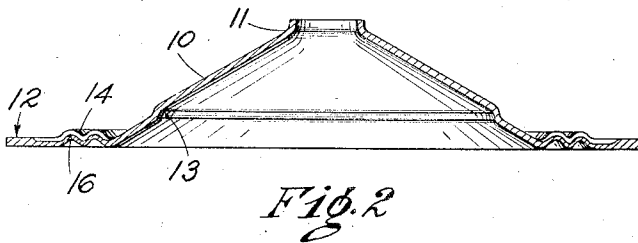
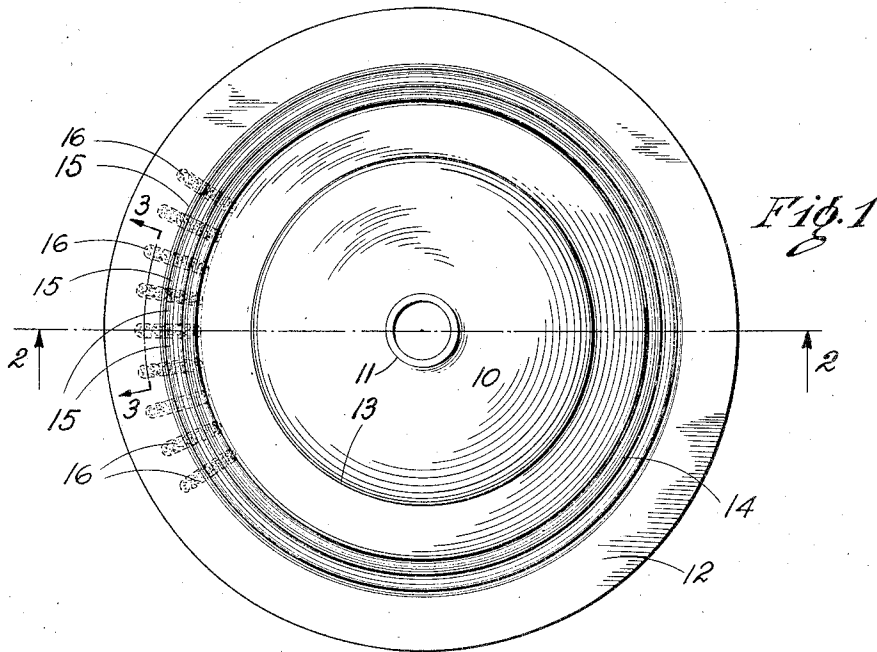
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2,302,178

