

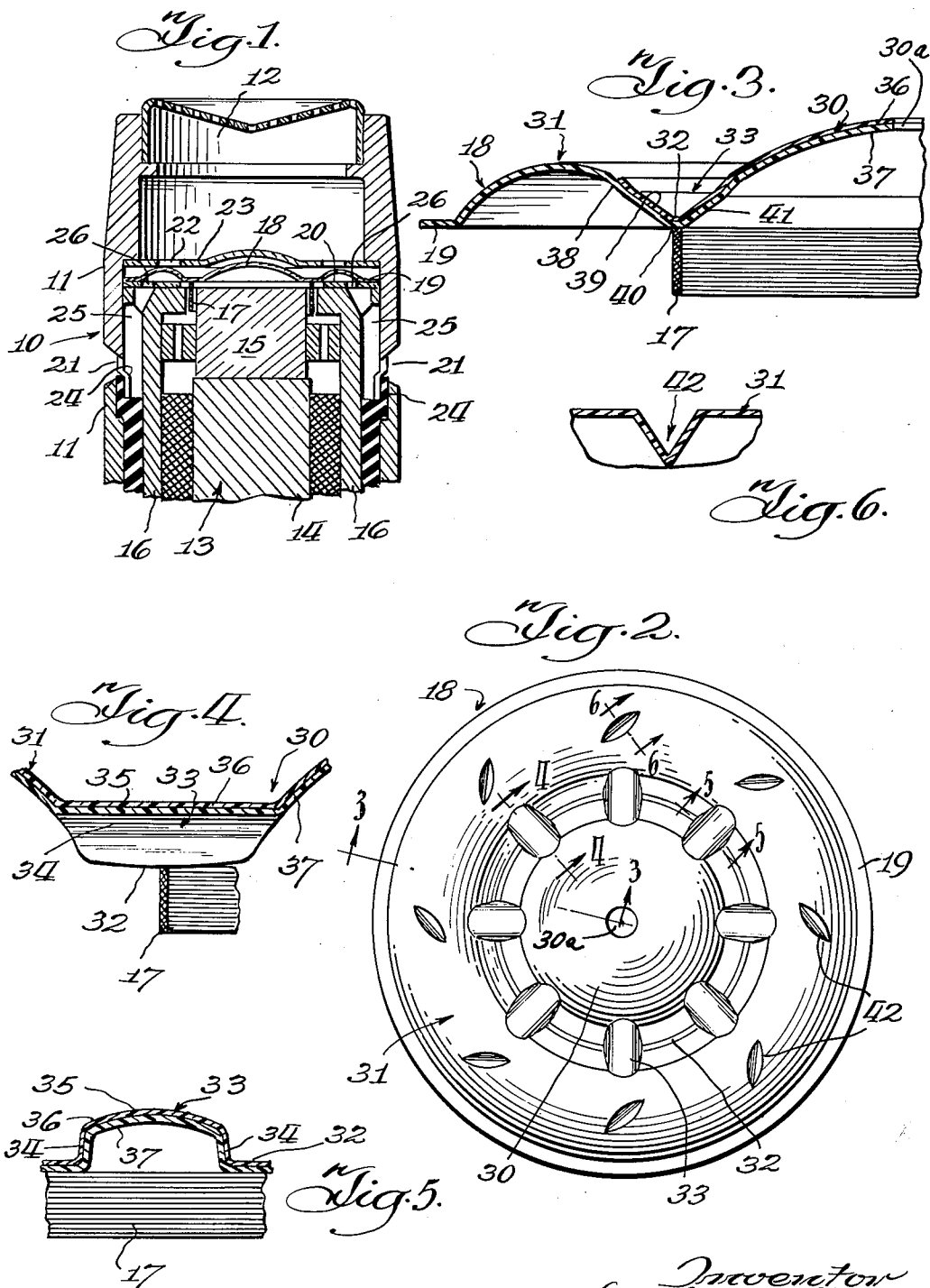
May 12, 1964

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3,132,713

MICROPHONE DIAPHRAGM

Filed May 25, 1961



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MICROPHONE DIAPHRAGM

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Filed May 25, 1961, Ser. No. 112,684

7 Claims. (Cl. 181-32)

The present invention relates to a microphone diaphragm and more particularly to a diaphragm which has uniform deflection characteristics over a wide frequency range without "break-up" and without rocking the voice coil carried thereby.

