July 31, 1951 W. A. CODD 2,562,526

TELEPHONE TRANSMITTER

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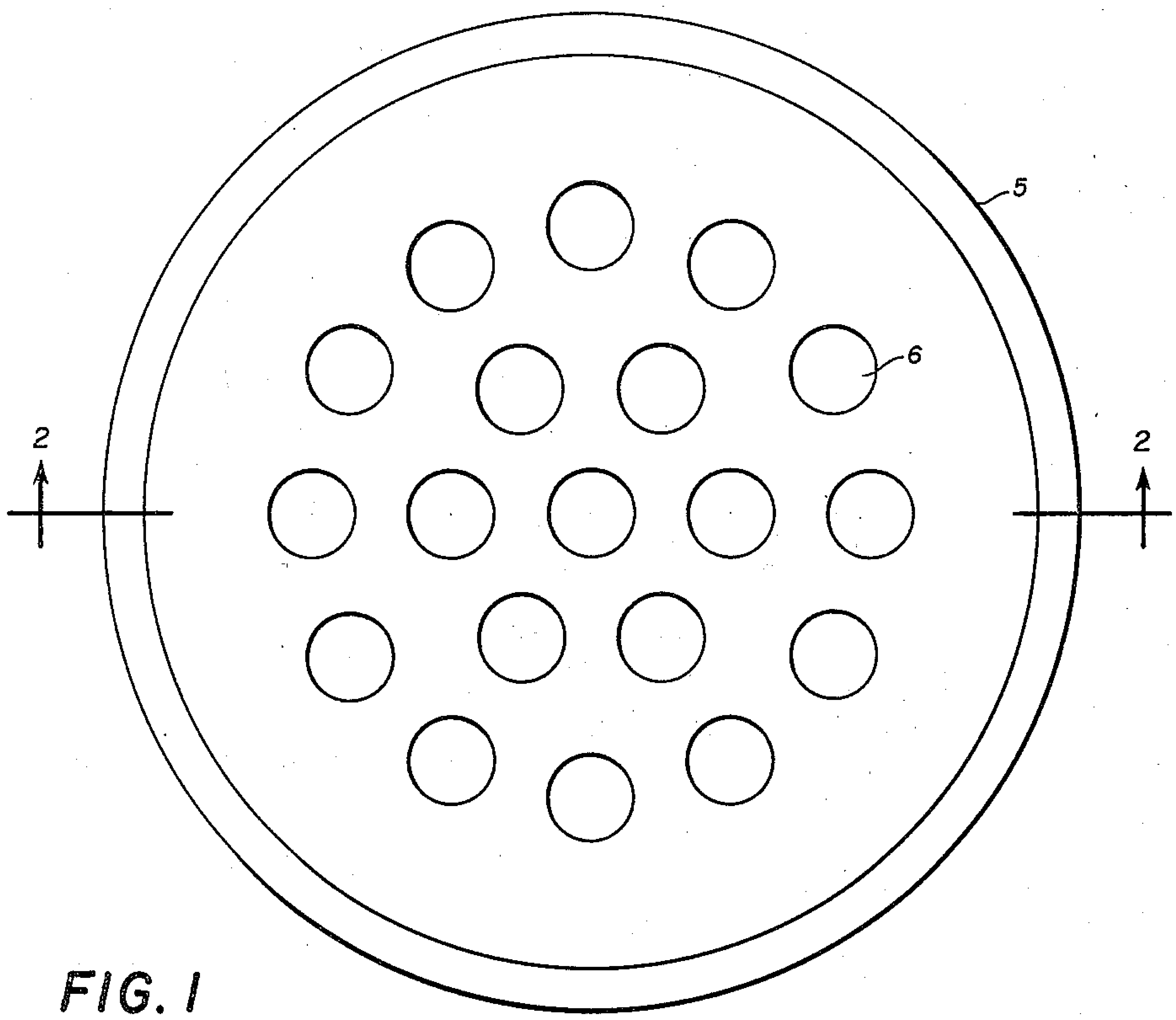