ACOUSTIC DIAPHRAGM

Filed Nov. 12, 1940

2 Sheets-Sheet 1



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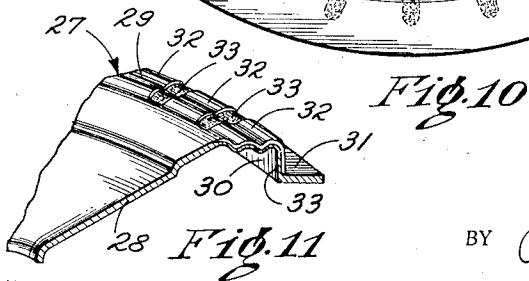
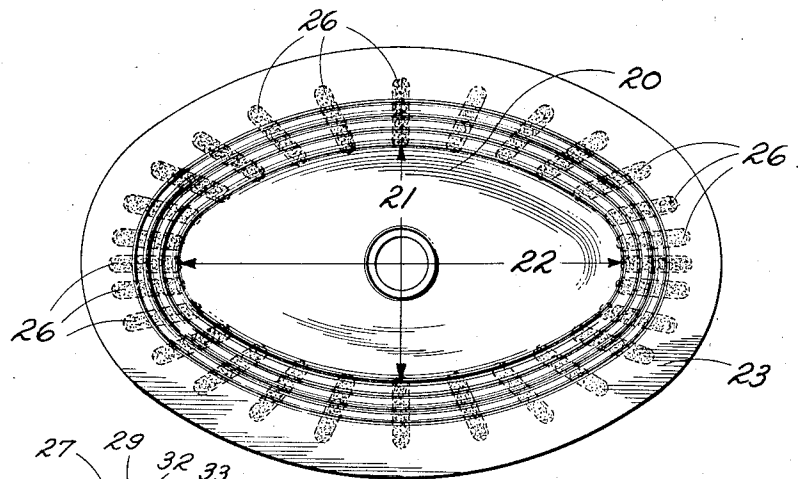
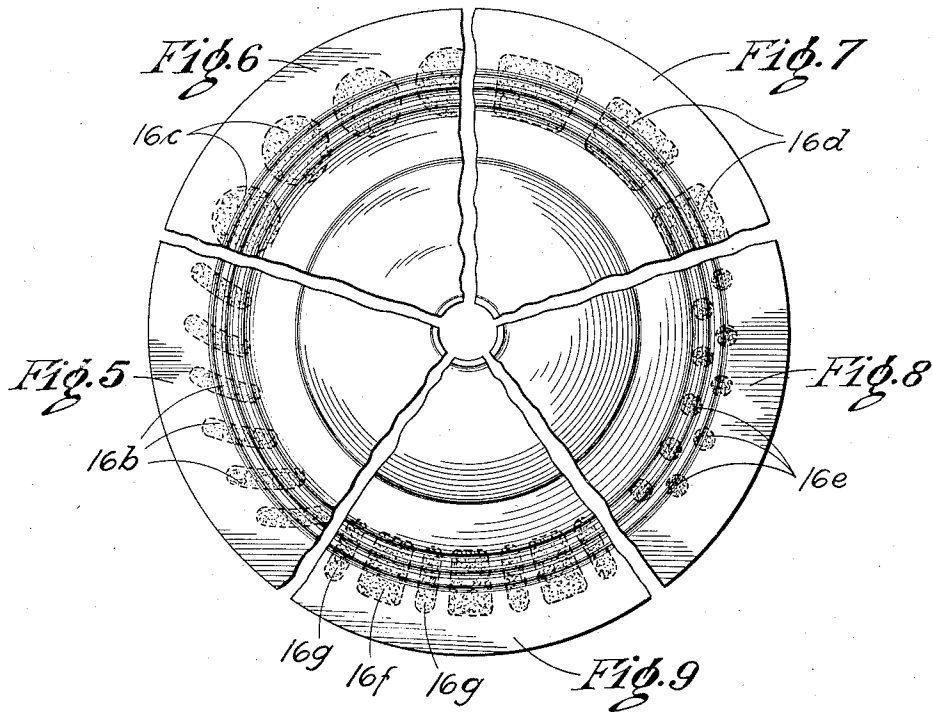
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ACOUSTIC DIAPHRAGM

Filed Nov. 12, 1940

2 Sheets-Sheet 2



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2,302,178

ACOUSTIC DIAPHRAGM

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Application November 12, 1940, Serial No. 365,916

17 Claims. (Cl. 181-32)

This invention relates to acoustic diaphragms such as are used in radio receivers, public address systems and the like. Insofar as common subject matter is concerned, this application constitutes a continuation in part of my copending applications Serial No. 121,604, filed January 21, 1937, and Serial No. 351,791, filed August 8, 1940.

A diaphragm of this type ordinarily comprises a generally conical or conoidal portion which is provided at its smaller end with a cylindrical neck to which a moving voice coil is secured. This coil is disposed in a magnetic field and voice currents flowing through the coil result in vibration of the cone. At its larger end the cone is provided with a generally radially extending flange which is clamped or otherwise secured to a support and which functions as a support for the cone. The cones preferably are made of fibrous material deposited on a form and, in order to secure different characteristics of the cones, the material may be impregnated with various substances such as lacquers, latex and various plastics.

The outer rim of the cone which functions to support the cone has little, if any function so far as the production of sound is concerned, but unless the flange or rim is properly constructed, it may adversely affect the performance of the cone or diaphragm. Thus, the stiffness and inertia of the rim affect the natural period of vibration of the diaphragm, and the rim further functions as a part of the usual baffle which is employed to improve the efficiency and acoustical characteristics of the device.

