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[54] **ELECTRET DIAPHRAGM MICROPHONE WITH MEANS TO CORRUGATE THE DIAPHRAGM WHEN IN AN OVERSTRESSED CONDITION**

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[52] **U.S. Cl.** ..... **179/111 R;** 179/111 E

[51] **Int. Cl.²** **H04R 19/04**

[58] **Field of Search** ..... 179/111 R, 111 E

[56] **References Cited**

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[57] **ABSTRACT**

A condenser microphone comprises two electrodes spaced from each other by a small distance, of which one electrode is a diaphragm responsive to sound waves and the other electrode is formed with raised pin-like portions or projections projecting into the interspace between the electrodes, toward the diaphragm. The raised portions extend through only a part of the interspace so that a free space is left permitting unimpeded oscillation of the diaphragm in response to normal sound waves. The raised portions act as stops determining the maximum amplitude so that if the sound waves are abnormally strong, the diaphragm is deflected only up to contact with the end faces of the raised portions thus remaining spaced from the main surface of the opposite electrode. The electrostatic attractive forces are thereby limited and do not prevent the diaphragm from further free oscillation. To further reduce the electrostatic forces in the extreme position of the diaphragm, the end faces of the raised portions against which the diaphragm may apply are concave or electrically non-conductive. The electrodes preferably comprise an electretic material.

6 Claims, 3 Drawing Figures

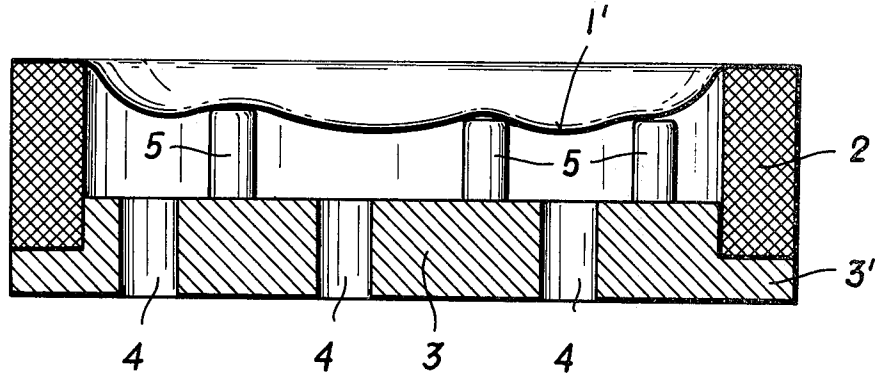


FIG. 1

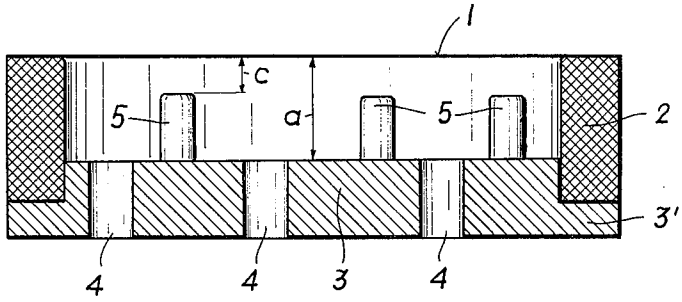


FIG. 2

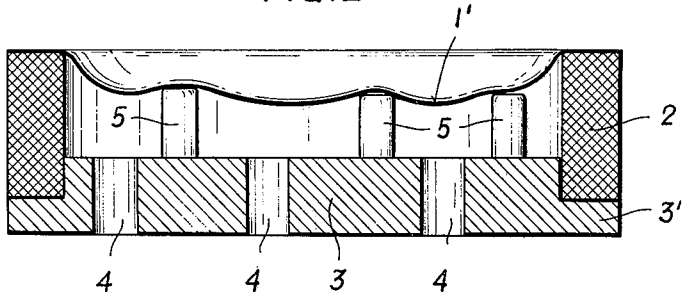
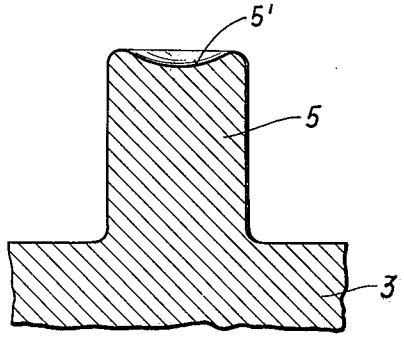


FIG. 3



ELECTRET DIAPHRAGM MICROPHONE WITH MEANS TO CORRUGATE THE DIAPHRAGM WHEN IN AN OVERSTRESSED CONDITION

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates in general to condenser microphones and, in particular, to a new and useful design of such a microphone in which the electrode responsive to sound can freely oscillate under normal conditions but is prevented from applying against the opposite electrode when exposed to abnormally strong sound waves.