Microphone diaphragms are mechanical devices which are subjected to acoustic vibrations and undulations and which flex in accordance therewith. The diaphragms carry an electrical device such as a voice coil composed of a number of turns of fine wire cemented together to form a substantially rigid cylindrical structure. The vibrations of the diaphragm cause vibration or movement of the voice coil in a magnetic field, when assembled in a microphone structure, whereby the acoustic signals impinging on the diaphragm are transformed into electrical signals for excitation of the system to be affected by the electrical signals, such as a public address system or the modulation network of a transmitter.

Diaphragm structures of the type here under consideration are subject to a number of malfunction difficulties which create undesired distortions of the electric signals with respect to the acoustic signals. In general, such structures have natural resonant or fundamental frequencies of vibration such that they provide a peak response when excited at the fundamental frequency and seriously attenuate the response signal at frequencies above the fundamental frequency. This latter attenuation effect is often the result of overtone resonant vibration. When a diaphragm vibrates at an overtone frequency which may take one or more of several modes, the effective movement of the diaphragm and, therefore, the effective movement of the voice coil may be substantially nil.

Attempts to stiffen diaphragm structures in order to avoid higher modes of vibration have generally resulted in the creation of hinge or flexure areas of lesser rigidity than the remainder of the diaphragm in order to provide compliance for the diaphragm. But this was done in such a manner that the diaphragm was subject to "break-up" more easily at higher overtone frequencies or had a tendency to rock. When a diaphragm rocks, the axis of the voice coil is tilted and there may be no effective output from the voice coil.

Numerous attempts have been made to overcome these problems. One of the most well-known diaphragms is the Harrison diaphragm which has a radially corrugated structure wherein the corrugations extend outwardly tangentially from the voice coil mounting circle. The magnitude of the corrugations increases in this diaphragm in the direction toward the outer periphery of the diaphragm. While this type of structure has been effective in reducing overtone and rocking problems, since the magnitude of the corrugations approaches zero at the voice coil circle, the tendency of the diaphragm to break up exists in the region close to the voice coil circle even though the tendency is not apparent until higher audio frequencies than those which break up other forms of diaphragms, are reached.

Diaphragms embodying the present invention overcome the foregoing problems and embodiments thereof have demonstrated flat response characteristics to frequencies in excess of 15 kilocycles, substantially without breakup, substantially without rocking and substantially without demonstrating variations due to excitation at fundamental and overtone frequencies. In accordance with this invention, diaphragm structures are provided with selectively

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disposed regions of increased stiffness so that the hinge and flexure areas are so located and arranged that diaphragm movement closely resembles undistorted movement.

5 Bridging deformation and multiple cone configuration in accordance with this invention provide a diaphragm with isolated flexure areas, stiffened areas, and reduced axial dimensions, strengthening for voice coil support and for acceptance of inertia loads, in addition to preventing 10 rocking and higher mode break-up.

Further, by utilizing the structural features of the present invention, diaphragms of substantially reduced mass may be made and lighter, thinner materials may be employed.

15 There is shown in the drawings an illustrative embodiment of the invention. In the drawings which form a part of this specification:

FIGURE 1 is a cross-sectional illustration of the diaphragm and surrounding portions of a microphone, shown 20 in cross-section;

FIGURE 2 is a plan view of a diaphragm forming an illustrative embodiment of the invention;

FIGURE 3 is a fragmental sectional view of the diaphragm of FIG. 2, viewed substantially along the radial 25 line 3;

FIGURE 4 is a fragmental sectional view of a portion of the diaphragm viewed substantially along the line 4-4 of FIG. 2;

FIGURE 5 is a fragmental sectional view taken substantially along the line 5-5 of FIG. 2;

FIGURE 6 is a fragmental sectional view taken substantially along the line 6-6 of FIG. 2.

A microphone structure which is effective to advantageously employ a diaphragm embodying the present invention is fragmentally, sectionally illustrated in FIG. 1. The microphone 10 has a multi-part housing 11 at the head end of which the housing is open and receives a perforated screen 12 for the passage of acoustic vibrations into the microphone. Within the microphone there is disposed a microphone cartridge 13 having a magnet 14 at forward end of which there is mounted an inner pole piece 15. An outer pole piece 16 of cylindrical structure is secured in closed magnetic circuit relation with the rearward end of the magnet 14 and with its forward end surrounding the forward end of the inner pole piece 15 in fixed space relation therewith. The spacial relation between the inner and outer pole pieces is fixed to define a cylindrical airgap having a radial field therein.