In order to produce a flexible connection between the conical part of the radial extending flange, it has been the practice to provide the radial extending flanges of cones with circumferential corrugations. It has also been proposed to make the connecting portion between the conical portion and the radial extending flange of lesser thickness than the conical portion or the flange. Both of these constructions have met with some success but neither construction has given completely satisfactory results for the radial corrugations do not sufficiently increase the flexibility for all purposes and the thinning of the material cannot be carried out with sufficient accuracy to produce in quantity cones having identical characteristics and, further, a reduction in thickness throughout the circumference of the cone to a sufficient extent to materially affect its characteristics may result in a serious weakening of the structure.

cones in which the flexibility of the connection between the conical portion and the radial flange may be accurately controlled to produce cones having the desired characteristics while at the same time the acoustical properties and baffle effect are not substantially impaired and the flange retains adequate strength to support the cones and accurately center them with respect to the frame of the loud speaker or other device. In order to accomplish this result, I preferably provide in the flange a sufficient number of portions of sufficient strength to properly support and center the cone while the remaining portions of the flange are weakened as by reducing the thickness or density of the material in these portions. Thus, for example, the supporting portions may be of the same thickness and strength as the material of the body of the cone, while the intermediate portions may be weakened so as to be of negligible structural strength so long as the weakened areas are such as to block the passage of sound from one side of the cone to the other to a sufficient extent that the acoustical properties of the cone are not substantially impaired by the weakened areas. Or, depending upon the characteristics desired, the supporting portions may be of either greater or less thickness than the body of the cone so long as they have sufficient strength properly to support the diaphragm, while the intermediate portions are weakened.

In the drawings, in which I have illustrated various preferred forms of diaphragms embodying my invention, Fig. 1 is an elevation of one type of cone embodying my invention; Fig. 2 is a section along the line 2-2 of Fig. 1; Fig. 3 is a fragmentary section through the rim portion of the cone as indicated by the line 3-3 of Fig. 1, the view somewhat diagrammatically illustrating the weakened portions of the rim or flange; Fig. 4 is a section similar to Fig. 3 but showing a modified construction insofar as the mode of increasing the flexibility of the flange is concerned; Figs. 5 to 9, inclusive, are fragmentary elevations of diaphragms embodying my invention and with modified forms of rim structures; Fig. 10 is an elevation showing my invention adapted to an elliptical diaphragm, and Fig. 11 is a fragmentary perspective view illustrating my invention applied to a construction wherein the supporting flange, while generally radial, has an intermediate cylindrical portion. Throughout the drawings, the thickness of the diaphragm is considerably exaggerated for convenience of illustration.

Referring particularly to Figs. 1 and 2, a diaphragm made according to my invention may

According to my present invention, I provide

comprise a generally conical body portion 10 having at the small end thereof a neck portion 11 to which the voice coil is secured and at its large end a generally radially extending flange 12, the peripheral edge of which is adapted to be clamped or otherwise secured to the frame of an acoustic device to assist in supporting the diaphragm. The conical portion 10 may be provided with a corrugation as indicated at 13, while the rim or flange 12 preferably is provided with a plurality of circumferentially extending corrugations 14 in order to increase the flexibility thereof in a manner well understood by those skilled in the art. Preferably the cone or diaphragm is of one-piece, seamless construction, being integrally formed by depositing fibrous material upon a base or mold having substantially the shape of the finished diaphragm. This may be accomplished in various ways understood by those skilled in the art, as by depositing the fibrous material from an aqueous suspension of the material onto a porous former or mold. The material may be pressed to make it more dense after being removed from the porous form and, if desired, may be impregnated with various materials such as condensation products of urea and formaldehyde, phenolic condensation products, synthetic resins, lacquers, latex and other similar materials.

