April 16, 1957 J. B. BRENNAN 2,789,161

LOUD-SPEAKERS

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Fig. 1

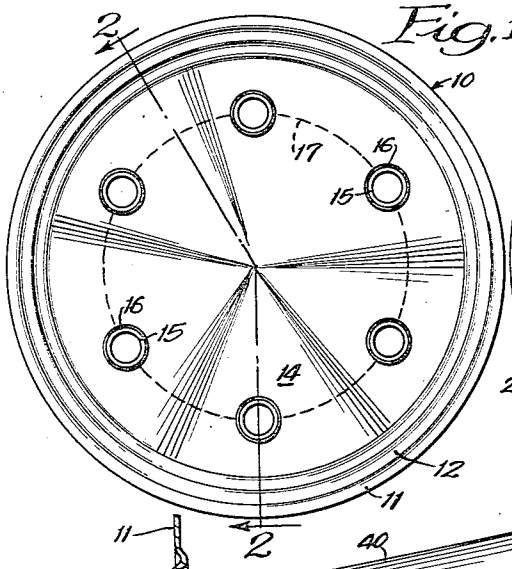



Fig. 4

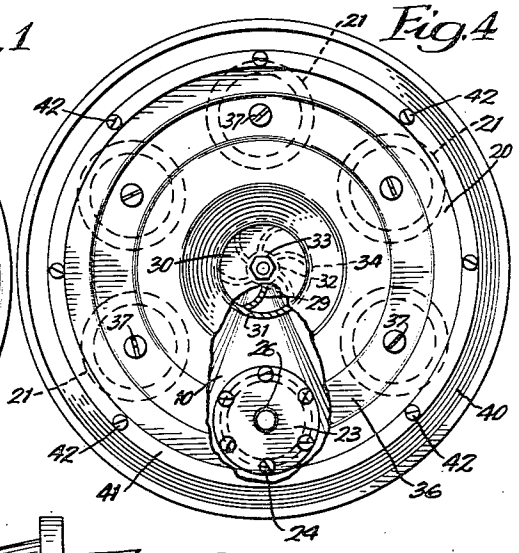



Fig. 2

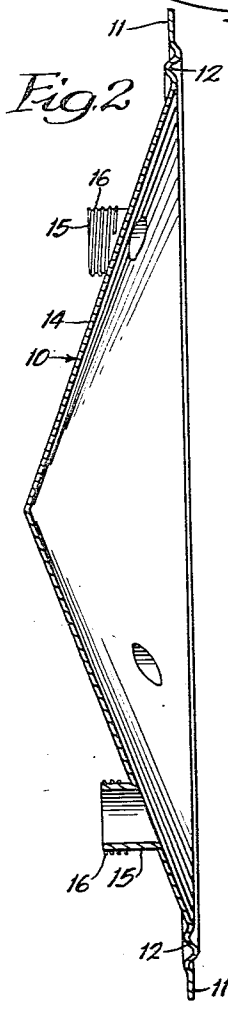



Fig. 3

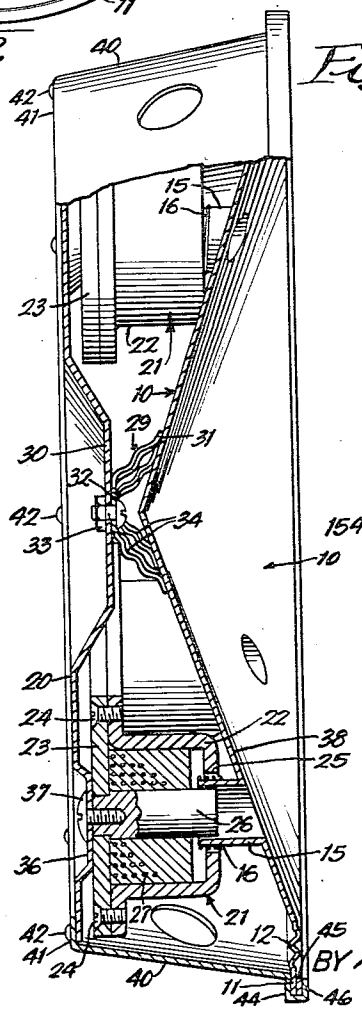
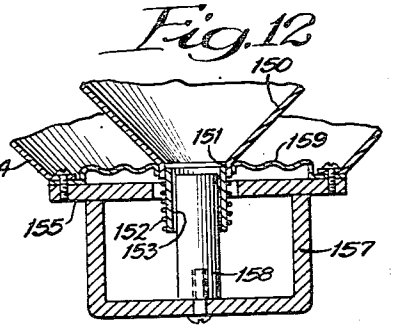