The airgap is of proper proportions to receive a voice coil 17 formed of a plurality of turns of fine wire cemented together in a self-sustaining cylindrical shape. The voice coil is cemented to the underside of a diaphragm 18, the outer rim 19 of which is cemented to a resistance ring 20 that is secured to the front face of the outer pole piece to hold the diaphragm in proper operating position.

The particular type of microphone shown in FIG. 1 is a unidirectional microphone of the phase-shifting variety so that the diaphragm receives signals from both the front opening covered by the screen 12 and rear entry openings 21 at the junction of two of the parts of the casing or mounting 11. The primary signals pass through the screen 12 and through perforations 22 in a resonator plate 23 to the front face of the diaphragm. Rear entry signals pass through a screen 24 covering the rear entry apertures 21, pass through longitudinal curves 25 in the outer pole piece, through apertures 26 in the resistance ring 20 to the rear surface of the diaphragm 18.

These rear entry signals are acted upon by a network 70 of acoustic capacitances, resistances and inductance to provide appropriate phase shifting thereof so that the microphone will demonstrate unidirectional qualities and a

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generally cardioid response pattern. To facilitate this action means is provided in the diaphragm structure for the passage of acoustic signals and air along the under-surface of the diaphragm radially thereof.

The diaphragm per se is shown in detail in FIGS. 2-6, inclusive. In the preferred embodiment illustrated in the drawings, the diaphragm is molded of Mylar although other selected, desired material may be employed. Mylar was selected in this instance because it was found that the physical properties which it demonstrated were attractive for the purposes of a diaphragm, i.e., its stiffness, elasticity, mass and strength.

Representation of the diaphragm in straight-line, schematic drawing, shows the diaphragm to be a multiple cone structure having an inner or central cone structure and a concentric "outer cone of revolution" defined by rotation of a triangle in a radial plane including the normal axis of the diaphragm. The actual molded structure of the diaphragm shown in the drawings is best seen in the sectional illustration of FIG. 3 where the inner cone is indicated at 30 with central aperture 30a, and the outer cone of revolution is indicated at 31. It will be seen also that the actual molded form, expressed alternatively with the foregoing, has an effective configuration of a plurality of alternately inverted intersecting frusto-conical wall sections which are joined at the front of the diaphragm by smoothly curved regions and which intersect at the back of the diaphragm in finely defined circles. The voice coil 17 is secured at the circle of maximum rigidity, the intersection circle 32 of the base portions of the cone forms 30 and 31.

The multiple cone configuration provides a structure in which there are no flat plane circular sections perpendicular to the direction of deflection parallel to the normal axis of the diaphragm, whereby break-up is avoided and rigidity and strength are substantially increased in the axial direction.

As noted above, the multiple cone configuration also provides a region of high rigidity at the intersection circle of the base portions of the central cone and outer cone of rotation. The voice coil is attached to the diaphragm, on the underside thereof, at this circle so that maximum voice coil support with minimum strain on the diaphragm is effected with diaphragms embodying this invention.

In addition to the multiple cone configuration for high rigidity and increased voice coil support the rigidity of the diaphragm in the region of the voice coil support circle is increased by the provision of integrally molded bridge-like formations spanning portions of the region between the inner and outer cone structures. These bridge formations 33 are shown in section in FIGS. 4 and 5. The structural arrangement of the bridges 33 is such that they are symmetrically arranged about the diaphragm although the number thereof may be a prime or multiple number depending on the particular structure desired. This further increases the rigidity of the diaphragm structure between the cones and is such that radial side walls 34 of each of the bridges are preferably disposed substantially perpendicular to the plane of the voice coil support circle with an arcuate bridge top 35.

This arrangement of the bridges between the inner and outer cones of the diaphragm also provides for acoustic and pneumatic communication between the cone volumes at the back or underside of the diaphragm. This attribute of the structure is highly advantageous when the diaphragm is employed in a unidirectional microphone such as that discussed above in conjunction with FIG. 1.

The rigidity of the structure in the cone base and bridge area is further increased by the provision of a multiple layer, laminated structure extending over the entire area of the inner cone, the base junction and bridge portions and a substantial portion of the radially inward face of the outer cone of revolution. The partial layer 36 is shown in the drawings on the exterior or front face of the full layer 37 of the diaphragm.

