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"UNIDIRECTIONAL ELECTRET MICROPHONE"

The present invention relates to an electret microphone which employs an electret as a diaphragm or back electrode and has unidirectional characteristics.

5 In a unidirectional electret microphone, sound reaches the diaphragm from behind and the velocity component of such sound is made to have a suitable relationship with the velocity component of sound reaching the front of the diaphragm, thereby providing a unidirectional characteristic. In the prior art, for instance, as disclosed in Figure 2 of U.S. Patent No. 4281222 issued on 10 July 28, 1981, an air-permeable damper cloth is held in contact with a back electrode on the opposite side from the diaphragm so that the sound from behind may reach the back of the diaphragm due to the air permeability of 15 the damper cloth. In order to obtain the desired unidirectional characteristics, the velocity component of the sound from behind has to be of a suitable value and is controlled by adjusting the acoustic impedance of the damper cloth. In the prior art, the acoustic impedance 20 of the damper cloth is controlled by adjusting the pressure applied to the damper cloth which is held between the back electrode and another holding member. For instance, the diaphragm, the back electrode, the damper cloth and so forth are disposed in assembled relationship in a case 25 and the rear end portion of the case is staked to the back of a rear plate member which closes the case during assembly of the microphone. The velocity component of the sound from behind is controlled by adjusting the staking force. Accordingly, desired characteristics are 30 difficult to obtain with this method and, sometimes, the microphone has to be disassembled and reconstructed in order to obtain the desired characteristics.

35 Felt, nonwoven fabric, air-permeable foamed resin and so forth have been employed as the damper cloth. In the case of cloth formed as felt or the like, fraying can occur making it difficult to uniformly control the velocity

component of the sound. Nonwoven fabric is non-uniform in weave, so that several layers must be used and this increases the manufacturing costs.

5 The object of the invention is to provide a unidirectional microphone in a simple and convenient form.

10 According to the invention a unidirectional electret microphone contains a tubular case having at one end a front end plate with a front sound hole formed therein, a diaphragm positioned in the case in spaced relationship with the front end plate, a back electrode positioned in the case and spaced from the diaphragm, at least one first sound hole formed in the back electrode, the back electrode or the diaphragm being formed as an electret, a partition wall positioned in the case and in contact with the face of the back electrode remote from the diaphragm, at least one second sound hole formed in the partition wall, the second sound hole or holes being covered by said face of the back electrode, an acoustic path formed between said face of the back electrode and the contacting face of the partition wall, said acoustic path coupling said first and second sound holes, and a rear sound hole formed in a member serving to close the end of the case remote from the front end plate, said rear sound hole acting to acoustically couple a rear compartment defined between the partition wall and said member, with the exterior of the case, said second sound hole or holes opening into said rear compartment.

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30 In the accompanying drawings:-

Figure 1 is a longitudinal sectional view showing a conventional unidirectional electret microphone;

Figure 2 is a longitudinal sectional view showing a microphone in accordance with the present invention;

Figure 3 is a bottom view of a back electrode;

5 Figure 4 shows a bottom view of another example of a back electrode and a plan view of a terminal plate for use with the back electrode;

Figure 5 shows a bottom view of another example of a back electrode and a plan view of a terminal plate for use therewith.

Figure 6 is a sectional view of part of the microphone shown in Figure 2; and

Figures 7, 8, and 9 are sectional views illustrating further embodiments of the invention.

5 To facilitate a better understanding of the present invention, a description will be given first, with reference to Figure 1 of a conventional unidirectional electret microphone. In a cylindrical metal case 14 having an
10 apertured front end, there is located an electret diaphragm 16 in spaced relation to the front end plate 17 of the case 14. The electret diaphragm 16 is a film of a synthetic resinous material polarized in the direction of its thickness and has a metal layer deposited on one surface of the film. The electret diaphragm 16 has the metal layer engaging
15 a metal ring 15, which is, in turn, held in contact with the front end plate 17 of the case 14. A back electrode 19 made of metal, is disposed opposite the electret diaphragm 16 with a ring-shaped spacer 18 held therebetween. Behind the back electrode 19 is located a
20 disc-shaped damper cloth 21 which is made of felt, non-woven fabric, air-permeable porous urethane or like material. The back electrode 19 has bored therethrough a plurality of sound holes 20, and the front end plate 17 has a centrally disposed front sound hole 23. A dust-proof cloth 24 is stuck on the front end plate 17 to
25 cover the front sound hole 23.