Fig. 12




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Fig. 5

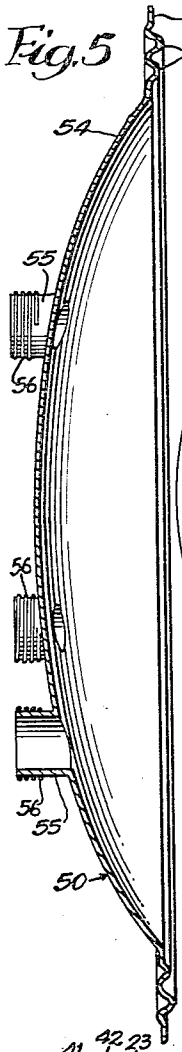



Fig. 7

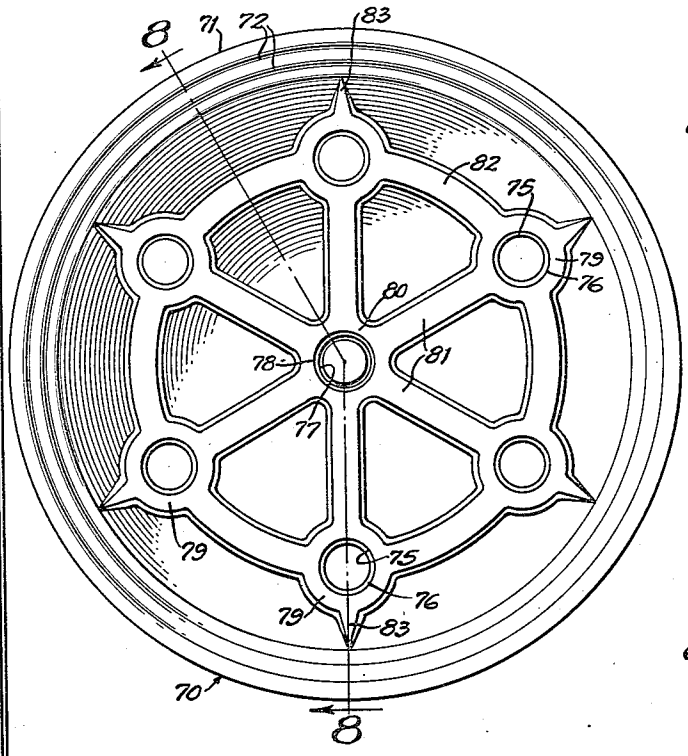



Fig. 6

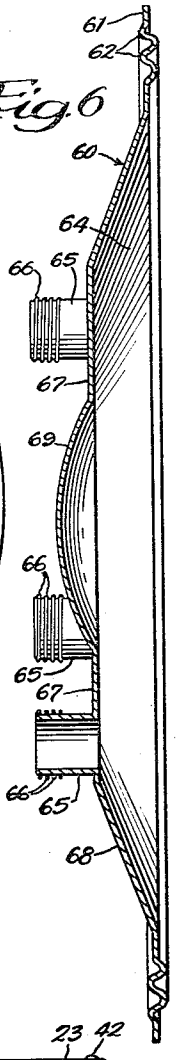
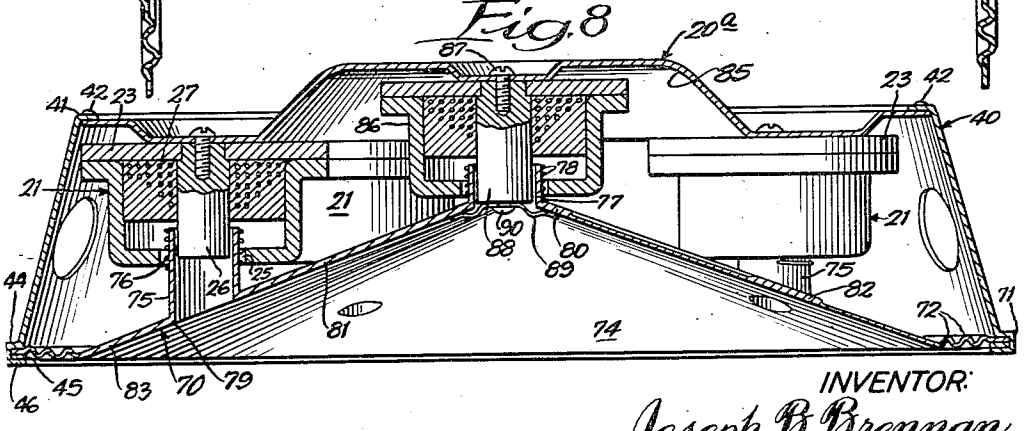