FIG. 1

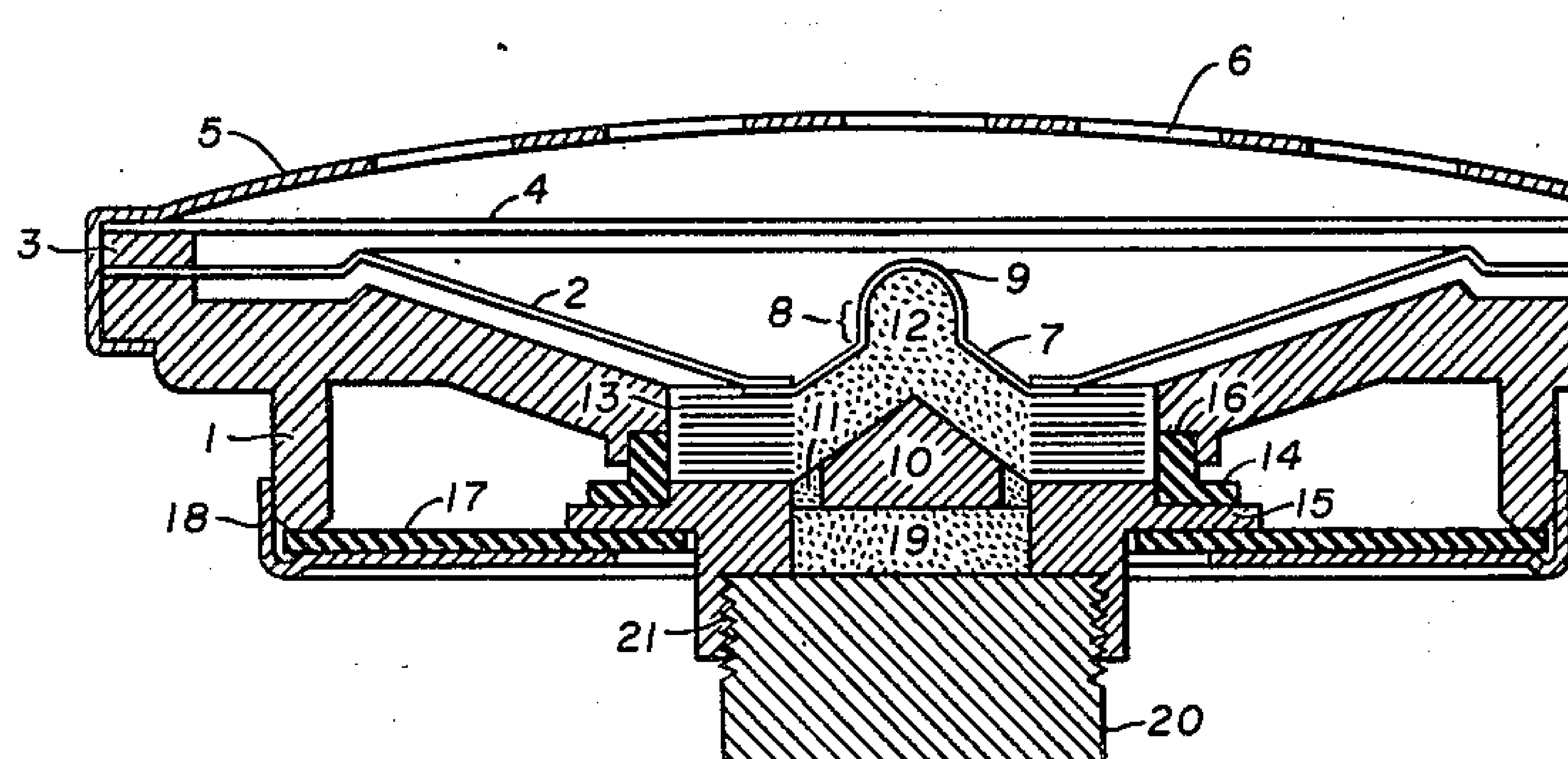

FIG. 2

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TELEPHONE TRANSMITTER

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This invention relates to improvements in sound translating apparatus and particularly to microphones of the class known as telephone transmitters.

Microphones of this class generally comprise a vibratile diaphragm adapted to compress comminuted resistance material in accordance with the sound waves striking the diaphragm. In such microphones, the comminuted resistance material usually is composed of carbon granules. The granules are contained within a chamber having two spaced apart electrodes. One electrode is stationary, and the other is arranged to be driven, or vibrated, by the diaphragm. A source of direct current potential is connected between these electrodes, causing a current to flow through the resistance material. Under these conditions, actuation of the diaphragm by a sound wave will cause a variation in the amount of current flowing through the resistance material. This action is termed modulation of the current.