A terminal plate 32, which has a centrally disposed projection 33, is placed behind the damper cloth 21 in
30 contact therewith, and the projection 33 is snugly fitted in a through hole 34 formed in the damper cloth 21 centrally thereof and is held in contact with the back electrode 19 as by spot welding. The terminal plate 32 is provided with a plurality of holes 35. The back
35 electrode 19, the damper cloth 21 and the terminal plate 32 are held together by a back electrode holder 22. The back electrode holder 22 is a cylindrical member made from

a synthetic resinous material, and its front end portion has a larger internal diameter to define a step 39, the reduced thickness portion forming a holding portion 37. In the holding portion 37, the terminal plate 32, the damper cloth 21 and the back electrode 19 are sequentially placed one on another, the terminal plate being located on the step 39. In this case, the front of the back electrode 19 projects beyond the holding portion 37 to define an air gap 41 between the spacer 18 and the front edge of the holding portion 37.

A printed circuit board 26 is disposed in contact with the rear end face of the back electrode holder 22. The rear end portion of the case 14 is bent inwardly to be staked against the back of the printed circuit board 26 so that the parts in the case 14 are fixedly urged against the front end plate 17. In the back electrode holder 22, an impedance converter element 27 is mounted on the printed circuit board 26, and an input terminal 42 of the impedance converter element 27 is connected with the terminal plate 32. The impedance converter element 27 is to convert the high impedance input into a low impedance output and is usually constituted by a semiconductor integrated circuit in which a field effect transistor and resistance element are inter-connected in the source follower manner. A terminal lead-out portion of the impedance converter element 27 faces towards the inner surface of the back electrode holder 22 and an input terminal 42, an output terminal 43 and a grounding terminal 44 (not shown) are bent forwardly and backwardly of the impedance converter element 27, respectively, and the terminals 43 and 44 are soldered to individual leads of the printed circuit board 26, as indicated at 48.

Inside the back electrode holder 22 is defined a rear compartment 45, which is designed to communicate with the outside. That is, the printed circuit board 26 has formed therein a plurality of sound holes 29. Accor-

dingly, sounds entering into the back compartment 45 from the outside through the sound holes 29 reach the back of the electret diaphragm 16 passing through the holes 35, the damper cloth 21 and the sound holes 20, and the sounds reaching the electret diaphragm 16 both from behind and from in front are made to bear a suitable relationship to each other in terms of magnitude to achieve the unidirectional characteristics.

In the prior art microphone described above, the velocity component of the sound reaching the diaphragm 16 from behind is controlled by the damper cloth 21. This control is adjusted by adjusting the force that compresses the damper cloth 21, for instance, by adjusting the force that presses the rear end portion of the case 14 against the printed circuit board 26 for staking. With such adjustment, however, it is very difficult to achieve optimum control of the directivity. When the adjustment is unsatisfactory, the microphone has to be disassembled for reconstruction. Furthermore, in the case of using cloth as the damper cloth 21, it is frayed into a fringe, making it impossible to uniformly control the velocity control of sound. When nonwoven fabric is employed as the damper cloth 21, since it is non-uniform in weave, if several sheets of such nonwoven fabric were put one on another to make the weave uniform, the manufacturing costs would increase. In addition, in order to microminiaturize the microphone only a few sheets of extremely thin fabric can be used and, consequently, uniform control of the velocity component of sound is difficult.

Figure 2 illustrates an embodiment of the microphone of the present invention. In Figure 2, the parts corresponding to those in Figure 1 are identified by the same reference numerals. In this embodiment, the terminal plate 32 serves as a partition wall and it is contacted over substantially the entire area of its upper surface by the back electrode 19. The damper cloth 21 is omitted.

A fine groove 51 is cut in the surface of the back electrode 19 which contacts the terminal plate 32 so that a pair of sound holes 20 made in the back electrode 19 intercommunicate as shown in Figures 2 and 3. The groove 51 extends over a sound hole 35 in the terminal plate 32 and the sound holes 35 and 20 are acoustically coupled with each other through the groove 51. That is to say, the terminal plate 32 functions as a partition wall for acoustically separating the rear face of the back electrode 19 and the rear compartment 45 directly from each other.