2. Description of the Prior Art

A condenser microphone is conventionally so constructed that an electrically conductive diaphragm is disposed at a small distance from and opposite to a flat electrode having a conductive surface. The electrode can be made, for instance, directly from metal or plastic having a surface which has been metallized. As a rule, the distance between the electrode and the diaphragm is 30–40 μ, the necessary insulating layer being obtained either by a thin lacquer coating of the electrode or by using plastic sheets which are vapor treated on one side.

Condenser microphones are conventionally connected via a high-ohmic resistance to a voltage source, the externally applied voltage being about 60 volts. The movement of the diaphragm causes direct fluctuations in voltage which are picked up by a high-ohmic amplifier. Microphone constructions of this kind are expensive high precision products and they are difficult to manufacture in mass production. To obviate this disadvantage, it has been suggested to provide the electrode with raised portions which support the diaphragm at a number of points or zones so as to make the microphone easier to assemble and more reliable in operation. However, the disadvantage of this suggestion is that it reduces the effective diaphragm surface and also impedes the movement of the diaphragm and this results in a loss of sensitivity, more particularly in the case of microphones with reniform directional characteristic.

Since, as a rule, optimum acoustic transducer properties cannot be obtained by taking such steps, in practice, attempts to partially support the diaphragm have been abandoned and conventional condenser microphones have been constructed.

The sensitivity of a condenser microphone is directly proportional to the applied DC voltage, i.e., the polarization voltage, so that it is advantageous to make the latter as high as possible. In practice this can be done only up to a predetermined limiting value which is reached when, due to the electrostatic force of attraction, the diaphragm can no longer lift off the electrode after the occurrence of extremely high sound or wind pressures or the like. This means that the mechanical return force of the diaphragm must in all instances be greater than the electrostatic force of attraction, particularly if the diaphragm bears against the electrode.

If the diaphragm is made of electret foil there is extra difficulty that the charge is not very uniformly distributed on any given foil and there are different charges on different foils. The only solution to this problem hitherto has been to increase the distance between the diaphragm and the electrode correspondingly, resulting in a substantial sensitivity loss.

No improvement is obtained if the electrode itself is made of an electret material with a metallized surface.

SUMMARY OF THE INVENTION

In accordance with the present invention, there is provided a condenser microphone comprising an electrode having a surface presenting raised portions and a diaphragm disposed at a small distance from the said surface of the electrode, in which microphone the raised portions of the electrode project from the surface of the electrode a distance which is less than the distance between the electrode and the diaphragm, so that an unimpeded space is provided for the oscillation of the diaphragm when sound impinges normally on the microphone.

In a microphone embodying the invention, therefore, the diaphragm is as a rule completely free from any support by the electrode, so that the diaphragm as a whole can follow the sound oscillations. In the event of an extreme stress, which would make the diaphragm of a conventionally constructed condenser microphone come into engagement with the electrode surface, the raised portions of the electrode of a microphone embodying the invention at least impede a fairly large surface of the diaphragm from impinging on the electrode surface, if not actually preventing all contact therewith.

Since, in such a case, the electrostatic force occurring represents only a fraction of the force which occurs if the diaphragm bears flush against the electrode surface, the mechanical tensioning of the diaphragm is fully adequate to return it to the inoperative position when the external applied force has ceased to be operative.

If the external force should be so great that, in spite of the raised portions, the diaphragm is applied flush to the electrode, the fact that the diaphragm is applied at points to the individual raised portions produces an enhanced return force which is still adequate to lift the diphragm diaphragm again when such forces have ceased to be exerted.

The invention can be used in general for capacitive transducers, but is particularly advantageous for capacitive transducers which obtain the polarization voltage on the electret principle; it is immaterial whether electret diaphragms or electret electrodes are used.

The invention enables the polarization voltage to be increased, or the distance to be reduced if the electret effect is used, thus substantially increasing sensitivity.

As a rule, to produce the effect of the present invention, it is enough to provide the raised portions projection from the surface of the electrode with flat end faces nearest the diaphragm. However, it has been found that the effect can be further enhanced by making the end face of each raised portion not flat, but concave. As a result, when it bears against the raised portions, the diaphragm is forced to assume a corrugated shape, and the bending rigidity of the diaphragm makes it difficult for it to bear flush against the electrode.

Accordingly, it is an object of the invention to provide a condenser microphone comprising two electrodes of which the first one is formed with raised portions projecting toward the second electrode which is a diaphragm spaced from the first electrode by a small distance and facing the free end faces of the raised portions of the first electrode without contacting them under normal conditions so that a free space is pro-

vided between the raised portions and the diaphragm permitting unimpeded oscillations of the latter.

Another object of the invention is to provide electrodes of which at least one comprises an electretifiable material.

A further object of the invention is to provide the raised portions projecting from the first electrode in the form of cylindrical bodies having concave or non-conductive end faces.

Still another object of the invention is to provide an improved condenser microphone which is simple in design, rugged in construction and economical to manufacture.