Fig. 8




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LOUD-SPEAKERS

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Fig. 9

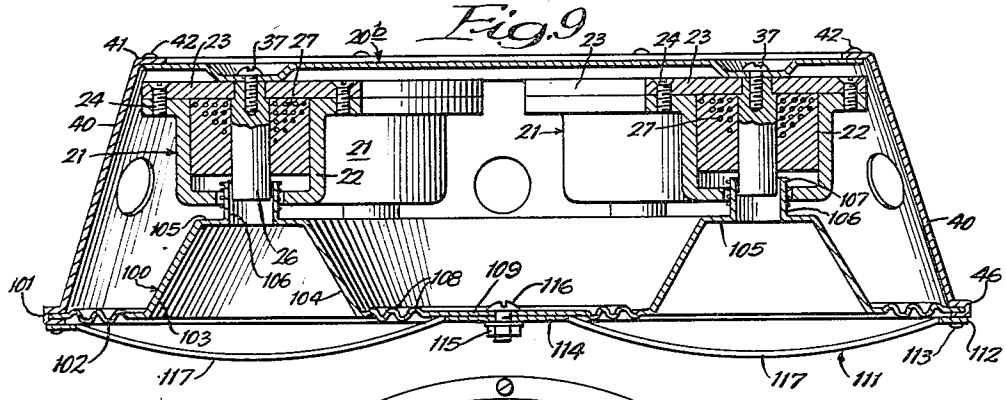


Fig. 10

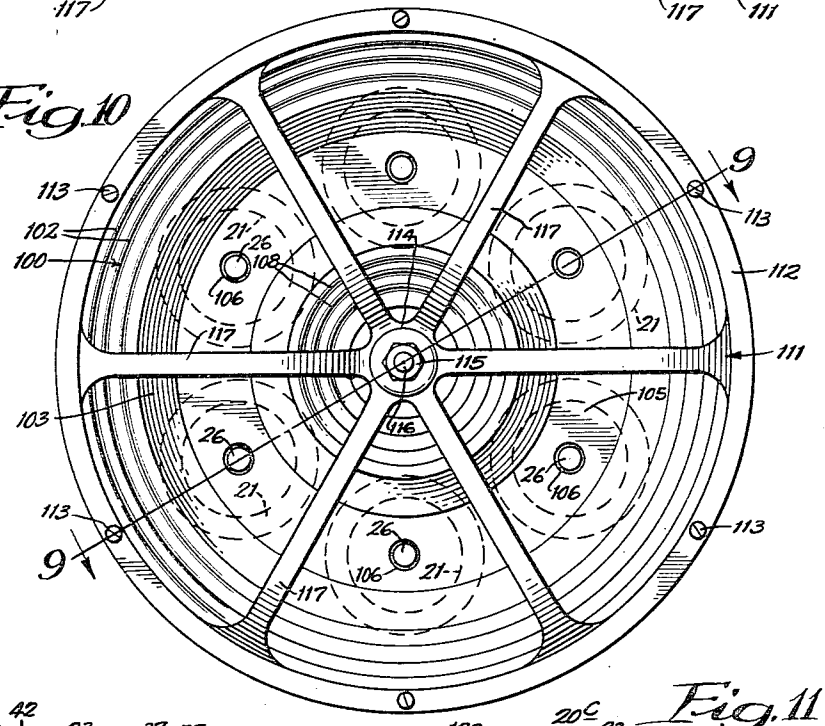
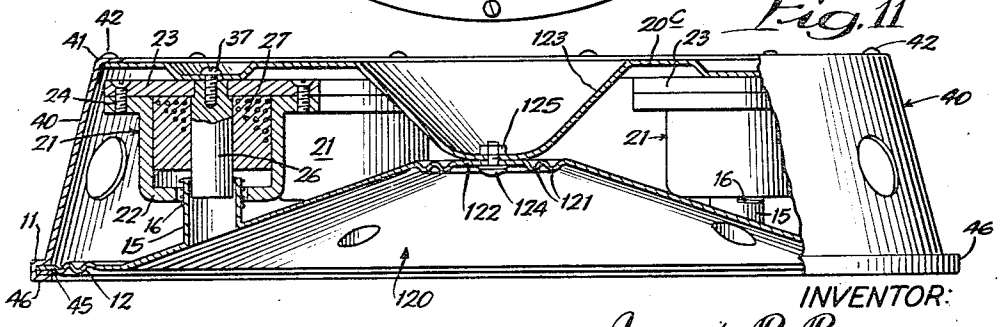


Fig. 11



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United States Patent Office 2,789,161 Patented Apr. 16, 1957



2,789,161

# LOUD-SPEAKERS

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Application April 5, 1951, Serial No. 219,451

6 Claims. (Cl. 179—115.5)

This invention relates to loud speakers such as are employed in radio speakers, public address systems and the like.

A general object of the invention is the provision of an improved loud speaker in which increased efficiency in the operation, and increased efficiency in the use of materials in constructing the apparatus are obtained. Other objects of the invention are the provision of a loud speaker whereby increased fidelity of sound reproduction can be obtained as compared to present practices; the provision of a loud speaker whereby high efficiency and intensity of sound output can be obtained while maintaining the fidelity of sound reproduction; the provision of an acoustic diaphragm and a loud speaker embodying the same whereby substantially the entire diaphragm is caused to vibrate in unison; the provision of a diaphragm and loud speaker assembly in which the ratio of power input as compared to the mass of diaphragm may be high, whereby the diaphragm is constrained to vibrate in accordance with the electric currents supplied to the loud speaker with a high degree of fidelity; and the provision of a loud speaker embodying a diaphragm having a plurality of voice coils, and which can be manufactured economically and by simple manufacturing operations.