The rear face of the back electrode 19 and the rear compartment 45 are acoustically coupled only through the groove 51 and the sound hole 35. With such an arrangement, the sound from the rear sound holes 29 reaches the back of the diaphragm 16 through the sound hole 35, the groove 51 and the sound holes 20. By suitable selection of the size and shape of the groove 51, the velocity component of the sound from behind can be controlled to a predetermined value, providing excellent unidirectional characteristics. The groove 51 constitutes a fine acoustic path. For instance, when the groove 51 was formed to have a V-shaped cross-section, about 40 μ deep and about 90° in angle, excellent unidirectional characteristics could be obtained. The groove 51 of predetermined size and shape can easily be formed. When using the back electrode 19 having the groove 51 of predetermined size and shape and the terminal plate 32 having the sound hole 35 of predetermined size, a microphone of excellent unidirectional characteristics can readily be constructed without the necessity of adjustment. Moreover, this structure is free from such problems as fray and non-uniform weave experienced in the prior art employing the damper cloth, thus permitting easy and inexpensive fabrication of a microminiature microphone.

Figure 4 shows a modified form of the groove 51, in which it is formed crosswise in the back electrode 19 and the centre of the cross-shaped groove 51 is aligned

with the centre of the sound hole 35 of the terminal plate 32. It is also possible to cut a groove 52 in the terminal plate 32 as depicted in Figure 5. In this case, one sound hole 20 is made in the back electrode 19 centrally thereof in opposing relation to the groove 52. In Figure 5, recesses 35 formed in the terminal plate 32 at both ends of the groove 52 are provided ^{to} acoustically couple the rear compartment 45 and the groove 52. Also it is possible to form a cross-shaped groove in the terminal plate 32 in opposing relation to the sound hole 20 of the back electrode 19. Further, instead of forming the grooves 51 and 52, small irregularities of the order of several microns, for instance, may be formed as minute acoustic paths over the entire area of the surface of one or both of the back electrode 19 and the terminal plate 32. The connection between the back electrode 19 and the terminal plate 32 can be achieved by urging them against each other between the stepped portion 39 and the space 18 by staking the rear marginal portion of the case 14 to the printed circuit board 26; however, the back electrode 19 and the terminal plate 32 may also be connected together by means of spot welding in the same manner, as described previously in respect of Figure 1.

A plate of a synthetic resinous material is used as a partition wall 53 in place of the terminal plate 32 as shown in Figure 6 and the input terminal 42 of the impedance converter element 27 is connected to the back electrode 19 through a sound hole 35 of the partition wall 53. Also in this case, the groove 51 or 52 can be formed in either the back electrode 19 or the partition wall 53 as described above in connection with Figures 2, 3, 4 and 5.

It is also possible to employ such an arrangement as shown in Figure 7 in which a partition wall 54 contiguous to the stepped portion 39 of the back electrode holder 22 and making contact with the rear face of the back electrode

19 is formed integrally with the back electrode holder 22, the sound hole 35 is made in the partition wall 54 and the contact surface of the partition wall 54 with the back electrode 19 is made rough as indicated by 55 to provide minute acoustic paths for intercommunication between the sound holes 20 and 35. In this case, the back electrode 19 and the input terminal 42 of the impedance converter element 27 may be connected together holding the end portion of the latter between the former and the partition wall 54 as shown in Figure 8. In Figure 7 and 8, it is also possible to make the contact surface of the partition wall 54 with the back electrode 19 smooth and the contact surface of the back electrode 19 with the partition wall 54 rough. The contact surfaces of both the partition wall 54 and the back electrode 19 may also be made rough. Further, it is also possible to cut the groove 51 in either the back electrode 19 and the partition wall 54 instead of forming the rough surface 55. In the example of Figure 9 the face of the partition wall 54 presented to the back electrode is recessed to accommodate a plate 56 formed from elastic material such as rubber. The plate is provided with a sound hole 58 in register with the sound hole 35 in the recessed partition wall. The plate 56 together with the recessed partition wall serve the same purpose as the non-recessed partition wall of the earlier examples. Acoustic coupling between the rear compartment 45 and the rear face of the diaphragm 16 takes place through the sound hole 20, the groove 51, the sound hole 58 in the plate 56 and the sound hole 35.

