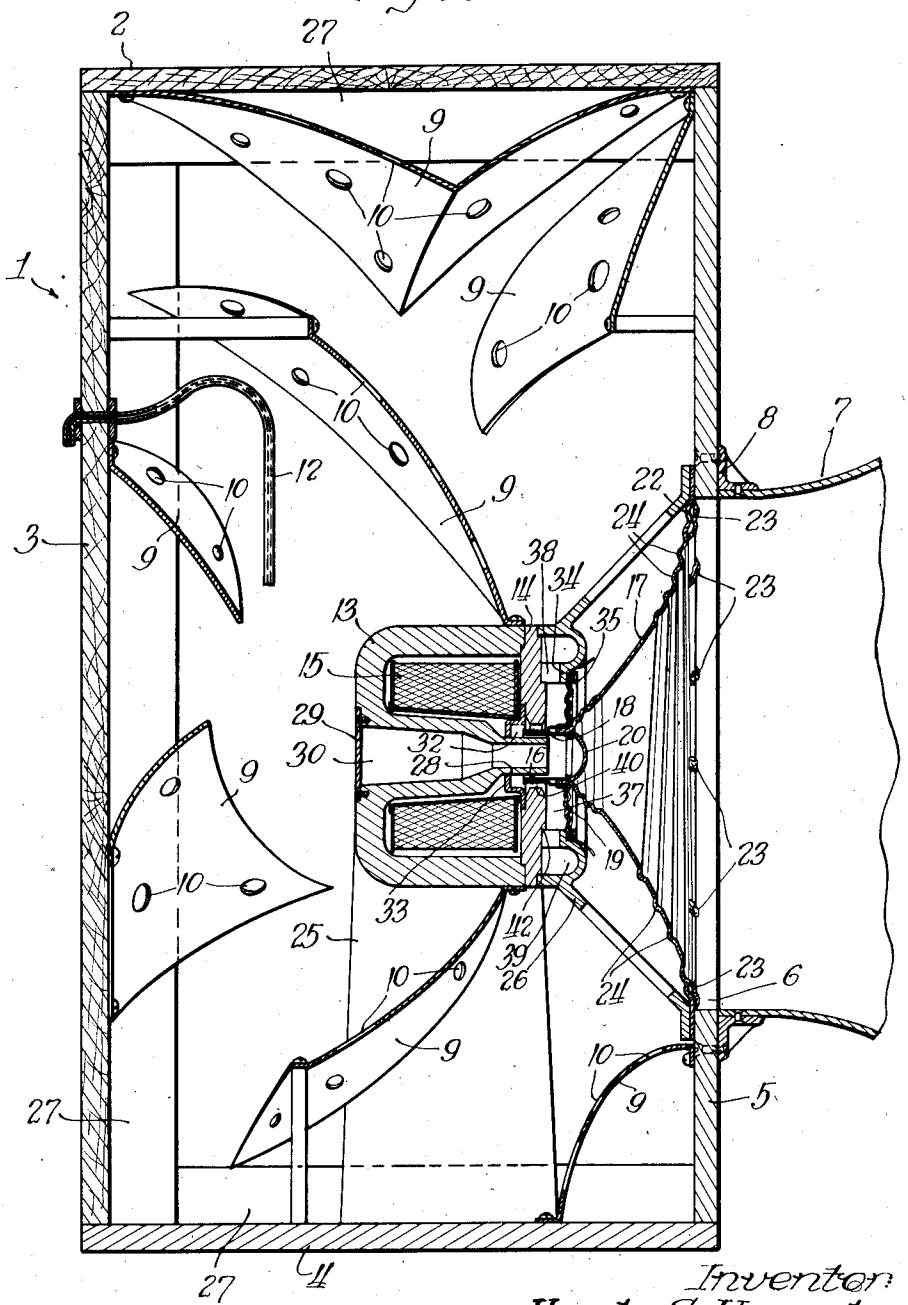
Sept. 8, 1942. H. S. KNOWLES 2,295,483

LOUDSPEAKER

Filed June 4, 1934 4 Sheets-Sheet 1

Fig. 1.