Further objects and advantages of my invention will become apparent from the following description of preferred forms thereof, reference being made to the accompanying drawings wherein Fig. 1 is a rear elevation of a preferred form of acoustic diaphragm embodying my invention; Fig. 2 is a section, on an enlarged scale, through the diaphragm of Fig. 1 taken along the line 2—2 of Fig. 1; Fig. 3 is a generally similar sectional view showing a loud speaker embodying the diaphragm of Figs. 1 and 2 with parts of the loud speaker housing broken away for convenience in illustration; Fig. 4 is a rear elevation, on a reduced scale, of the loud speaker shown in Fig. 3 with parts of the housing broken away for convenience in illustration; Figs. 5 and 6 are sectional views generally similar to Fig. 2 but showing modified forms of diaphragms; Fig. 7 is a rear elevational view of a still further modification of my diaphragm; Fig. 8 is a sectional view illustrating a loud speaker embodying the diaphragm of Fig. 7 and taken on the plane indicated by line 8—8 of Fig. 7; Fig. 9 is a transverse sectional view of a loud speaker embodying another modification of my invention; Fig. 10 is a front view of the speaker shown in Fig. 9 on a slightly reduced scale, the line 9—9 of Fig. 10 indicating the section plane of Fig. 9; Fig. 11 is a transverse sectional view taken along a line corresponding to the lines 2—2 of Fig. 1 and 8—8 of Fig. 7 and illustrating a loud speaker embodying a still further specification of my invention; and Fig. 12 is a fragmentary section of a further modification of the invention showing how a spider may be used in positioning a loud speaker of the invention. Throughout the drawings the thicknesses of various portions of the diaphragm themselves are necessarily somewhat exaggerated.

Briefly my invention, in its preferred forms, contemplates an acoustic diaphragm having a body portion adapted to be vibrated to generate sound, said body having, instead of the usual single, centrally located voice coil support, a plurality of voice coil supports spaced about the body portion to distribute the vibratory forces applied thereto. The body portion may be hollow or flat, and may be of conical shape with the centers of the voice coil supports symmetrically disposed between the center of the diaphragm and the outer peripheral edge thereof. The diaphragm may be supported at its outer edge in the usual manner and may also be centered at its central portion by a spider or other convenient means which may be either unitary with or separate from the body of the diaphragm. Each voice coil support is provided with a voice coil, and the diaphragm is incorporated in a loud speaker structure in which a separate field structure is provided for each voice coil associated with the diaphragm.



In use, the several voice coils may be connected in parallel or series depending upon the electrical characteristics of the coils and the circuit with which the device is used, and thus the voice coils vibrate in unison in response to the voice currents of the radio receiver, loud speaker or the like with which the device is employed. With this arrangement, instead of attempting to vibrate the entire diaphragm from a single coil at the apex of the diaphragm as is the conventional practice, the diaphragm is vibrated by like forces applied at spaced points around the diaphragm with the result that the entire diaphragm vibrates in phase and much more nearly as a unit than is the case with a conventional diaphragm embodying only a single voice coil. Greater volume of sound output per unit of electrical input and higher fidelity of reproduction, can be obtained with such diaphragms than is possible with a conventional diaphragm of the same size.

Referring now to Figs. 1 and 2 of the drawings, one preferred form of acoustic diaphragm embodying my invention is indicated in general at **10**. This comprises a peripheral supporting flange **11** joined by the corrugated flexible portion **12** to the hollow conical body portion **14** of the diaphragm. The diaphragm is provided with a plurality of tubular necks **15** projecting therefrom which are adapted to support the usual voice coils **16**. Usually these necks **16** are glued or cemented to integral necks between about .010" and ⅛" long on the diaphragm. In the embodiment shown there are six tubular voice coil supporting necks **15**, each with its associated voice coil **16**. The voice coils may be mounted on the supports in any convenient manner, and may be provided with the usual lead wires (not shown). Alternatively, the construction disclosed in the Moynihan Patent No. 2,328,836 may be utilized and the necessity for lead wires eliminated.

The voice coil supports are preferably spaced uniformly inwardly from the edge of the diaphragm and are also spaced uniformly in circumferential directions. Thus with a circular diaphragm as shown, the axes of the several voice coil supports **15** are parallel to each other and to the axis of the body portion and are evenly spaced around a circle which is concentric with the diaphragm itself. However, those skilled in the art will understand that different spacing arrangements may be employed to suit different purposes and that the axes of the voice coil supports need not lie on a circle, particularly in instances where the diaphragms are of elliptical, rectangular or other non-circular shape; in such cases the axes preferably lie on a line which is similar in shape to the periphery of the body portion, i. e., the juncture of the body portion with the flexible portion **12**. Also, it is to be understood that a greater or lesser number of voice coil supports and voice coils may be employed, the number

chosen depending upon the size of the diaphragm, the power output desired and other design considerations.