In microphones known before my invention, either the modulation efficiency and the resistance changed over wide limits when the orientation, or position in space, of the microphone was changed, or else the modulation efficiency was low. Resistance changes were generally the consequence of changes in pressure of the granules against the electrodes as the microphone was moved. In particular, the pressure increased when the microphone axis was horizontal, but decreased when the axis was vertical.

Poor efficiency resulted from some microphone designs because extraneous granular masses were present. These extraneous masses could not be directly compressed by the diaphragm, and hence did not contribute appreciably to the modulation process. The extraneous masses furthermore formed a mechanical load on the diaphragm which impaired frequency response and tended to increase amplitude distortion.

It is accordingly an object of my invention to provide a microphone having a granule chamber in which the range of pressure variation of the granules is more restricted than in prior microphones.

It is another object of my invention to provide a microphone having a modulation efficiency greater than that achieved by previously known microphones through the elimination of extraneous granular masses and inefficiently modulated current paths.

It is a still further object of my invention to provide a microphone having an improved frequency response and a low degree of amplitude distortion.

In general, I achieve these and other objects of my invention by providing a new configuration for the microphone elements. As part of this configuration, I employ a pair of substantially

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conically shaped electrodes, one stationary and the other movable. The stationary electrode is supported by the frame of the microphone, while the movable electrode is arranged to be driven by the diaphragm. These electrodes are arranged coaxially with each other and with the diaphragm. The apex of the stationary electrode extends toward the concave side of the movable electrode. The electrodes are uniformly spaced apart, with as small a separation as can be maintained without excessive current flow between any two granules. (As is well known, excessive current flow causes undesirable arcing.) I prefer the movable electrode to have a substantially frustoconical shape.

If free carbon granules are piled up on a horizontal surface, it will be found that the granules form a cone-shaped heap. It will be found further that the angle of the conical surface with respect to the vertical axis of the conical heap is largely independent of the size of the heap; that is, the cone retains the same shape (though not the same size) as more granules are added. In accordance with my invention, I prefer to employ electrodes having conical surfaces whose acute angle with respect to their axes is smaller than the corresponding natural angle that would be assumed by the granules when heaped in an unconfined pile on a horizontal surface. This insures that the granules within the main chamber will not fall away from the electrode surfaces when the microphone is oriented with the electrode axis vertical.

It is a feature of my invention that the major mass of carbon granules is confined to the space directly between the electrodes. In the illustrated embodiment of my invention, I accomplish this confinement with a compressible means, such as a bellows. A main chamber is thus formed, having the electrodes as its ends and the compressible means as its side walls.

A further part in achieving the objects of my invention is played by a filling chamber located behind the stationary electrode, that is, on the side of the stationary electrode farthest from the main chamber. The filling chamber communicates with the main chamber by means of one or more filling holes, preferably adjacent to the outer circumference of the main chamber. Both the filling and main chambers are substantially filled with granules. When the microphone is oriented with the stationary electrode uppermost, the pressure of the granules in the filling chamber increases the pressure of the granules in the main chamber against the stationary electrode.

Another feature of my invention resides in a housing meeting the movable electrode at the smaller end of its frustum, extending away from the stationary electrode, and closed at its end farthest from the main chamber. The housing, like the main chamber, is substantially filled with granules and thus provides a reservoir of granules. Although the housing may be attached to the movable electrode by any convenient means, I prefer that the housing be formed as an integral part of the movable electrode as by stamping or drawing the electrode material. When the movable electrode is uppermost, the granules in the housing are higher than those in the main chamber. The granules in the housing therefore increase the pressure of the granules in the main chamber against the concave side of the movable electrode.

Still other objects and advantages of my invention will become apparent as the following description proceeds and the features of novelty which characterize my invention will be pointed out with particularity in the claims annexed to and forming a part of this specification.

For a better understanding of my invention, reference may be had to the accompanying drawing in which:

Fig. 1 is a top view of a preferred embodiment of my invention; and

Fig. 2 is a sectional view taken along line 2—2 in Fig. 1.