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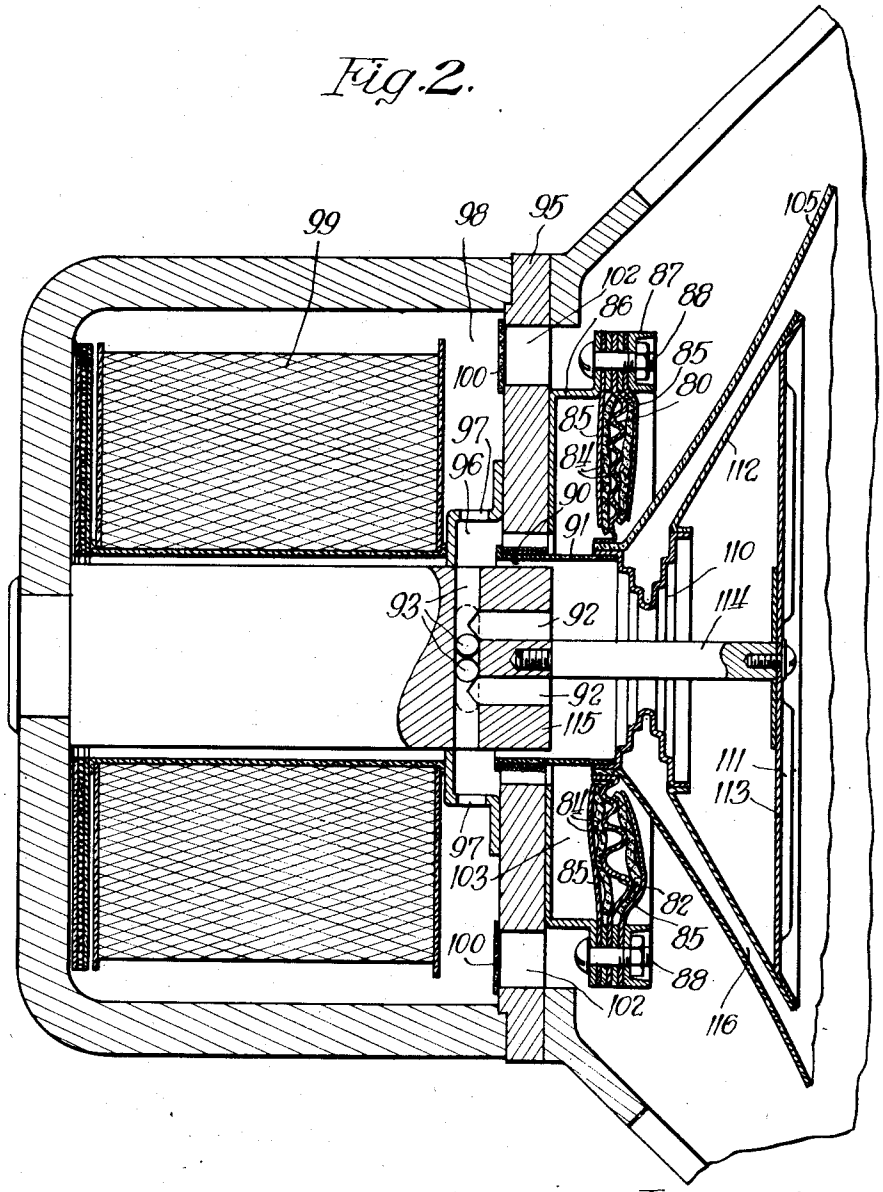
By Brown, Jackson, Boettcher & Dienner
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Sept. 8, 1942. H. S. KNOWLES 2,295,483

LOUDSPEAKER

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Fig. 2.



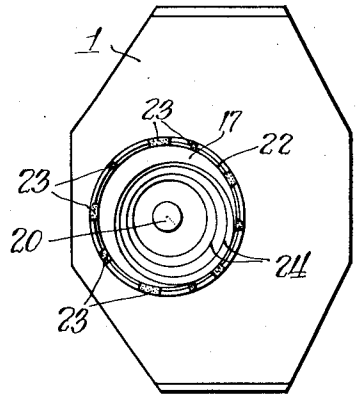
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LOUDSPEAKER

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Fig. 3.



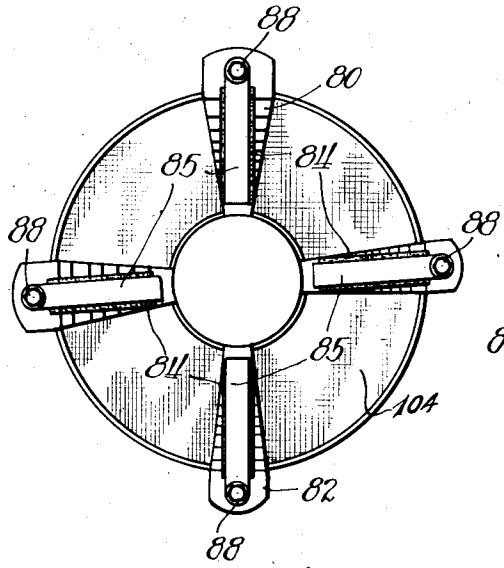


Fig. 4.

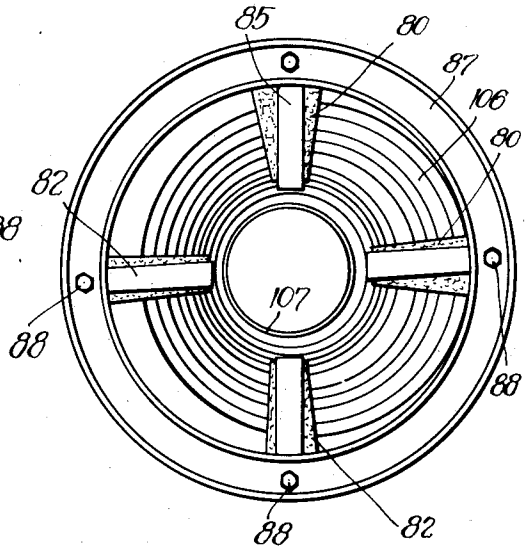


Fig. 5

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LOUDSPEAKER

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Fig. 6.