In the arrangement shown in Figs. 1 and 2, the center lines of the axes of the voice coil supporting members **15** lie on a circle which divides the projected area of the conical diaphragm into two substantially equal parts. That circle is indicated in broken line in Fig. 1 at **17**, and the arrangement is such that the projected area of the body of the diaphragm within the circle **17** is substantially equal to the projected area of the body of the diaphragm between the circle **17** and the juncture of the body of the diaphragm within the corrugated portion **12**. This is one method of distribution of the voice coil supporting members with respect to the body of the diaphragm which may be employed to obtain substantially equal vibratory effects throughout the diaphragm, i. e., to produce a diaphragm in which all parts of the diaphragm vibrate in approximately identical fashion at any given instant. Obviously, it is difficult, if not impossible, to determine the frequency and amplitude of vibration of all parts of a diaphragm at a given instant, but it appears probable that the distribution of the voice coil supporting members are described above which results in a corresponding distribution of the vibratory forces applied to the diaphragm when it is installed in a loud speaker gives a much better approximation of this desired result than has been obtainable heretofore.

The diaphragm is preferably integrally formed of fibrous, felted material. The diaphragms may be made by depositing fibrous material from a suspension in liquid upon a perforate form in the usual manner, or may be produced by spraying fibrous material and a binder upon a form preferably in the manner described in my copending application, Ser. No. 422,388, filed December 10, 1941. Depending upon the characteristics desired, the felted material may be subject to further operations after it is initially deposited, or it may be used after merely drying. A preferred method of drying or curing is disclosed in my copending application Ser. No. 615,720, filed of even date herewith. As examples of other treatments the deposited material may be subjected to a pressing operation, may be cured by heat, and/or may be impregnated with various stiffening and strengthening materials such as various lacquers, resins, binders and the like. The thickness of various portions of the diaphragm may be varied to provide different characteristics of flexibility; thus the edge portions of the diaphragm may be constructed as described in my Patent No. 2,302,178 in order to provide increased flexibility. If desired, and as described below, the body of the diaphragm may be provided with reinforcing portions of increased thickness and stiffness as described in my copending application Ser. No. 422,388 aforesaid. It is believed that no detailed description of various materials for and methods of making the diaphragms is necessary for the purposes of the present disclosure inasmuch as appropriate materials and methods are known to those skilled in the art and/or are disclosed in my patent and applications aforesaid.

Diaphragms embodying my invention lend themselves readily to incorporation in loud speakers of simple and efficient design. An example of such a loud speaker embodying the diaphragm **10** of Figs. 1 and 2 is illustrated in Figs. 3 and 4. The device comprises a supporting frame embodying a supporting plate **20** to which a plurality of field structures, each indicated in general at **21**, are secured; the field structures being spaced to correspond to the spacing of the voice coil supports **15** and coils **16**. As shown particularly in Fig. 3, each field structure comprises a hollow cup-shaped member **22** provided with an open end to which a plate **23** is secured, for example by screws **24**, and with an aperture **25** at the end opposite the plate **23**. A pole piece **26** is pressed into an opening in the plate **23** or otherwise suitably secured thereto and projects through the opening **25**. The pole piece is accurately centered with respect to the opening **25**, providing an annular air gap within which the voice coil **16** and support **15** are disposed.

In the form shown, the requisite magnetic field is set up by means of a coil **27** surrounding pole piece **26** and disposed within the member **22** in the usual manner, but those skilled in the art will understand that permanent magnet fields may be employed. The flow of voice currents through the voice coil will cause the coil to vibrate in the magnetic field set up by the coil in accordance with the direction, frequency and amplitude of the voice currents as is well known. The field structures **21** are all preferably identical with each other, are energized in the same manner, and each coacts with its associated voice coil **16** in the same way. The voice coils are preferably identical and are connected in parallel or in series in the output circuit of the radio receiver, public address system or the like with which the speaker is used. Therefore, substantially identical forces are applied at any given instant to all of the voice coils associated with the diaphragm.

The diaphragm may be centered with respect to the plate **20** by a spider **29** connected to the indented portion **30** of the plate and cemented into the outer surface of the diaphragm. As shown particularly in Fig. 4, the spider may comprise a rim portion **31** secured to the diaphragm, a central hub portion **32** secured to the plate as by the bolt or screw **33** and a plurality of flexible spiral spokes **34**.

The plate **20** supports the several field structures in proper relationship to coact with the coils of the diaphragm, the plate being provided with an annular indentation **36** and having holes therein corresponding to the position of the axes of the voice coils. Screws **37** threaded into the pole pieces **26** secure the respective field structures in the desired positions, the holes in the plate **20** preferably being somewhat larger than the shanks of the screws to permit of a limited amount of adjustment to enable the pole pieces and members **22** to be accurately centered with respect to the voice coils and supports. It will be noted that the voice coil supports **15** are of sufficient length so that the voice coils **16** are positioned within the air gap and at the same time there is sufficient clearance between the inner portion of the member **22** and the surface of the diaphragm as indicated at **38**. The necessary length, of course, depends upon the diameter of the member **22** and the shape of the diaphragm.