Referring now to the drawing, the microphone illustrated in Figs. 1 and 2 comprises an annular frame 1 made of a suitable substance, as for example metal. Supported by this frame is a vibratile diaphragm 2 which is clamped to frame 1 by some means such as the annular spacing ring 3. It is desirable to mount a dust and moisture shield 4 in front of the diaphragm 2. Frame 1, diaphragm 2, spacing ring 3, and shield 4, may be secured in place by clamp 5, which crimps these parts together at their outermost circumference. To allow sound waves to pass through clamp 5, holes 6 are provided therein.

Attached to the center of the diaphragm of the illustrated embodiment by some convenient means, such as spot-welding, is a movable electrode 7 of frusto-conical shape having at its center portion a housing defined by a cylindrical portion 8, which is terminated at its outer end by a portion 9. I prefer portion 9 to be of hemispherical shape for ease of forming, but it may be of any convenient shape that will attain my aim of providing a reservoir of carbon granules above the movable electrode 7 when the movable electrode is above the stationary electrode 10. This stationary electrode 10 is opposite electrode 7, and is of substantially conical shape. Furthermore, it is arranged such that its apex extends in the direction of the first-mentioned electrode 7. As previously explained, the acute angle of each electrode surface with respect to its axis is preferably no larger than the corresponding natural angle that would be assumed by the granules when heaped in an unconfined pile on a horizontal surface.

Electrode 10 is provided with filling holes 11 which may be arranged in a circle coaxial with the conical section, preferably adjacent to the outer circumference of the main chamber. Electrodes 7 and 10 define the ends of a main chamber substantially filled with carbon granules 12. This chamber is of substantially cylindrical shape as determined by compressible means 13. I prefer means 13 to be highly flexible in the axial direction but not in the radial direction. Means 13 may be a bellows arrangement formed of a suitable material, such as paper, for example. The folds of bellows 13 are preferably made closer together than the smallest of the carbon particles, thus insuring that the resistance material will be confined in the space directly between electrodes 7 and 10.

It is convenient to form diaphragm 2 of metal, in which case electrode 7 is conductively connected to frame 1. Frame 1 thus forms one terminal of the microphone. Frame 1 is insulated from electrode 10 by means of the annular insulating ring 14 which extends between a shoulder 15 on the outer circumference of electrode 10 and a shoulder 16 on the inner circumference of frame 1. A washer-shaped insulating disk 17 seals the microphone against the entry of air or moisture, and also serves to insulate electrode 10 from the clamping ring 18 used to clamp electrode 10 in fixed relationship to frame 1.

In assembling this embodiment of my invention, the microphone is held upside down from the position shown in the accompanying Fig. 2. Carbon granules are poured into filling chamber 19 and pass through filling holes 11, thus filling the housing (portions 8 and 9) and the main chamber between electrodes 7 and 10 substantially completely. Filling space 19 is then filled with granules, and plug 20 is screwed into electrode 10 by means of threaded means 21.

In the preferred embodiment of my invention, I provide a housing which meets the central portion of the frusto-conically shaped electrode 7 and extends away from the stationary electrodes. Although I have shown this housing being formed of a cylindrical portion 8 terminated by a hemispherical portion 9, it may be of any shape suitable for attaining maximum capacity in the housing with minimum cross-sectional area.

When the microphone is oriented with electrode 7 uppermost, as shown in Fig. 2, the carbon granules within the housing exert pressure through the granular mass, thus increasing the pressure of the granules in the main chamber against the concave side of electrode 7. On the other hand, when the microphone is inverted from the position shown in Fig. 2, the granules within the filling chamber 19 increase the pressure of the granules in the main chamber against the convex side of electrode 10. Thus the pressure of the granules against the uppermost electrode is increased whenever the axis of the microphone is at or near the vertical position. Since the resistance of a carbon microphone (of given electrode dimensions and spacing) depends to a considerable extent upon the pressure of the granules against the electrodes, it is seen that the tendency of the resistance to decrease when the microphone axis is vertical is largely counteracted.