While in the foregoing the present invention has been described in connection with the case where the diaphragm 16 is an electret, the invention is also applicable to a microphone in which the back electrode

19 is an electret. In the embodiments described above, it is also possible to employ a rear covering plate in place of the printed circuit board and to lead the output terminal of the impedance converter element 27 through the covering plate.

CLAIMS

1. A unidirectional electret microphone comprising a tubular case having at one end a front end plate with a front sound hole formed therein, a diaphragm positioned in the case in spaced relationship with the front end plate, a back electrode positioned in the case and spaced from the diaphragm, at least one first sound hole formed in the back electrode, the back electrode or the diaphragm being formed as an electret, a partition wall positioned in the case and in contact with the face of the back electrode remote from the diaphragm, at least one second sound hole formed in the partition wall, the second sound hole or holes being covered by said face of the back electrode, an acoustic path formed between said face of the back electrode and the contacting face of the partition wall, said acoustic path coupling said first and second sound holes, and a rear sound hole formed in a member serving to close the end of the case remote from the front end plate, said rear sound hole acting to acoustically couple a rear compartment defined between the partition wall and said member, with the exterior of the case, said second sound hole or holes opening into said rear compartment.

2. A unidirectional electret microphone according to Claim 1, wherein the partition wall is defined by a terminal plate electrically connected with the back electrode; and an impedance converter element having its input terminal connected to the terminal plate is disposed in the case.

3. A unidirectional electret microphone according to Claim 2, wherein a tubular back electrode holder is disposed in the case substantially co-axially therewith



on the side of the diaphragm remote from the front end plate, the terminal plate and the back electrode being disposed one on the other with their marginal portions supported on a step formed in the inner peripheral surface of the back electrode holder at the front end thereof, and the impedance converter element is disposed in said rear compartment.

4. A unidirectional electret microphone according to Claim 3, wherein a covering plate forming said member is mounted on the back electrode holder at the end thereof adjacent said end of the case, the end portion of the case being staked to the back of the covering plate to press the diaphragm, the back electrode, the terminal plate and the back electrode holder towards the front end plate thereby mechanically fixing them in the case.

5. A unidirectional electret microphone according to Claim 4, wherein the covering plate is a printed circuit board, and a terminal of the impedance converter element is connected to the printed circuit board.

6. A unidirectional electret microphone according to Claim 1, wherein the partition wall is a plate formed from an insulating material.

7. A unidirectional electret microphone according to Claim 6, wherein an impedance converter element is disposed in the case, and an input terminal of the impedance converter element is connected to the back electrode through the or a second hole in the partition wall.



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8. A unidirectional electret microphone according to Claim 1, wherein a tubular back electrode holder is disposed in the case substantially co-axially therewith on the side of the diaphragm remote from the front end plate, said partition wall being integrally formed in the front end portion of the back electrode holder, the back electrode being held by the back electrode holder in contact with the front of the partition wall.
9. A unidirectional electret microphone according to Claim 8, wherein a space is defined by the back electrode holder inside thereof to the rear of the partition wall, said space forming said rear compartment and an impedance converter element located in said space, an input terminal of the impedance converter element being connected to the back electrode through the or a second sound hole.
10. A unidirectional electret microphone according to Claim 1 in which said partition wall includes a plate presented to the said face of the back electrode, said plate being formed from an elastic material and having said sound hole formed therein, said acoustic path comprising a groove formed in said back electrode, said groove extending between said first and second sound holes.
11. A unidirectional electret microphone according to any one of Claims 1-9, wherein the acoustic path comprises a groove communicating at opposite ends thereof with sound holes respectively made in either one of the back electrode and the partition wall, the intermediate portion of the groove being opposite a sound hole made in the other of the back electrode and the partition wall.



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- 5 12. A unidirectional electret microphone according to any one of Claims 1 to 9, wherein the acoustic path comprises a cross-shaped groove communicating at each end thereof with one of four sound holes made in either one of the back electrode and the partition wall, the intersection of the cross-shaped groove being opposite a sound hole made in the other of the back electrode and the partition wall.
- 10 13. A unidirectional electret microphone according to any one of Claims 1 to 9, wherein the acoustic path comprises a plurality of fine paths formed by irregularities of the contact surface of either one of the back electrode and the partition wall with the other.
- 15 14. A unidirectional electret microphone comprising the combination and arrangement of parts substantially as hereinbefore described with reference to Figures 2-10 of the accompanying drawings.
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