As heretofore stated, the sound output of the diaphragm and the natural period of vibration of the diaphragm depend to a considerable extent on the flexibility of the supporting rim or flange. Every movement or vibration of the diaphragm requires bending and distortion of the rim or flange. In order to control the stiffness of the rim, and preferably to reduce the stiffness, thus reducing the natural period of vibration of the diaphragm and increasing the efficiency of sound production thereby, I preferably form the diaphragm as indicated in Fig. 2 with the rim 12 provided with alternate relatively strong and relatively weak portions indicated at 15 and 16 respectively. The portions 15, which are separated by the portions 16, function accurately to support and center the diaphragm with respect to the supporting frame of the acoustic device and preferably are made of substantially the same thickness as the conical portion 10 so that they will have ample strength, and will have the ability to withstand the vibrations of the diaphragm for long periods of time.

In order to increase the flexibility of the flange or rim the intermediate portions 16 are preferably formed as shown diagrammatically in Figs. 2 and 3 of considerably reduced thickness. These weakened portions increase the flexibility of the rim in two ways, first, by removing some of the material of the rim and, second, by permitting the changes in shape and distortion of the rim incident to vibration to take place more readily. That is, the relatively strong portions 15 may be distorted slightly in circumferential directions more readily than in a continuous rim structure. While the weakened portions 16 are of such thickness that they have very little structural strength and, in fact, may be porous and even so thin as to be translucent, nevertheless the interlaced deposited fibers extend between the stronger portions 15 and form a sufficient barrier to the passage of sound and air to prevent the efficiency and acoustical qualities of the diaphragm from being impaired, whereas these qualities would be impaired if the material were completely removed from the regions 16. Further, the fibers make the flange substantially continuous and function

to prevent the annoying phenomenon known as "edge buzz."

Thus, by providing weakened portions which nevertheless function as sound blocking portions, the stiffness of the rim can be varied within wide limits to produce the desired characteristics without impairing the efficiency and acoustical qualities of the cone. Variations in the stiffness of the rim and correspondingly, in the natural frequency of vibration of the diaphragm may be produced by varying the spacing in size of the weakened portions 16, by varying their shape and general arrangement, by varying their strength and by other similar changes. For example, as indicated diagrammatically in Fig. 4, instead of reducing the thickness of the material in the weakened portions, the density of the material may be reduced as indicated diagrammatically at the regions 16a, the portions 15 of the rim 12a being of normal density and strength.

In Figs. 5 to 9, inclusive, I have illustrated various arrangements of relatively strong and weak rim portions. In Fig. 5 the weakened portions 16b extend in spiral fashion from the conical portion of the cone toward the peripheral edge of the rim rather than radially as in Fig. 1. In Fig. 6 the portions 16c are circular rather than elongated as previously described. Fig. 7 shows weakened portions 16d in the shape of sectors, while Fig. 8 shows a construction embodying a relatively large number of small weakened portions 16a arranged in staggered relationship particularly along the corrugations 14 of the cone. Fig. 9 shows an arrangement in which alternately disposed large and small weakened portions 16f and 16g, respectively, are employed.

Various other arrangements will undoubtedly occur to persons skilled in the art.

The flexibility and adaptability of my scheme make diaphragms embodying my invention particularly desirable where the diaphragms are of non-circular shape. Thus in Fig. 10 I have illustrated a diaphragm of elliptical cross-section. In such a diaphragm I prefer to vary the stiffness of the rim in generally inverse ratio to the distance of the rim from the center of the diaphragm. Thus the least diameter of the elliptical diaphragm 20 is indicated at 21, while the greatest diameter is indicated at 22. If the rim 23 were of uniform stiffness throughout, the material of the cone 20 would be subjected to the greatest bending stresses along its major diameter 22 and to the least bending along the shortest diameter 21. Such a difference in the bending forces exerted on the material of the diaphragm may result in impairing the acoustic characteristics thereof, and in order to compensate for this variation in diaphragms of this type, I preferably make the rim of the diaphragm more flexible adjacent the greater diameter and gradually reduce the flexibility of the rim as the smaller diameter is approached. For example, the rim may be provided with a plurality of weakened portions 25, the weakened portions gradually increasing in size from the region adjacent the diameter 21 to the region adjacent the larger diameter 22. By this means the stresses in the material of the cone can be substantially equalized with resulting improvement in the characteristics thereof. Obviously, instead of varying the size of the weakened portions, their spacing can be changed or other means may be adopted to vary the stiffness of the diaphragm around the periphery of the cone. Varying the stiffness of the rim is also of value in

conjunction with diaphragms of other non-circular sections, such as the rectangular section described in my application Serial No. 351,791, aforesaid.