The use of a compressible means, such as bellows 13, confines the granules to the space between electrodes 7 and 10, yet has sufficient flexibility to allow free vibration of electrode 7 with diaphragm 2. Because of this confinement, there are no extraneous granular masses present, as in some microphones; because there are no extraneous granular masses present, the sound energy driving the diaphragm is effective to compress only granules between the electrodes. These granules are therefore fully modulated, and the modulating efficiency is consequently improved over that of previously known microphones intended to achieve minimum positional variation.

The elimination of extraneous granular masses improves the frequency response of the microphone because in this way the diaphragm is as lightly loaded as possible. It also results in lowered amplitude distortion.

Confinement of the granules to the inter-electrode space is also beneficial because the pressure increase when the microphone axis is horizontal is less than in previous microphones having extraneous granular masses. As previously pointed out, the pressure decrease when the axis is vertical is less, according to my invention, than in previously known microphones because of the housing defined by portions 8 and 9 and of filling chamber 19. In this way, the over-all range of pressure variation and consequently of resistance variation, is less than achieved before.

While I have shown and described a particular embodiment of my invention, other modifications will readily occur to those skilled in the art. For example, it is not necessary that the particular configuration of the housing defined by portions 8 and 9 be employed to produce beneficial results. Furthermore, other compressible means may be employed instead of bellows 13. I do not therefore desire my invention to be limited to the specific arrangement shown and described and I intend, in the appended claims, to cover all modifications within the spirit and scope of my invention.

What I claim is:

1. In a microphone, a vibratile diaphragm, two electrodes, one of said electrodes being stationary and having a convex surface and the other being movable with said diaphragm and having a concave surface, said two surfaces being generally cone shaped, being coaxial with each other and with said diaphragm and facing each other in mutually spaced relation to define the ends of a chamber; closure means yieldable only in a direction substantially parallel to the axis of said electrode surfaces and extending generally cylindrically around said chamber to completely define said chamber; and comminuted resistance material completely filling said chamber and adapted to be compressed in accordance with incident sound waves; each of said electrodes having the acute angles between their respective generally cone shaped surfaces and their common axis smaller than the corresponding natural angle that would be assumed by said comminuted resistance material when heaped in an unconfined pile on a horizontal surface; and said closure means including a bellows the folds of which extend inwardly to the cylindrical zone connecting the base portions of said cones in an axial direction and are so narrowly spaced as to substantially prevent said comminuted resistance material from entering said folds, thereby confining said material within the space between said electrodes.

2. In a microphone, a vibratile diaphragm, two electrodes, one of said electrodes being stationary and having a convex surface and the other being movable with said diaphragm and having a concave surface, said two surfaces being generally cone shaped, being coaxial with each other and with said diaphragm and facing each other in mutually spaced relation to define the ends of a chamber; closure means yieldable only in a direction substantially parallel to the axis of said electrode surfaces and extending generally cylindrically around said chamber to completely define said chamber; and comminuted resistance material completely filling said chamber and adapted to be compressed in accordance with incident sound waves; and a filling chamber which is also filled with said material and is in communication with said first mentioned chamber; each of said electrodes having the acute angles between their respective generally cone shaped surfaces and their common axis smaller than the corresponding natural angle that would be assumed by said comminuted resistance material when heaped in an unconfined pile on a horizontal surface; and said closure means including a bellows the folds of which extend inwardly to the cylindrical zone connecting the base portions of said cones in an axial direction and are so narrowly spaced as to substantially prevent said comminuted resistance material from entering said folds thereby confining said material within the space between said electrodes.

3. In a microphone, a vibratile diaphragm, two electrodes, one of said electrodes being stationary and having a convex surface which is generally cone shaped and the other of said electrodes being movable with said diaphragm and having a concave surface which is generally truncated-cone shaped, said two surfaces being coaxial with each other and with said diaphragm and facing each other in mutually spaced relation to define the ends of a chamber; yieldable closure means extending between and contiguously to the peripheral base portions of the cone formed by said surface of the stationary electrode and the truncated cone formed by said surface of the movable electrode, generally cylindrically around said chamber to completely define said chamber; comminuted resistance material completely filling said chamber and adapted to be compressed in accordance with incident sound waves; and a reservoir housing which is movable with said movable electrode, extends centrally from the smaller end of said truncated cone away from said chamber, is closed at the end farthest from said chamber, is also filled with said material and is in communication with said chamber; each of said electrodes having the acute angles between their respective generally cone shaped surfaces and their common axis smaller than the corresponding natural angle that would be assumed by said comminuted resistance material when heaped in an unconfined pile on a horizontal surface; and said closure means being yieldable only in a direction substantially parallel to the axis of said electrode surfaces for confining said material within the space between said electrodes.