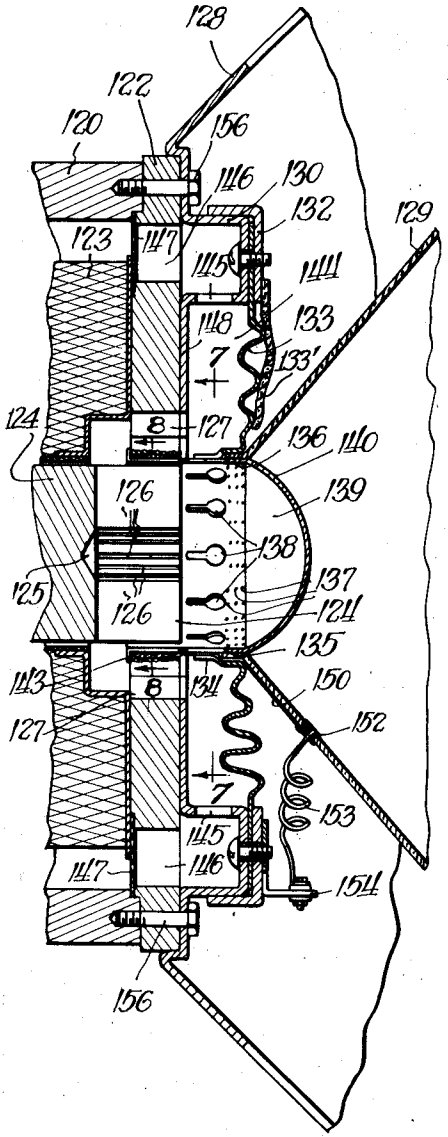
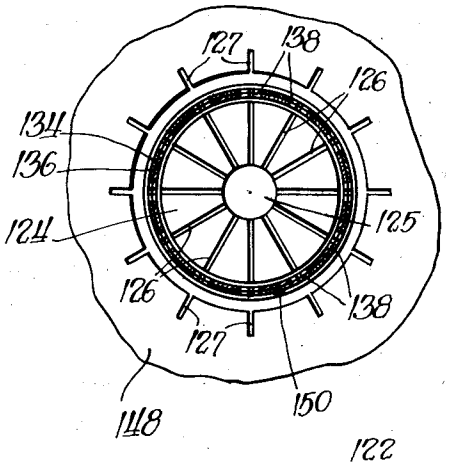


Fig. 7.



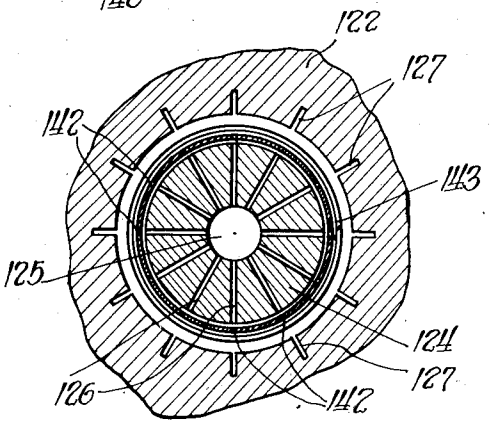


Fig. 8.

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UNITED STATES PATENT OFFICE

2,295,483

LOUDSPEAKER

Hugh S. Knowles, Chicago, Ill., assignor to Jensen Radio Manufacturing Company, Chicago, Ill., a corporation of Nevada

Application June 4, 1934, Serial No. 728,993

7 Claims. (Cl. 179—115.5)

This invention relates to loud speakers, and is more particularly directed to loud speakers or telephones of the electro-dynamic or moving coil type.

A speaker of this type, when operating in open or unconfined fluid, radiates little power at low frequencies, because the compression wave from one side of the moving system is almost completely neutralized by the rarefaction wave on the other side. The use of an infinite baffle for separating the front and rear radiation of a moving diaphragm system will effectively overcome this difficulty, but such a construction is, of course, not of practical utility.

In attempting to provide means for performing the function of an infinite baffle while yet remaining within practical limits, the use of various types of enclosures for the back side of the moving system has been resorted to in order to accomplish this result. However, certain inherent difficulties and disadvantages have occurred in the use of such enclosures, which has rendered them unsatisfactory in speakers of this type.

For example, there is considerable power loss or loss of effective sound radiation with the ordinary type of enclosure due to the resistance caused by forcing the air in and out through the annular gap between the top plate of the coil assembly and the voice coil bobbin, and between the voice coil bobbin and the core. At low frequencies, below the fundamental resonance of the system, the resistive component reduces the velocity of the diaphragm with a corresponding decrease in effective sound radiation, which may be termed a power loss, due to this highly resistive impedance. Also, the enclosure produces constructive and destructive interference at various frequencies, causing changes in the velocity of the moving system, or resonance. Particularly is this true when the enclosure is made large enough to provide low stiffness reactance at low frequencies in order to avoid any objectionably high fundamental resonant frequency of the system.

In attempting to overcome these difficulties, enclosures have been provided which have a sink or the like for absorbing all back side radiation, this sink having sound absorbing material therein. Sound absorbing materials of the type now known, however, inherently have poor absorbing characteristics at low frequencies. In order to increase the effectiveness of the material, therefore, and to reduce pressure on the back side of the cone due to stiffness, vents are ordinarily provided. These vents and the sound absorbing material introduce resistive components into the mechanical impedance of the vibrating system.

Also, with the use of the electro-dynamic type of speakers having a moving voice coil disposed in the annular gap between the core and the top plate, there is a tendency for any paramagnetic particles suspended or moving in the fluid in which the unit operates to be drawn into this gap, which is of relatively small area, and consequently disturb the electrical and mechanical relationship of the movable parts interfering with effective operation of the unit. While such units ordinarily operate in air, I employ the term "fluid" to include both gases and liquids, since such sound producing means might be employed for sub-aqueous transmission of sound, if so desired.

The present invention has for its primary object the elimination of the undesirable features heretofore mentioned, as well as providing a speaker of this type which has certain mechanical and acoustical features not present in the present type of unit with which I am familiar.

A still further advantage secured by the present invention is the provision of a centering member for the inner end of the diaphragm which may be employed as a closure member for entirely excluding air flow therethrough, thereby preventing dust or the like from entering the air gaps, or may form a filter or screen excluding the dust particles while allowing the fluid to filter therethrough. When imperforate, this member provides one defining surface of a volumetric fluid displacement chamber employed in the overcoming of the resistance loss through the air gap. Further, this dust excluding screen or cover is employed to reduce the resonance of the spider which forms the centering means for the diaphragm. This is accomplished by forming the centering member in such manner as to provide an eccentrically corrugated surface, which produces a non-resonating centering support, and which may be suitably supported at its outer end by means of damping members mounted upon the spider for the cone. The eccentric surface may be formed by providing eccentric rings, if desired, which may be fibrous rings which add mass, stiffness and resistance so proportioned as to break up the natural modes of vibration of the spider or centering member, which rings may be formed by means of felting or the like, or by eccentrically disposed corrugations, variations in cross-sectional area, or in any other suitable manner.