The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this disclosure. For a better understanding of the invention, its operating advantages and specific objects attained by its uses, reference should be had to the accompanying drawing and descriptive matter in which there is illustrated a preferred embodiment of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

In the Drawings:

FIG. 1 is a cross-sectional view of a condenser microphone embodying the invention showing the diaphragm in normal position;

FIG. 2 is a view similar to FIG. 1 showing the position of the diaphragm when extreme sound wave pressure conditions occur; and

FIG. 3 is an enlarged cross-sectional view of a raised portion of the electrode, having a concave end face.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings in particular, the invention embodied therein, comprises a condenser microphone, which is diagrammatically illustrated and is not drawn to scale.

As shown in FIG. 1, the condenser microphone comprises an annular mount 2 of insulating material and two electrodes 3 and 1 affixed to mount 2 in spaced relationship. Electrode 1 is a diaphragm, for example, an electret foil. The electret foil 1 is attached, for instance by gluing, to the top edge of the annular mount 2. The co-acting electrode 3 is inserted from the bottom into mount 2. Electrode 3 has an annular recess 3' which defines the depth of penetration of the annular mount 2. As a rule, electrode 3 has a number of bores 4, so that a connection can be established between the lower air chamber behind the diaphragm and atmosphere. Raised portions or projections 5, which are preferably regularly distributed, are disposed on the webs between bores 4 of electrode 3. The height of the portions 5 is less the whole distance a between the electrode and the diaphragm. Portions 5 terminate at a free distance c from the underside of the diaphragm. Unless the raised portions 5 are to be too numerous, their height above the electrode is conveniently about $\frac{2}{3}\,a$. There is then left for the diaphragm a free space of height $c = \frac{1}{3}\,a$, in which it can oscillate without impediment. In practice, the distance a is about 40 μm.

When diaphragm 1 is overstressed, it is forced against electrode 3. As a result of the raised portions 5, disposed on the electrode 3, diaphragm 1 is prevented from bearing flush against electrode 3. Diaphragm 1, therefore, occupies a position 1', as shown approximately in section in FIG. 2. The raised portions 5 act as

a support for diaphragm 1', and prevent it from contacting those areas of electrode 3 which have no raised portions 5. Since the electrostatic force of attraction increases in direct proportion to the contact surface and decreases quadratically with the distance between the opposite surfaces, it can be seen that with a condenser microphone embodying the invention, if the diaphragm is overstressed, the effect of electrostatic attraction represents only a fraction of that which would be exerted if the diaphragm 1 were to bear flush against electrode 3. In any case, in the condenser microphone embodying the invention, the mechanical tensioning of the diaphragm 1 is adequate to return it to its normal position after the overstressing has ceased.

Raised portions 5 can take the form of small cylinders having a flat end face adjacent the diaphragm. However, it has been found to be particularly advantageous, if the applied forces are so great as to cause the diaphragm to bear against the electrode, to make the end face 5' of the raised portion concave, as shown in section in FIG. 3. As a result, the mechanical tensioning of the diaphragm and therefore its return force are substantially enhanced.

Where the surface of the electrode presenting the raised portions 5 is metallized, it is advantageous to leave the end faces of the raised portions unmetallized.

It has been found in practice that, in comparison with the prior art construction, a condenser microphone embodying the invention has either high sensitivity or, for at least equal sensitivity, a substantially improved reproducibility, accompanied by increased resistance to overloadings of all kinds.

While a specific embodiment of the invention has been shown and described in detail to illustrate the application of the principles of the invention, it will be understood that the invention may be embodied otherwise without departing from such principles.

What is claimed is:

1. A condenser microphone, comprising an electrode having a surface, an electret diaphragm at a spaced location from said surface, and means for corrugating said diaphragm in the event said diaphragm becomes overstressed, comprising at least one pin-like projection extending outwardly from said surface in normally spaced relation to said electrode, the space between said pin-like projection and said diaphragm being unimpeded to permit oscillation of said diaphragm in response to normal sound waves.

2. A condenser microphone comprising a mount, a first electrode connected to said mount and having an upper surface, and a second electrode in the form of an electretifiable foil diaphragm connected to said mount and having a lower surface facing said upper surface of said electrode and spaced therefrom by a small distance, and means for corrugating said diaphragm in the event said diaphragm becomes overstressed, comprising a plurality of pin-like raised projections projecting from and distributed over said upper surface of said first electrode and having end faces turned to said lower surface of said diaphragm and spaced therefrom by a free distance so that a free space adjacent said diaphragm is provided between said end faces and said diaphragm permitting unimpeded oscillations of the latter in response to normal sound waves.

3. A condenser microphone, according to claim 2, wherein said free distance between said end faces and said diaphragm is approximately one-third of said small distance separating said upper surface of said first elec-

trode from said lower surface of said diaphragm.

4. A condenser microphone, according to claim **2,** wherein said end faces of said raised portions are concaved.

5. A condenser microphone, according to claim **2,** wherein said end faces of said raised portions are electrically non-conductive.

6. A condenser microphone, according to claim **2,** wherein said raised projections have the form of upright cylindrical bodies.

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