4. In a microphone, a vibratile diaphragm, two electrodes, one of said electrodes being stationary and having a convex surface which is generally cone shaped and the other of said electrodes being movable with said diaphragm and having a concave surface which is generally truncated-cone shaped, said two surfaces being coaxial with each other and with said diaphragm and facing each other in mutually spaced relation to define the ends of a chamber; yieldable closure means extending between and contiguously to the peripheral base portions of the cone formed by said surface of the stationary electrode and the truncated cone formed by said surface of the movable electrode, generally cylindrically around said chamber to completely define said chamber; comminuted resistance material completely filling said chamber and adapted to be compressed in accordance with incident sound waves; and a reservoir housing which is formed on said movable electrode, has a cylindrical portion extending centrally from the smaller end of said truncated cone away from said chamber, has a substantially hemispherical portion closing said housing at its end farthest from said chamber, is also filled with said material and is in communication with said chamber; each of said electrodes having the acute

angles between their respective generally cone shaped surfaces and their common axis smaller than the corresponding natural angle that would be assumed by said comminuted resistance material when heaped in an unconfined pile on a horizontal surface; and said closure means being yieldable only in a direction substantially parallel to the axis of said electrode surfaces for confining said material within the space between said electrodes.

5. In a microphone, a vibratile diaphragm, two electrodes, one of said electrodes being stationary and having a convex surface which is generally cone shaped and the other of said electrodes being movable with said diaphragm and having a concave surface which is generally truncated-cone shaped, said two surfaces being coaxial with each other and with said diaphragm and facing each other in mutually spaced relation to define the ends of a chamber; yieldable closure means extending between and contiguously to the peripheral base portions of the cone formed by said surface of the stationary electrode and the truncated cone formed by said surface of the movable electrode, generally cylindrically around said chamber to completely define said chamber; comminuted resistance material completely filling said chamber and adapted to be compressed in accordance with incident sound waves; a first reservoir housing which is located on the side of said stationary electrode away from said chamber; and a second reservoir housing which is movable with said electrode, extends centrally from the smaller end of said truncated cone away from said chamber, and is closed at the end farthest from said chamber; each of said electrodes having the acute angles between their respective generally cone shaped surfaces and their common axis smaller than the corresponding natural angle that would be assumed by said comminuted resistance material when heaped in an unconfined pile on a horizontal surface; said closure means being yieldable only in a direction substantially parallel to the axis of said electrode surfaces for confining said material within the space between said electrodes; and both said reservoirs being also filled with said material and being in communication with said chamber; whereby the range of pressure variation of said material in said chamber is restricted and the modulation efficiency of said microphone is maintained at a high level regardless of its orientation.

6. In a microphone, a vibratile diaphragm, two electrodes, one of said electrodes being stationary and having a convex surface which is generally cone shaped and the other of said electrodes being movable with said diaphragm and having a concave surface which is generally truncated-cone shaped, said two surfaces being coaxial with each other and with said diaphragm and facing each other in mutually spaced relation to define the ends of a chamber; yieldable closure means extending between and contiguously to the peripheral base portions of the cone formed by said surface of the stationary electrode and the truncated cone formed by said surface of the movable electrode, generally cylindrically around said chamber to completely define said chamber; comminuted resistance material completely filling said chamber and adapted to be compressed in accordance with incident sound waves; a first reservoir housing which is located on the side of said stationary electrode away from said chamber; and a second reservoir housing which is formed on said movable electrode, has a cylindrical portion extending centrally from the smaller end of said truncated cone away from said chamber and a substantially hemispherical portion closing said housing at its end farthest from said chamber; each of said electrodes having the acute angles between their respective generally cone shaped surfaces and their common axis smaller than the corresponding natural angle that would be assumed by said comminuted resistance material when heaped in an unconfined pile on a horizontal surface; said closure means being yieldable only in a direction substantially parallel to the axis of said electrode surfaces for confining said material within the space between said electrodes; and both said reservoirs being also filled with said material and being in communication with said chamber; whereby the range of pressure variation of said material in said chamber is restricted and the modulation efficiency of said microphone is maintained at a high level regardless of its orientation.