Another object secured by the present invention is the provision of a vibrating cone or diaphragm which possesses relatively great mechanical strength to static deflection, and which is so formed as to have eccentric radial sectors for decreasing or distributing the resonance at higher frequencies. This eccentricity may be produced in any desired manner as will be pointed out hereinafter. Further, the outer peripheral mounting for the diaphragm preferably is supported by non-uniformly spaced damping supports, which break up the resonance or natural modes of vibration of the diaphragm itself. The eccentric rings, corrugations or the like, may be formed in the cone, or may be of material such as fibrous rings, which add mass, stiffness and resistance to the diaphragm.

This diaphragm itself is preferably disposed in eccentric position with respect to the enclosure, in order to break up the sound radiation reflected from the interior of the enclosure, the eccentric position of the diaphragm preventing any two paths from the enclosure walls to a point on the diaphragm being equal.

A still further object of the present invention is the provision of an enclosure which is substantially weather-proof and air-tight, and which is internally provided with a plurality of dissimilar baffle means for still further breaking up sound radiation reflected from the walls of the enclosure, and to prevent internal resonance in the enclosure. The construction of the enclosure is for the purpose of serving as an equivalent of an infinite baffle, to avoid back side radiation, and to add distributed stiffness to the vibrating system which improves high frequency radiation thereof. In addition, novel means are provided within the enclosure for conducting the heat generated in the coil assembly of the speaker to the outer surface of the enclosure, which heat conducting means is so constructed as to eliminate any internal resonating chambers therein. Another feature provided by the enclosure is the utilization of a high resistance vent for equalizing low pressure differentials between the interior of the enclosure and the front side of the diaphragm, but preventing rapid equalization of pressure differentials at an audible frequency rate. Further, the walls of the enclosure are provided with stiffening channels or members which prevent resonance thereof, and which still further tend to break up sound radiation within the enclosure. The dispersion vanes or baffles are preferably perforated, and, in addition, have damping material of low sound absorbing characteristics disposed on the surfaces thereof With the present enclosure construction, I am able, if desired, to eliminate the use of sound absorbing material, such as formerly used, since the construction itself effectively prevents resonances in the enclosure and takes care of back side radiation, while adding distributed stiffness for improving high frequency radiation of the moving system.

Other objects and advantages of the present invention, such as certain details of construction and operation which present novel features not, to my knowledge, heretofore provided, will be described in detail in connection with the following description, which, taken in connection with the accompanying drawings, will disclose to those skilled in the art a preferred embodiment of the present invention.

In the drawings:

Figure 1 is a sectional elevational view of a speaker unit embodying the teachings of the present invention;

Figure 2 is a vertical sectional view of a modified form of the invention;

Figure 3 is an end elevation of the diaphragm shown in Figure 1;

Figure 4 is a detail view of one form of centering means;

Figure 5 is an end elevational view of the centering means shown in Figure 2;

Figure 6 is a sectional elevational view of a modified form of speaker unit;

Figure 7 is a sectional view taken substantially on the line 7—7 of Figure 6;

Figure 8 is a sectional view taken on line 8—8 of Figure 6.

Referring now in detail to the drawings, in Figure 1, I have provided an enclosure indicated generally at 1, comprising a top wall member 2 formed of wood or the like, a rear wall member 3 formed of wood, a lower wall 4 preferably formed of metal or a heat conducting material, and a front wall 5 formed of metal or a heat conducting material, the front wall 5 being provided with the opening 6 disposed below the center of the enclosure for centering the speaker unit with respect thereto. An annular outwardly flaring horn 7 is mounted about the defining edge of the opening 6 and is secured in position by means of the annular angle bracket member 8.

Within the enclosure 1, I preferably provide irregularly shaped rigid dispersion plates or vanes, which may be made of metal, wood, thin fibrous material, or any rigid dispersion surface which preferably occupies small volume so that the total effective volume of the enclosure is not appreciably reduced. These surfaces are so shaped and mounted that adjacent elements of area on the plates differ in distance from some element of area on the cone. Optionally, the surfaces of the vanes may be coated with material for damping their self-resonance.

Their effect on the wave front produced by the vibrating systems, since the enclosure 1 adds only a resistive component of approximately ten per cent or less of the total effective resistance of the vibrating system, including the resistance due to the electrical circuit, may be further modified by the use of perforations 10 varying in size and location in such manner as to break up the wave front. Since their effect on the wave front is a function of the wave length of the incident sound, this construction produces a different pattern and different frequencies and increases the random phase relation of the sound striking the back of the diaphragm.

The enclosure 1 need not be completely fluid tight, but when a horn is attached to the front of the diaphragm, as shown in Figure 1, it may be desirable to have the enclosure weather-proof. To provide for such changes in barometric pressure which otherwise might produce a differential pressure between the front and back sides of the diaphragm, a high resistance vent or tube 12 may be provided, which extends through a suitable opening in the rear wall 3 of the enclosure. This tube offers a very high impedance to the motion of fluid at a high velocity corresponding to sound frequency, but will permit a very slow flow of fluid such as would be required to equalize a quasi-static pressure differential between the two sides of the diaphragm. While the vent could also be made in the form of a low-pass acoustic filter, because of the low cut-off fre-

quency which would be required, it would not be desirable with a smaller type of enclosure.