In order to complete the frame structure for the loud speaker mechanism and to support the outer rim or flange **11** of the diaphragm, I preferably provide an annular member **40** having an inwardly extending flange **41** which is secured as by self-threading screws **42** to the outer surface of the plate **20**. The openings in the flange **41** which receive the screws **42** may be made oversize to permit adjustments to compensate for inaccuracies in manufacture and to insure accurate mounting of the supporting flange **11** and of the entire diaphragm with respect to the several field structures. At its opposite end the member **40** is flanged outwardly as at **44**, providing an annular surface to receive the supporting flange **11** of the diaphragm **10**. The flange **11** may be secured in position by a clamping ring **45** which is held against the flange by the inwardly extending portion **46** of the axially extending flange **44**, the portion **46** being crimped or spun into engagement with the ring **45** after the parts have been assembled and accurately adjusted to proper position.

Fig. 5 illustrates a modified form of diaphragm embodying my invention wherein the diaphragm, indicated in general at **50**, is provided with a supporting flange **51** and a corrugated portion **52**. Here the body portion **54** of the diaphragm is curved rather than conical in

section, for example, a parabolic shape may be employed. The diaphragm is also modified slightly in that the voice coil supporting members 55 and voice coils 56 are disposed substantially midway between the center of the diaphragm and the outer peripheral edge of the body portion. This arrangement places the voice coil supports 55 on a flatter portion of the curve of the body of the diaphragm and makes it possible to employ shorter voice coil supports and still obtain the requisite clearance between the field structures and the diaphragms. Obviously the positioning of the voice coil supports described in connection with Figs. 1 and 2 may also be employed in diaphragms of this type, or if desired the spacing shown in Fig. 5 may be employed with conical diaphragms such as shown in Figs. 1 and 2.

Fig. 6 illustrates a further modification wherein the diaphragm indicated in general at 60 has a supporting flange 61 and a flexible corrugated portion 62 but in which the body 64 of the diaphragm is shaped so that the voice coil supports 65, carrying voice coils 66, are disposed on an annular flat surface 67 interposed between a conical portion 68 and a curved portion 69 of the body. This arrangement also makes possible the utilization of shorter voice coil supports without interference between the diaphragm and the several field structures. In this modification, the voice coil supports are again positioned about midway between the center of the diaphragm and the edge of the body portion where the body portion joins the corrugated portion. Here again, the spacing described in connection with Figs. 1 and 2 may be employed. Instead of utilizing a curved central portion as shown, the central portion may be conical as shown in Figs. 1 and 2. Also, if desired, a curved central portion such as the portion 69 of Fig. 6 could be employed in conjunction with the diaphragm of Figs. 1 and 2.

The diaphragms of Figs. 5 and 6 may be incorporated in loud speakers of designs similar to that shown in Figs. 3 and 4 except for the positioning of the several field structures which obviously must be spaced to correspond to the spacing of the voice coil supports. Also, it may be necessary to reduce the diameter of the field structures somewhat for the same size of diaphragm, for with the field structures disposed closer to the center of the diaphragm they are necessarily spaced closer to each other.

In Figs. 7 and 8 I have illustrated a diaphragm and loud speaker adapted for particularly heavy duty. As before, the diaphragm indicated generally at 70 is provided with a flange portion 71 and a flexible corrugated portion 72. The body 74 of the diaphragm is constructed as described in my copending application Serial No. 422,388 aforesaid with reinforcing areas to increase the strength and rigidity of the diaphragm. The diaphragm may be of conical form, and the voice coil supporting members 75 carrying voice coils 76 are preferably positioned as described in connection with Figs. 1 and 2. Here, however, there is an additional voice coil support 77 carrying a voice coil 78 and disposed in the center of the diaphragm, and the diaphragm is reinforced by thickened annular portions 79 surrounding each voice coil support 75, a central thickened annular portion 80 surrounding the voice coil 77. Also, I may provide radial thickened reinforcing portions 81 extending between the central reinforcing portion 80 and the reinforcing portions 79, arcuate reinforcing portions 82 extending between the reinforcing portions 79, and/or radial reinforcements 83 extending outwardly from the annular reinforcements 79 to the juncture of the body portion 74 with the corrugated portion 72 of the diaphragm.

This arrangement produces an exceptionally rigid and powerful diaphragm which, however, may be made of reasonably light weight. The reinforcing portions insure that the entire diaphragm will vibrate substantially as a unit at all times even under high input of power. The thickness and the width of the reinforcing portions may be varied in accordance with requirements; however, I prefer that the reinforcing portions be at least several times as thick as the remainder of the diaphragm, and I preferably produce them by the method described in my aforesaid application Ser. No. 422,388.