In Fig. 11 I have illustrated my present invention as it may be applied to a diaphragm with a different type of flange. In this modification, the flange 21, extending from the body 28, may have a radially extending corrugated portion 29, an axially extending portion 30, and a further radial portion 31. The flange is provided with alternate strong and weak portions 32 and 33, respectively, the portions 33 preferably extending along the axial portion 30 approximately to the junction of the axial portion with the radial portion 31. This provides a very flexible support for the body of the diaphragm. Obviously, the various modified arrangements of openings described heretofore may also be employed with flanges of this type.

The diaphragms embodying my invention may be made, for example, as described above, by depositing fibrous material upon a suitable form. The weakened portions may be produced by partially or entirely masking or blocking the openings in the porous form so that only a small amount of fibrous material will be deposited if the fibrous material is deposited by suction, and by generally similar masking of these areas if the fibrous material is sprayed upon the form. Lesser quantities of fibrous materials are deposited in the weakened portions. In some instances this will result in thinner portions, but if desired, the weakened portions may be made of substantially the same thickness; in this case lesser quantities of fibrous material are deposited, but the diaphragms are subjected to a pressing operation to compact the deposited material and compress it down to approximately the thickness deposited in the weakened areas.

If desired the diaphragms may be impregnated with the various materials heretofore noted. Preferably, the diaphragms are produced with enough material in the weakened areas to support a continuous film of the various impregnating materials, thus an impervious supporting flange can be produced, if desired, but, as noted above, a porous structure will also give excellent results.

From the foregoing description of my invention it will be seen that I have provided diaphragm structures which can be economically and readily produced by my preferred methods, utilizing existing machinery and without requiring extensive modification in existing processes. My diaphragms, further, are adaptable to well-known types of acoustic devices without requiring any modification thereof. By my invention the efficiency of acoustic diaphragms can be greatly increased as by reducing the stiffness of the rims the power required to vibrate the diaphragms is reduced. Further, the stiffness of the rims can be controlled by varying the size and shape of the weakened areas so that diaphragms having definite natural frequencies of vibration can readily be produced and such frequencies of vibration can be selected to suit the demands of the manufacturers of the acoustic devices. Further, by reducing the rigidity of the supporting rim, the response of the diaphragm may be made more nearly uniform over a wide range of frequencies and peaks in the response curves may be substantially reduced. All of these results may be obtained without any substantial impairment in the acoustic qualities of

the diaphragms and while the weakened areas have very little mechanical strength and offer little resistance to bending, nevertheless they are sufficient to block the transmission of sound from one side of the diaphragm to the other and do not substantially reduce the efficiency of the baffle of the acoustic device in which they are assembled. My construction further results in a considerable reduction in weight of the rim of the diaphragm and, accordingly, a reduction in the inertia thereof. For example, the weight of the rim may be reduced by half without seriously impairing the strength of the rim and while maintaining the rim as an accurate centering device for supporting the diaphragm.

In the foregoing specification I have described various preferred forms of my invention. Those skilled in the art will appreciate that various changes and modifications may be made therein without departing from the spirit and scope of my invention. Accordingly, it is to be understood that the foregoing description is given by way of example and not by way of limitation, and that my patent is not limited to the preferred forms described herein or in any manner other than by the scope of the appended claims when given the range of equivalents to which my patent may be entitled.

Reference is hereby made to my divisional application Serial No. 439,142, filed April 15, 1942, which contains claims directed to the method disclosed herein.

I claim:

1. An acoustic diaphragm comprising a body portion and a peripheral flange, said flange being formed of deposited fibrous material and comprising supporting portions extending from said body portion to the peripheral edge of said flange, and sound blocking portions integral with and of lesser strength than said supporting portions.