The speaker unit, which, in this particular embodiment, is of the large diaphragm electrodynamic type, has a field structure 13, comprising a substantially cup-shaped housing, which is secured to a top plate 14, and has mounted therein the field coil 15. This coil, when energized, produces the desired magnetic flux in the annular air gap 16. The vibrating assembly consists of the diaphragm 17, the voice coil and bobbin assembly 18, the flexible centering member 19, the dome-shaped cover 20, the flexible annular diaphragm support 22 and the self-damping strips 23. It is of course to be understood that the various speaker units shown in the several embodiments of my invention as disclosed herein will all be mounted in an enclosure in an offset position with respect to the center front wall of the enclosure, and the outer peripheral edges of the various diaphragms may be supported as hereinabove described, and provided with irregularly spaced damping strips corresponding to the damping strips 23 of Figure 1.

The rings or corrugations 24, since they may comprise rings felted or otherwise mounted on the diaphragm, or corrugations formed directly in the diaphragm, are preferably so made that the annular ring sections of the diaphragm between them are not of constant width. The rings may be disposed to lie in the position as determined by the intersection of the surface of the diaphragm and a plane not quite perpendicular to the axis of the speaker. The radial distance between different sections of the rings and between the rings and the annular flexible support 22 should preferably not be a constant.

As will be noted in Figure 3, the damping support strips 23 may be irregularly spaced about the periphery of the diaphragm 17, or may be unequal in surface extent, in order to break up the natural modes of vibration of the diaphragm.

The field assembly 13 is held in position by means of a pair of strip supporting members 25 which are formed of heat conducting material, and which are spaced apart to provide a through air space therebetween in order to eliminate any resonating effects from the provision of a confined chamber formed by these conducting strips. These strips serve to conduct the heat generated in the coil 15 from the housing 13 to the metal wall 4 of the enclosure, and, in combination with the metallic cone housing 26 which extends between the top plate 14 and the outer peripheral edge of the diaphragm 17, serves to conduct this heat away from the coil assembly and to the bottom and front walls 4 and 5 of the enclosure.

The wall members 2, 3 and 4 are provided with stiffening channels or ridges 27 formed therein, which, in addition, serve to prevent self-resonance of these wall surfaces.

In the conventional type of speaker, the movement of the voice coil bobbin assembly 18 into and out of the air gap 16 between the core indicated generally at 28 and the defining edge of the opening in the top plate 14 results in movement of the diaphragm 17. This produces an increase in the pressure of fluid on the back side of the diaphragm as the diaphragm moves inwardly, which ordinarily results in some flow of fluid from the back of the diaphragm through the air gap between the top plate 14 and the voice coil assembly 18, and between the voice coil assembly and the core tip 28 of the field structure.

With such an air flow, there is a considerable power loss due to frictional resistance of the air, which results in loss of effective sound radiating capacity, especially at low frequencies. In the present invention, the resistive component of the reaction of the fluid on the moving system, due to unwanted movement of the fluid through this gap, is substantially eliminated.

The core 28 is preferably made hollow, and is closed at its outer end by means of the closure plate 29 which is substantially fluid-tight. Thus, when the voice coil assembly 18, with the dome 20, moves inwardly with respect to the field assembly, there is compression of fluid in the space 30 of the core assembly. At the same time, due to the volume of the defining end of the voice coil assembly, there is compression of fluid in the annular chamber 32 surrounding the core tip 28, and sealed from the coil assembly 15 by means of the annular shield member 33. The volumes 30 and 32 are preferably so chosen that, with the proportionate displacement of the end of the voice coil assembly 18 and the displacement of the dome 20, the fluid is compressed by an equal amount in these two chambers so that there is no differential in pressure therebetween, which prevents the flow of fluid from the chamber 32 past the outer surface of the tip 28 and within the voice coil assembly 18 into the space 30, or vice versa.

The flexible centering member 19, which is, in this embodiment of the invention, composed of an imperforate, eccentrically-corrugated flexible member, is substantially fluid-tight, being mounted upon a shoulder 34 formed on the spider 26, by means of an annular channel member 35, which allows tightening of the outer defining edge of the member 19 into sealing engagement with the shoulder 34 without producing any torsional stresses therein. As the diaphragm, therefore, moves inwardly, the flexible member 19 compresses the air in the chamber 37, which air may be allowed to escape to some extent through the ports 38 formed in the spider 26, and which lead to an annular chamber 39 therein. Preferably, the volume of the chambers 37, 38 and 39 is so proportioned with respect to the chambers 30 and 32 that, upon inward movement of the voice coil bobbin assembly 18 and the dome 20, the compression effected in the chamber 37, or in the chambers 37, 38 and 39, is substantially equal to the compression existing in the chambers 30 and 32, which means that the pressure upon opposite sides of the gap 40 between the top plate 14 and the outer surface of the voice coil assembly 18 is substantially equalized, so that no flow of fluid through this gap is permitted. This provides for inward movement of the voice coil assembly without producing a flow of fluid through the annular gap between the core and the top plate, which means that the resistive component or friction loss is eliminated, and thus provides for effective sound radiation at low frequency. The pressure provided in the chambers 30, 32 and 37 produces a pure stiffness for the vibrating assembly, which stiffness is relatively low at low frequencies, since the three chambers may be made as large as desired, so that the unit increase in pressure is considerably reduced.