As shown in Fig. 8, diaphragms of this type may be incorporated in loud speakers generally similar to the structures shown in Figs. 3 and 4, and in Fig. 8, the same reference characters that were used in Figs. 3 and 4 have been applied to those parts which are identical with those previously described. However, the plate 20*a* of Fig. 8 is provided with a recessed portion as at 85 in order to receive the additional field structure 86 required for the central voice coil 78. This structure may be identical with the field structures 21 heretofore described and may be secured to the plate 20*a* as by a screw 87 extending through an opening in the plate and into the pole piece 88 of the field structure. As before, there is preferably clearance between the opening in the plate 20*a* and the screw 87 to permit adjustment of the field structure with respect to the plate. In this type of device a conventional spider 89, secured to the interior of the diaphragm 70 and to the pole piece 88 as by a screw 90, may be employed.

Figs. 9 and 10 illustrate a loud speaker embodying another form of diaphragm made according to my invention. Here the diaphragm 100 is provided with a supporting flange 101 and a flexible corrugated portion 102 corresponding to similar parts in the previously described modifications, but the body of the diaphragm is made up of two oppositely inclined frusto conical surfaces 103 and 104 connected by an annular surface 105 from which the voice coil supports 106 project; the supports being provided with the usual voice coils 107. In this modification the need for a separate central support or spider is eliminated, the diaphragm being provided with a central flexible corrugated portion 108 and a central plane portion 109 which is adapted to be secured to a suitable support. Thus the flexible corrugated portion 108, which is disposed within the locus of the several voice coil supports, permits the annular body of the diaphragm to vibrate freely yet insures proper alignment of the diaphragm with respect to the remaining structure of the loud speaker.

Diaphragms of this type may be employed with loud speaker structures generally similar to those heretofore described and the same reference characters used in the description of the previous modifications are applied to corresponding parts shown in Figs. 9 and 10 of the drawings. In this form, however, the supporting plate 20*b* differs from the plate 20 heretofore described in that no provision need be made for supporting the central portion of the diaphragm therefrom. The central portion of the diaphragm is supported adjacent the front of the speaker inasmuch as the corrugated portion 108 and the central portion 109 lie in substantially the same plane as the edge or flange 101 and the corrugated portion 102. In order to support the central portion 109, I preferably employ a member such as the spoked member 111, the edge 112 of which is secured to the flange 46 as by screws 113 or any other suitable means; the central portion 114 being secured to the central portion 109 of the diaphragm as by a nut 115 and bolt 116 or any other convenient securing means. The central portion 114 is supported by spokes 117 which are preferably bowed outwardly, as shown, to eliminate any possibility of contact between vibrating portions of the diaphragm and the spokes.

Fig. 11 illustrates another form of diaphragm and speaker assembly in which the need for a separate supporting spider in the central portion of the diaphragm is eliminated. In this modification the diaphragm and the speaker structure in general are substantially identical with the construction shown in Figs. 1, 2 and 3, except for the central portion of the diaphragm and here again the same reference characters are employed.

to indicate parts which have not been substantially changed. However, in this modification the diaphragm itself, indicated in general at 120, instead of continuing on to the apex of the cone as in Figs. 1, 2 and 3, is terminated short of the apex of the cone and has integrally formed with the body portion thereof a flexible corrugated portion 121 connecting the conical body of the diaphragm with the central plane portion 122. In the speaker the supporting plate 20c is formed with a depression 123 of greater depth than the depression 30 previously described and the central portion 122 of the diaphragm is secured to the center of the depression 123 by the bolt and nut 124—125 or by other convenient means. Otherwise, as noted above, the structure shown in this figure is substantially identical to that previously described in connection with Figs. 1, 2 and 3.

In the modifications of Figs. 9, 10 and 11 the necessity for separate central supporting spiders is eliminated thus obviating the troubles which frequently occur with such devices and cutting down the cost of the assembling operations while improving the accuracy of the support of the diaphragm itself. The diaphragms of Figs. 9 and 10 are particularly adapted to large installations of high output while the diaphragm shown in Fig. 11 is of high efficiency and provides an economical assembly. Those skilled in the art will appreciate that the same principle of utilizing an integrally formed flexible portion adjacent the center of the diaphragm may be used with diaphragms of various different shapes and with arrangements of voice coils different from those illustrated herein.

A further modification of the invention is shown in Fig. 12 and in this instance a conical diaphragm 150 is provided and it has a short voice coil support neck 151 thereon usually made as a unit therewith. A cylindrical voice coil 152 is supported on the neck 151 preferably by a voice coil support tube 153. A metallic cone housing 154 positions the diaphragm 150 and a top or outer pole plate 155 is secured to the housing 154, which plate 155 has an annular opening 156 therein through which the voice coil support tube 153 extends in centered but spaced relation thereto. A magnet pot 157 is suitably secured to the top plate 155 and a magnet 158 is carried by the magnet pot 157 and extends through the tube 153 in centered but spaced relation thereto. As an important feature of this type of loud speaker of the invention, a corrugated spider 159 is suitably secured to the plate 155 and is fixed to the coil support neck 151 or the voice coil support tube to aid in resiliently centering the voice coil in the air gap intermediate the plate 155 and magnet 158.