2. An acoustic diaphragm according to claim 1, wherein the said supporting portions are opaque and the said sound blocking portions are so thin as to be translucent.

3. An acoustic diaphragm according to claim 1, wherein the flange is impregnated with one of the materials from the group consisting of lacquer, latex, synthetic resins, phenolic condensation products, and condensation products of urea and formaldehyde.

4. A one piece, seamless, acoustic diaphragm of deposited fibrous material comprising a body portion and a peripheral flange, said flange comprising supporting portions extending from said body portion to the peripheral edge of said flange and sound blocking portions integral with and of lesser strength than said supporting portions.

5. A one piece, seamless, acoustic diaphragm of deposited fibrous material comprising a body portion and a continuous peripheral flange, said flange comprising supporting portions extending from said body portion to the peripheral edge of the flange and of substantially the same thickness and density as said body portion, and intermediate sound blocking portions integral with and of lesser strength than said supporting portions.

6. A one piece, seamless, acoustic diaphragm of deposited fibrous material comprising a body portion and a continuous peripheral flange, said flange comprising supporting portions extending from said body portion to the peripheral edge of the flange and of substantially the same thickness and density as said body portion, and inter-

mediate sound blocking portions integral with and of lesser thickness than said supporting portions.

7. A one piece, seamless, acoustic diaphragm of deposited fibrous material comprising a body portion and a continuous peripheral flange, said flange comprising supporting portions extending from said body portion to the peripheral edge of the flange and of substantially the same thickness and density as said body portion, and intermediate sound blocking portions of substantially the same thickness as, and of lesser density than said supporting portions.

8. A one piece, seamless, acoustic diaphragm of deposited fibrous material comprising a body portion and a substantially continuous peripheral flange portion, said flange circumferentially varying in strength.

9. An acoustic diaphragm comprising a body portion and a one piece substantially continuous peripheral flange, said flange circumferentially varying in strength.

10. An acoustic diaphragm comprising a body portion of non-circular cross-section, and a peripheral flange adapted to support said body portion within an acoustic device, said flange circumferentially varying in strength and stiffness.

11. A one piece, seamless, acoustic diaphragm of deposited fibrous material comprising a body portion and a peripheral flange, said flange comprising supporting portions extending from said body portion to the peripheral edge of said flange and sound blocking portions integral with and of lesser strength than said supporting portions, said flange being impregnated with a material forming a continuous film co-extensive with said sound blocking portions.

12. A one piece, seamless, acoustic diaphragm of deposited fibrous material comprising a hollow body portion having a non-circular cross-section on a plane perpendicular to its axis, and a peripheral flange adapted to support said body portion within an acoustic device, said flange having different strength characteristics in dif-

ferent regions thereof, and being strongest in the region closest to the axis of the body portion, and weakest in the region farthest from said axis.

13. An acoustic diaphragm comprising a body portion and a continuous peripheral flange, said flange circumferentially varying in strength and comprising supporting portions extending from said body portion toward the peripheral edge of said flange, and intermediate sound blocking portions integral with and of lesser strength than said supporting portions.

14. An acoustic diaphragm comprising a body portion and a one piece substantially continuous peripheral flange, said flange circumferentially varying in strength and comprising supporting portions extending from said body portion toward the peripheral edge of said flange, and intermediate sound blocking portions integral with and of lesser thickness than said supporting portions.

15. An acoustic diaphragm comprising a body portion and a continuous peripheral flange, said flange circumferentially varying in strength and comprising supporting portions extending from said body portion toward the peripheral edge of said flange, and intermediate sound blocking portions of substantially the same thickness as, and of lesser density than said supporting portions.

16. An acoustic diaphragm comprising a body portion and a peripheral flange, said flange having a circumferentially extending corrugation and being formed of deposited fibrous material and comprising supporting portions extending from said body portion to the peripheral edge of said flange, and sound blocking portions integral with and of lesser strength than said supporting portions.

17. An acoustic diaphragm comprising a body portion and a one piece substantially continuous peripheral flange having a circumferentially extending corrugation, said flange circumferentially varying in strength.

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