To further reduce the stiffness contributed by the volumes 30, 32 and 37, it may be desirable to substitute a substantially air-tight bulbous enclosure for the cover plate 29, in order to increase the total volume of the chamber 30. It

is to be understood that these three volumes are not independently variable since the requirement is that the instantaneous pressure in all three be substantially the same at low frequencies. If desired, the entire volume of the enclosure may be used for one of the chambers, the other two volumes being proportioned in accordance therewith to produce the same instantaneous pressure in each of the chambers upon vibration of the system at low frequencies.

The cone housing 26 is centered on the top plate 14 by the shoulder 42, which shoulder is formed concentric with the gap and the voice coil assembly. It is important in an assembly of this type in which the voice coil is completely enclosed, to provide means for completely exposing the voice coil to permit repairs, adjustments, or the removal of foreign particles inadvertently introduced during assembly. The shielding member 33 fits snugly on the core, but may be removed from it and from the top plate 14 to permit the removal of particles which inadvertently get into the enclosure 32. This construction makes all parts of the enclosure readily accessible. By the use of eccentric rings or the like, in the imperforate spider or centering member 19, the resonating effects are broken up, so that the natural modes of vibration of the centering member itself are not added to the vibrating system.

In this embodiment of the invention, the dome 20 is a relatively light rigid member which may have embossings thereon to increase its rigidity, and is connected to the voice coil bobbin 18 by means of a stiff annular ring or shoulder which is centered on the bobbin and helps to keep the voice coil round. The stiffness of the ring and the mass of the dome are normally so chosen as to give a rise in velocity of the dome at high frequencies. This frequency may be slightly above the frequencies at which the sound output of the speaker without the dome would begin to fall. This extends the frequency range of the speaker.

The use of the imperforate spider or centering member 19 prevents paramagnetic dust particles or the like which may be suspended in the fluid surrounding the magnetic circuit of the speaker from being drawn past the dome 20 around the outer periphery of the diagram 17 and into the annular gap about the core tip, since the introduction of such particles thereinto will destroy the operating efficiency of the speaker.

Considering now in detail the centering member 19, it is to be understood that at any mode of vibration of a flexible member, such as the member 19 or the diaphragm 17, such a member offers a large mechanical impedance when driven from the vibrating system. In other words, each mode of vibration may, to an approximation, be represented by an anti-resonant circuit, the impedance of which is usually large enough to reduce appreciably the velocity of the moving system. When a wide and flexible annular ring is used to reduce the stiffness of the ring and to permit large excursions of the voice coil, the first or fundamental mode of the ring driven from the diaphragm lies in the middle or lower voice frequency range, and appreciably alters the velocity of the mechanical system near the resonance frequency of this mode.

Likewise, when the dimensions of the centering member 19, are made sufficiently large so that the volume of the enclosure 37, under this member is made large enough to keep the stiffness low, and when the centering member is large enough to reduce the total stiffness added to the moving system, the fundamental mode lies roughly in the middle of the voice frequency range and introduces appreciable impedance at the frequence corresponding to this mode. In the case of both the annular supporting ring 22 and the centering member 19 appreciable impedance is also introduced at the higher modes of vibration, although these are, in general, less pronounced and more highly damped.

Since it is important that the device have a smooth velocity frequency curve, these resonances should be eliminated, and one method of reducing the same is shown in Figure 1. The centering member 19 is a complete, circular, imperforate member. It will be noted from the sectional view, however, that the ridges or grooves are not symmetrical and are so designed that the effective mass and stiffness varies continually from radial section to radial section around the centering member at high frequencies but provides substantially uniform stiffness at low frequencies. At low frequencies the distributed mass has negligible effect (i. e., negligible mass reactance). As the frequency is increased and approaches the first or gravest mode of vibration the effective stiffness reactance decreases.

At frequencies at which the centering member is antiresonant (viewed from the voice coil) the mechanical impedance may be very high and reduce the velocity of the voice coil and hence the sound output of the speaker. To prevent this resonance occurring at the same frequency in each radial sector the shape and distributed mass are so chosen as to prevent their resonating at the same frequencies. This minimizes changes in impedance to motion of the voice coil and of the spider and therefore to motion of the diaphragm to which it is attached. Since the distributed stiffness and mass control the natural modes of vibration of a mechanical system of this type, the higher modes of vibration will therefore vary from one radial sector to another so that no large increase in the velocity of the centering member can occur.

The anti-resonant effect of the centering member may be reduced as shown in Figure 2. In this embodiment, the centering member consists of two or more radially extending members 80 and 82, which have ridges or grooves formed in such a manner that the natural modes of vibration of the various radial centering members differ. The radial members may also be tapered longitudinally or shaped in such fashion that their cross section varies, for example, in the manner as determined by the tapered shape shown in Figure 4. The principal feature of this construction is that it avoids duplication of the modes of vibration of any of these members. This may also be achieved by changing the thickness of the various radial members, or tapering them in thickness or in section.

The fundamental modes of the centering members are damped by comparatively thin strips 84 of material such as rubber, felt or the like, which introduces a large resistive or damping component. This material, if it does not adhere directly to the centering member, may be held in place by thin flexible spring clamps 85 which are mounted in position about an an-

nular supporting member 86 by means of the mounting channel 87 and bolts 88.

While in Figure 1 the mechanical resistance added to the vibrating system by the flow of fluid through the air gap is reduced by the proper selection of enclosed volumes so that no pressure differential occurs across the gap at low frequencies, in Figure 2 a different method of accomplishing the same result is provided. For example, in Figure 2 this is accomplished by providing shunting low impedance paths for the fluid displaced, these paths by-passing the high impedance path offered by the annular air gap or any orifice which introduces an objectionable impedance. Thus, in Figure 2, the highly resistive fluid flow path shown at 90 between the core tip and the voice coil bobbin 91 is shunted by the low impedance paths made up of the passages 92 and 93, which passages may be drilled or cast in the core and should be limited to the size which will provide a low resistance path without unnecessarily increasing the reluctance of the magnetic circuit. Moreover, the high resistance path between the voice coil bobbin 91 and the top plate 95 is by-passed through slots in this plate through the chamber 96 and the vent or orifices 97 into the chamber 98 in which the field coil 99 is disposed. This chamber, in turn, may be vented by means of the screen 100 and the port 102 in the top plate 95 into the annular space surrounding the diaphragm.