From the foregoing description of preferred forms of my invention, it will be evident that I have provided diaphragms and loud speakers embodying the same giving advantageous results particularly in the fidelity of sound reproduction. The distribution of the forces throughout the diaphragms makes possible the application of more energy to the diaphragms without requiring that the weight of the diaphragms be increased in proportion. Thus more power can be applied to a diaphragm of a given size and weight constructed in accordance with my invention than can be utilized successfully by a conventional diaphragm of the same size and weight. The application of the forces by a plurality of voice coils spaced around the diaphragm is also advantageous in that the use of a plurality of smaller voice coils makes more efficient utilization of the metal necessary in constructing the fields and the voice coils than is possible in a single voice coil construction designed to have the same power output. The reason for this is that design considerations require the single voice coil and field structure to be of much larger diameter than the several smaller field and voice coil structures used in loud speakers embodying my invention, and the smaller structures obviously make more advantageous use of the metal in the coils and in the field because more ampere turns can be obtained with the same quantity of wire in small coils than can be obtained in coils of larger diameter.

Because of the distribution of the vibratory forces imposed by the voice coils, diaphragms made according to my invention vibrate substantially uniformly throughout. Because of this more nearly uniform vibration, my diaphragms are more efficient size for size as sound reproducing devices than the conventional diaphragms in which the force is applied only at the apex of the diaphragm, the increase in efficiency being particularly marked in the larger sizes. Furthermore, with diaphragms embodying my invention, sufficient input of power can be employed to render the natural periods of frequencies of vibration of the diaphragms inconsequential, and accordingly the diaphragms will vibrate more nearly in conformity to the voice currents flowing in the voice coils than has been possible with diaphragms of conventional type. The diaphragms are accurately supported in the speakers by flexible supporting portions at the periphery and also centrally, i. e., in the region within the locus of the voice coil supports. My loud speakers are compact and efficient and of relatively simple construction.

It is to be understood that various changes may be made in the preferred forms of my invention disclosed herein without departing from the teachings of my invention. For example, the size, shape and contour of the diaphragms may be changed as may the number and spacing of the voice coil supports. The design of the field structures may be varied. The invention is useful in speakers of the permanent magnet type as well as in the dynamic type disclosed herein. Various other changes may be made within the precepts of the invention. It is therefore to be understood that my patent is not limited to the preferred forms described herein.

This application is a continuation-in-part of my copending application Ser. No. 615,719.

Having thus described my invention, what I claim is:

1. A loud speaker comprising a frame formed with an opening at one side, an acoustic diaphragm secured at its periphery to the frame around said opening and dished inwardly at its outer surface, a plurality of laterally spaced tubular voice coil supports carried by and projecting from the inner surface of the diaphragm, said supports being symmetrically spaced with respect to the diaphragm with their axes parallel to the direction of movement of the diaphragm and spaced from each other, an annular voice coil carried by each of the supports, a plurality of magnetic units carried by the frame and laterally spaced from each other to register with the voice coil supports respectively, each of the magnetic units including a central magnetic pole extending into the adjacent support and an annular magnetic pole lying around the adjacent support and defining with the central pole an annular air gap in which the annular voice coil carried by the support is movable.

2. The construction of claim 1 in which the supports are spaced from the center of the diaphragm and means are provided connecting the center of the diaphragm to the frame.

3. The construction of claim 1 in which the central portion of the diaphragm is connected to the frame through a flexible spider.

4. The construction of claim 1 in which the supports are spaced from the center of the diaphragm and the central portion of the diaphragm is rigidly secured to the frame and is secured to the remainder of the diaphragm through a flexible corrugated portion.

5. The construction of claim 1 in which one of the supports is at the center of the diaphragm and the other supports lie in spaced annular array around said one of the supports.

6. A loud speaker comprising a hollow vibratile diaphragm having attached thereto a multiplicity of later-

ally spaced magnetically actuated coils at laterally spaced apart portions of the diaphragm, and laterally spaced separate actuating magnetic units for the coils respectively in magnetically coupled relationship with the coils.

**References Cited** in the file of this patent

UNITED STATES PATENTS

| | | |
|---|---|---|
| 1,604,532 | Kiegger | Oct. 26, 1926 |
| 2,034,882 | Scribner | Mar. 24, 1936 |



FOREIGN PATENTS

| | | |
|---|---|---|
| 312,756 | Great Britain | June 6, 1929 |
| 317,134 | Great Britain | Aug. 15, 1929 |
| 319,942 | Great Britain | Oct. 3, 1929 |