7. In a microphone, a vibratile diaphragm, two electrodes, one of said electrodes being stationary and having a convex surface which is generally cone shaped and the other of said electrodes being movable with said diaphragm and having a concave surface which is generally truncated-cone shaped, said two surfaces being coaxial with each other and with said diaphragm and facing each other in mutually spaced relation to define the ends of a chamber; yieldable closure means extending between and contiguously to the peripheral base portions of the cone formed by said surface of the stationary electrode and the truncated cone formed by said surface of the movable electrode, generally cylindrically around said chamber to completely define said chamber; comminuted resistance material completely filling said chamber and adapted to be compressed in accordance with incident sound waves; a first reservoir housing which is disposed such that the end of said reservoir farthest away from said chamber is located above said chamber when said microphone is oriented with said stationary electrode above said movable electrode; and a second reservoir housing which is formed by a recess in said movable electrode and is disposed such that the end of said reservoir farthest away from said chamber is located above said chamber when said microphone is oriented with said movable electrode above said stationary electrode; said closure means being yieldable only in a direction substantially parallel to the axis of said electrode surfaces for confining said material within the space between said electrodes; and both said reservoirs being also filled with said material and being in communication with said chamber; whereby the range of pressure variation of said material in said chamber is restricted and the modulation efficiency of said microphone is maintained at a high level regardless of its orientation.

8. In a microphone, a vibratile diaphragm, two electrodes, one of said electrodes being stationary and having a convex surface which is generally cone shaped and the other of said electrodes being movable with said diaphragm and having a concave surface which is generally truncated-cone shaped, said two surfaces being coaxial with each other and with said diaphragm and facing each other in mutually spaced relation to define the ends of a chamber; yieldable closure means extending between and contiguously to the peripheral base portions of the cone formed by said surface of the stationary electrode and the truncated cone formed by said surface of the movable

electrode, generally cylindrically around said chamber to completely define said chamber; comminuted resistance material completely filling said chamber and adapted to be compressed in accordance with incident sound waves; a first reservoir housing which is disposed such that the end of said reservoir farthest away from said chamber is located above said chamber when said microphone is oriented with said stationary electrode above said movable electrode; and a second reservoir housing which is disposed such that the end of said reservoir farthest away from said chamber is located above said chamber when said microphone is oriented with said movable electrode above said stationary electrode; said closure means being yieldable only in a direction substantially parallel to the axis of said electrode surfaces for confining said material within the space between said electrodes; and both said reservoirs being also filled with said material and being in communication with said chamber; whereby the range of pressure variation of said material in said chamber is restricted and the modulation efficiency of said microphone is maintained at a high level regardless of its orientation.

9. A microphone comprising a vibratile diaphragm, two electrodes, one of said electrodes being stationary and having a convex surface which is generally cone shaped and the other of said electrodes being movable with said diaphragm and having a concave surface which is generally truncated-cone shaped, said two surfaces being coaxial with each other and with said diaphragm and facing each other in mutually spaced relation to define the ends of a chamber; yieldable closure means completely defining said chamber; comminuted resistance material completely filling said chamber and adapted to be compressed in accordance with incident sound waves; a first reservoir housing which is located substantially in back of said stationary electrode as viewed from said movable electrode; and a second reservoir housing which is movable with said movable electrode, forms a recess extending centrally from the smaller end of said truncated cone away from said chamber, and is closed at its end farthest from said chamber; each of said electrodes having the acute angles between their respective generally cone shaped surfaces and their common axis smaller than the corresponding natural angle that would be assumed by said comminuted resistance material when heaped in an unconfined pile on a horizontal surface; and both said reservoirs being also filled with said material and being in communication with said chamber.

10. A microphone as claimed in claim 9 characterized in that said first reservoir opens into said chamber at the peripheral base portion of the cone formed by said surface of the stationary electrode and the second reservoir opens into said chamber centrally through the smaller end of the truncated cone formed by said surface of the movable electrode, whereby regardless of whether the microphone is oriented with one or the other electrode uppermost, said chamber communicates with the then uppermost reservoir substantially at the then uppermost portion of said chamber.

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