Where the centering means 80 comprises a continuous circular centering member, the air space 103 may be vented through fine holes in a perforate centering member, such as shown and described in Figures 4 and 5, which holes should be disposed away from the curved surfaces of the member. If the centering member is made up of radial arms 80 and 82, then it is desirable that a thin perforated screen, such as a very fine or light wire mesh or cloth should be cemented or held in contact with the centering means by means of the springs 85 in order to exclude foreign particles. Such a screen is shown in detail in Figure 4 and indicated at 104.

The diaphragms 17, 52 and the diaphragm 105 of Figure 2 may be supported at the opening in the enclosure in the manner described in connection with Figure 1, where the annular ring member 22 may be formed as an integral part of the diaphragm, or may be a separate piece cemented or otherwise attached thereto. The felt damping strips 23 should preferably be secured in position over the ring 22 by means of light spring members, such as the spring members 85, described in connection with Figure 2, and should preferably not be distributed symmetrically, or should vary in width in order to break up or damp the natural modes of vibration of the supporting rings 22.

These supporting or centering means, such as the member 19 of Figure 1, may be constructed in a number of ways. Preferably they are formed of some fibrous material, such as paper or cloth, which may be impregnated with a lacquer, varnish, phenolic compound or other substance which increases the strength and stiffness to the desired degree.

To increase the strength of this centering member when paper pulp is used, a light, coarse mesh cloth screen may be used on which the paper pulp is felted or deposited from the pulp bearing solution. If the paper is already fabricated, a separate cloth may be cemented to it, preferably at the time the paper is formed, to increase the strength to a considerable extent. In Figure 5 is shown another form of centering member in which the supporting radial arms 80 and 82, which are mounted by means of the annular channel mounting ring 87 upon a supporting member, serve in turn to hold a circular eccentrically corrugated flexible cloth mesh or screen indicated at 106. This member is clamped by means of spring members, such as springs 85, to the radial sectors or arms, and at its inner end is extended down and flanged, as shown at 107, to engage the inner flanged edge of a diaphragm such as the diaphragm 105.

In Figure 2, the dome member for the central portion of the inner end of the diaphragm is replaced by the annular member 110 of the shape shown in Figure 2. This member has secured thereto a substantially conically extending surface of revolution, comprising the member 112, which at its outer end is closed by the closure plate 113 having the reenforcing ribs 111 thereon, the center of the closure plate 113 being mounted by means of the stud 114 to the core tip 115. If desired, the diaphragm 105 may be centered by a member such as 113 secured to the inner surface thereof and supported eccentrically or otherwise upon tip 115.

Thus, in Figure 2, an annular air space 116 is provided between the diaphragm 105 and the conical surface 112. Upon movement of the diaphragm 105 at low frequencies, the air chamber volume 116 provides a low stiffness reactance to such movement, which does not appreciably damp the sound radiating effect of the diaphragm 105. However, when the frequency is increased, an increasing stiffness reactance or component in the space 116 is provided, which is, of course, desirable, as heretofore pointed out. If desired, the member 110 may be replaced by a single flanged member, and the member 112 may be joined directly to the juncture of the member 110 and the diaphragm 105 at the inner end of the centering means.

In the usual type of speaker with which I am familiar, the voice coil bobbin is provided, between the voice coil and the dome portion, with vents which are placed to relieve the pressure under the dome. However, these have always been so placed that if the excursions of the voice coil were large enough, the cross-section of the vents would be reduced when the voice coil moves into its innermost position within the gap. To overcome this difficulty, the voice coil was ordinarily made long enough and the vents were placed at the upper end of the neck thereof so that the area was never reduced. However, this increased the mass of the voice coil and consequently reduced its high frequency response.

In Figure 6, I have provided means for overcoming these difficulties. In this figure, reference numeral 120 indicates a field coil assembly, to which is secured the top plate 122, the coil being shown at 123. The core tip is shown at 124, and has a central cylindrically recessed portion 125 which is provided with a plurality of laterally extending radial slots 126 opening into the air gap between the top plate 122 and the end of the core tip. These slots 126 extend radially outwardly from the recess 125, and are aligned, as shown in detail in Figures 1 and 8, with corresponding slots 127 formed in the annular defining edge of the top plate 122 at the air gap. The supporting spider 128 for the diaphragm 129 is provided with a raised portion 130

over which is secured an annular supporting member 132 for supporting the flexible eccentrically corrugated member 133, the member 133 having an inwardly extending flange portion 134 which is adapted to extend over the inner flanged edge 135 of the diaphragm and has engagement with the outer peripheral surface of the voice coil bobbin 136. Suitable damping members, such as felt strips 133', may be provided at spaced intervals, and may be cemented or otherwise suitably secured to the member 133. The voice coil bobbin 136 is provided with a plurality of prick punches 137 for rigidly securing it to the flanged end 135 of the diaphragm 129.

Spaced substantially symmetically about the cylindrical portion of the bobbin 136 are a plurality of openings 138, which are adapted to vent the space 139 within the dome 140 upon inward movement of the voice coil assembly with respect to the core tip 124. The inner end of the voice coil bobbin 136 is slotted, as shown at 142 in Fig. 10, to provide for resilient tensioning of the voice coil conductor 143 thereon, and to reduce eddy currents.