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Still further rigidity increases in the area of the voice coil circle are provided by molding the diaphragm with a fragmental cone section 38 and cross-sectionally straight plane sections 39, 40 and 41 along the base portions of the inner and outer cones.

It has been found acoustically advantageous to minimize the height of the diaphragm and of the cones even though greater cone angles are desirable to avoid break-up and rocking of the diaphragm. In view of this, the cone angles have been made relatively steep but the top portions thereof have been rounded off as shown in FIG. 3. Such rounding off, however, has made it desirable to increase the rigidity of the top of the outer cone of revolution. For this purpose, inwardly disposed and bridging formations 42, shown in FIGS. 2 and 6, have been molded in the diaphragm at the apex of the outer cone. These bridging formations 42 are generally triangular in the cross section configuration, are elongated and extend generally tangential to the voice coil circle.

The inter-relation of the conical formations, laminated construction and bridges, along with the other details of the construction of the diaphragm, is such that the hinge areas of the diaphragm permitting axial vibration thereof and of the voice coil occur at the radial inner and outer extremities of the bridges 42 at the peak of the outer cone formation. This arrangement isolates the flexure area substantially to the radially outermost surface area of the diaphragm with a small, very limited flexure region at the inner extremity of the outer bridges 42.

It would be appreciated that numerous variations and modifications may be made in diaphragms embodying this invention without departing from the true spirit and scope of the novel concepts and principles of this invention.

I claim:

1. A microphone diaphragm comprising a flexible material formed in a plurality of concentric cones of revolution, said cones of revolution intersecting each other and providing a circular area of high rigidity for support of a voice coil, and bridge means between said cones of revolution along the area of increased rigidity providing acoustic communication between volumes defined by said cones of revolution inwardly and outwardly of the area of high rigidity.

2. A microphone diaphragm comprising a flexible material formed in a plurality of concentric cones of revolution, said cones of revolution being reduced in height by having rounded apexes, the apexes of the cones of revolution outwardly of the innermost cone having bridge formations therein increasing the rigidity thereof.

3. A microphone diaphragm comprising a flexible material formed in a plurality of concentric cones of revolution, said cones of revolution intersecting each other and providing a circular area of high rigidity for support of a voice coil, and bridge means between said cones of revolution along the area of increased rigidity providing acoustic communication between volumes defined by said cones of revolution inwardly and outwardly of the area of high rigidity, said bridges having radial faces substantially perpendicular to the mean plane of the diaphragm.

4. A microphone diaphragm comprising a flexible material formed in a plurality of concentric cones of revolution, said cones of revolution being reduced in height by having rounded apexes, the apexes of the cones of revolution outwardly of the innermost cone having bridge formations therein increasing the rigidity thereof, said bridge formations being triangular in cross-section and longitudinally extending substantially tangential to a circle formed by the intersection of base portions of inner and outer cones of revolution.

5. A microphone diaphragm comprising a flexible material formed in a plurality of cones of revolution, said cones of revolution being reduced in height by having rounded apexes, the apex of the outermost cone of revolution having bridge formations therein increasing the rigidity thereof and defining, at the extremities of the bridges,

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areas of flexure and hinging for axial movement of the portion of the diaphragm inwardly thereof.

6. A microphone diaphragm comprising a flexible material formed in a plurality of frusto-conical wall sections alternately arranged to intersect each other, bridge means formed in said wall sections at the intersections thereof, said intersections on one side of said diaphragm being rounded, and said intersections on the other side of said diaphragms being substantially sharp circular edges.

7. A microphone diaphragm comprising a flexible material formed in a plurality of frusto-conical wall sections alternately arranged to intersect each other, said intersections on one side of said diaphragm being rounded, and said intersections on the other side of said diaphragm

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being substantially sharp circular edges, and bridge means on said one side of said diaphragm in said intersections, and further bridge means on the said other side of said diaphragm, a voice coil secured to said diaphragm at a said substantially sharp circular edge, said further bridge means providing acoustic communication across said voice coil.

References Cited in the file of this patent

UNITED STATES PATENTS

1,833,055	Mitchell	Nov. 24, 1931
1,917,012	Blattner	July 4, 1933
2,003,908	Smith et al.	June 4, 1935
2,058,208	Blattner	Oct. 20, 1936
2,439,665	Marquis	Apr. 13, 1948