Upon inward movement of the dome 140, with a consequent tendency to compress the air or fluid above the tip 124, this fluid will pass outwardly through the vents 138 to the space 144 between the supporting member 130 and the centering means 133, and may then be vented through openings 145 and the ports 146 in the top plate 122 into the field assembly, through the screen 147. As the vents 138 pass beneath the outer surface or end of the member 124, pressure of the fluid in the space 139 compresses the fluid in the recess 125, and this compressed fluid passes outwardly through the radially extending slots 126 and through the vents 138 and the corresponding slots 127 into the space 144, and inasmuch as the center of the radial slots 126, the vents 138 and the slots 127 is at a common point in the same plane, the impedance to the flow of fluid is not appreciably altered during movement of the bobbin, and therefore the fluid is not strained through the vent, and no objectionable noise, or what is commonly termed "wheezing," results therefrom. In addition, this component of the mechanical resistance of the vibrating system, which is a function of its displacement and leads to distortion, is reduced.

The voice coil bobbin 136 is formed of a light weight metal, such as aluminum, beryllium or magnesium alloy, or a similar material, with the dome 140 preferably formed integral therewith to increase the strength and to insure good thermal conductivity. The voice coil bobbin has shoulders at the defining end thereof to retain the voice coil conductor in position. The pin pricks or embossings 137 engage the cone to increase the stress that can be applied without failure of the assembly.

Further, heat conduction may be provided by making the flexible support member 133 out of some light flexible metal with an extension to take the place of the reenforcing portion 134. If desired, a thin metallic film may be deposited either on the front or the back side of the diaphragm, near the apex, so as to provide thermal conduction with the dome 140 and the bobbin neck 136, this metal being sprayed on in a molten state, cemented or electrolytically deposited. It will be noted that the supporting spider 128 has an integral portion thereof forming the support for the flexible centering member 133, and is also provided with an additional inwardly extending flange portion 148, which portion lies on top of the top plate 122 and forms an integral part of the magnetic circuit. This increases the cross section of the top plate at the section near the voice coil where the flux density is a maximum, and therefore reduces the reluctance of the magnetic circuit. The voice coin leads, as indicated at 150, are run up between the flange portion 134 of the centering member 133 and the flange portion 135 of the diaphragm 129, and extend along the outer surface of the neck portion 136 of the bobbin to the voice coil itself. The lead 150 is extended through a grommet 152 secured in the diaphragm 129, and from the grommet a flexible connection 153 is extended to a terminal member 154 carried upon the support for the centering means which is carried upon the angular supporting ring 132.

An advantage secured by the construction shown in Figures 6 to 8 is the provision of the head bolts or cap members 156, which secure the cone housing 128 to the top plate 122, and also secure the field housing structure 120 to the top plate. By removing the bolt members 156, the entire cone housing 128, together with the diaphragm 129, the flexible centering member 133, the voice coil bobbin 136, the voice coil itself, the leads therefor and the like can all be removed from the top of plate 122, and the field assembly housing 120 can also be removed therefrom, if so desired. This permits the voice coil to be inspected, and provides for removal of foreign particles, without disturbing the alignment of the voice coil with respect to the cone housing and the flexible centering means.

Having described my invention in accordance with the patent statutes, what I claim as new and desire to secure by Letters Patent is:

1. In combination, an outwardly flaring main diaphragm, means for supporting the outer end of said diaphragm, eccentrically corrugated flexible centering means engaging the small end of said diaphragm, said means having substantially uniform stiffness against static deflection, and irregularly shaped damping members engaging said centering means.

2. In combination, a loud speaker housing substantially closed to atmosphere and having wall ends intersecting to form a single compartment, a speaker unit having a cone diaphragm, and means for supporting said unit in off center position with respect to one wall of said housing to provide a non-uniform sound path from any point on said cone to the walls of said housing.

3. In combination, an enclosure having substantially smooth walls normally reflecting sound waves therefrom, said enclosure having an opening disposed eccentrically in one wall thereof, a speaker unit within said enclosure having an outwardly flared diaphragm cone secured to the defining edge of said opening, and dissimilar dispersion vanes separated from said walls and within the space bounded by said enclosure for breaking up sound radiation therein.

4. In combination, an enclosure formed generally of material having poor heat conductivity and being substantially closed to atmosphere, a speaker unit having means normally generating substantial heat within said enclosure, thermal conducting means supporting said speaker unit in position within said enclosure and connected to the walls of said enclosure, at least one of the walls to which said thermal conducting means is connected having at least part thereof formed

of good heat conducting material and forming substantially continuous good heat conducting paths from said speaker unit directly to the atmosphere outside of said enclosure.

5. In combination, an outwardly flaring diaphragm, means for supporting the outer end of said diaphragm, and a centering disk engaging the small end of said diaphragm, said disk having non-uniform corrugations located asymmetrical with respect to the disk axis.

6. In combination, an outwardly flaring diaphragm, means for supporting the diaphragm outer end, a centering disk engaging the diaphragm smaller end and extending outwardly therefrom, and vibration damping means carried on said disk extending radially thereon, said damping means being so disposed around said disk to obtain irregular damping angularly around said disk axis.

7. In combination, an outwardly flaring diaphragm, means for supporting the outer end thereof, a voice coil at the small end thereof, a centering disk for said small end, said disk being formed at least in part of flexible metal having good heat conductivity and extending outwardly from the diaphragm small end, and metallic means for engaging the outer peripheral portion of the disk for anchoring the same

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