

United States Patent [19]**Cragg et al.**[11] **3,856,995**[45] **Dec. 24, 1974****[54] PRESSURE GRADIENT PIEZOELECTRIC MICROPHONE****[75] Inventors:** William Donald Cragg; Stuart Bradley, both of Harlow, England**[73] Assignee:** International Standard Electric Corporation, New York, N.Y.**[22] Filed:** May 11, 1973**[21] Appl. No.:** 359,300**Related U.S. Application Data****[63]** Continuation of Ser. No. 190,839, Oct. 20, 1971, abandoned.**[30] Foreign Application Priority Data**

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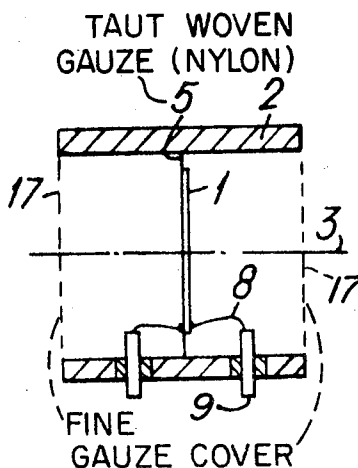
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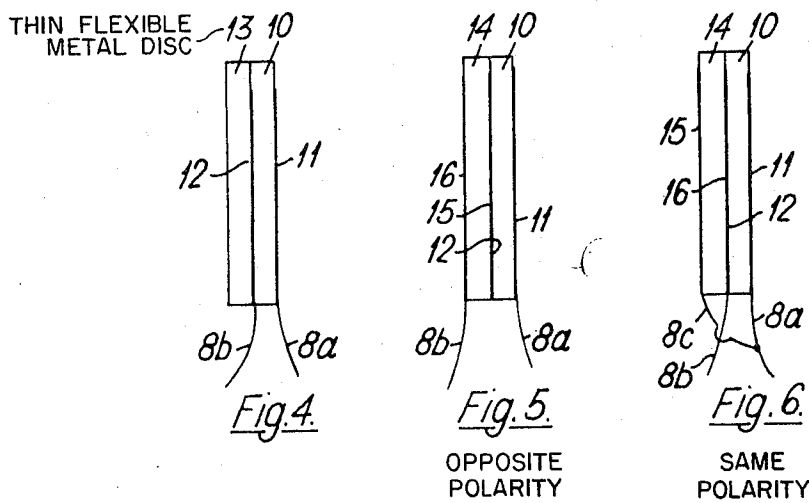
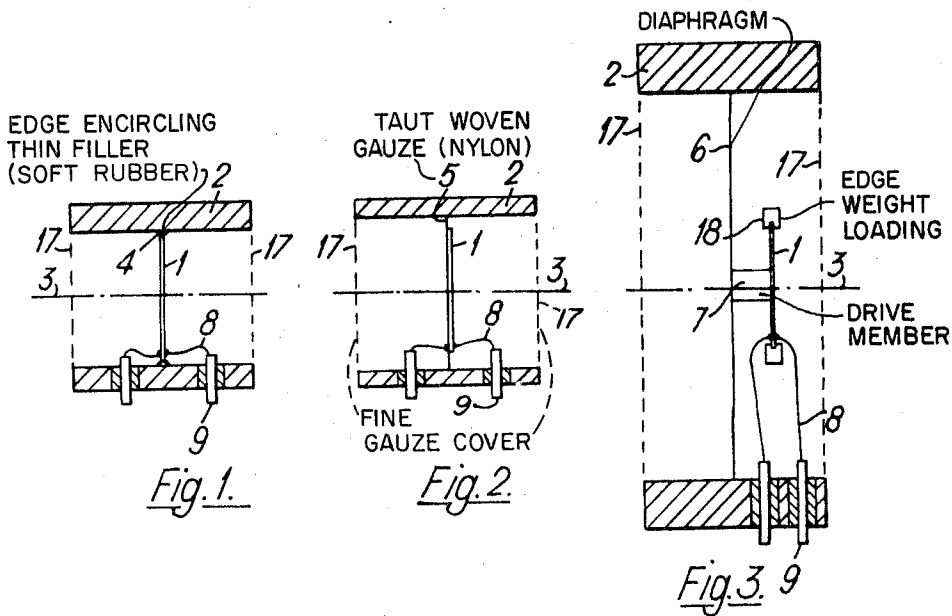
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[57]**ABSTRACT**

This invention relates to pressure gradient microphones. A piezoelectric ceramic disc is bonded, face to face, with a thin flexible metal disc. The composite disc is mounted in the center of an open ended hollow cylinder and transversely to the axis of said cylinder. The composite disc is driven by pressure differences between its two faces.

11 Claims, 6 Drawing Figures



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PRESSURE GRADIENT PIEZOELECTRIC MICROPHONE

CROSS-REFERENCE TO RELATED APPLICATIONS

This is a continuation of application Ser. No. 190,839 filed Oct. 20, 1971, now abandoned.

BACKGROUND OF THE INVENTION

This invention relates to microphones, and particularly to pressure gradient microphones.

The problem has long existed of providing microphones which are not overly sensitive to mechanical vibrations. Also, microphones which are used very near the mouth are subjected to turbulent air flow known as "blasting" caused by the normal air blasts of speech.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide an improved pressure gradient microphone which avoids the above described disadvantages.

According to the invention there is provided a pressure gradient microphone comprising a hollow cylinder, a piezoelectric disc transducer, and means for mounting said transducer within said cylinder such that the major surfaces of said discs are normal to the longitudinal axis of the cylinder.

The above and other objects of the present invention will be better understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectioned side view of a first construction of a pressure gradient microphone;

FIG. 2 is a sectioned side view of a second construction of a pressure gradient microphone;

FIG. 3 is a sectioned side view of a third construction of a pressure gradient microphone; and

FIGS. 4, 5 and 6 show alternative construction of the piezoelectric disc transducer element incorporated in the pressure gradient microphone.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIGS. 1, 2 and 3, a piezoelectric disc transducer element 1 is mounted centrally within a hollow cylinder 2 with the major surfaces of the disc normal to the longitudinal axis 3 of the cylinder.

In FIGS. 1 and 2 the hollow cylinder 2 has a length between 1 and 4 times its diameter, typically 0.375 inches, and the transducer element 1 has a diameter of 0.25 inches and a thickness of about 0.005 inches.

The two constructions shown in FIGS. 1 and 2 are of similar size and performance. The transducer element 1 has both faces open to free air, for the voice-frequency range, and is mounted centrally within the hollow cylinder 2 by an edge-encircling thin filler 4 (FIG. 1) of soft rubber or rubber-like material which seals the element 1 to the adjacent inside surface of cylinder 2 but does not apply any significant edge-clamping to the element 1.

Alternatively, as shown in FIG. 2, the element 1 is mounted on a taut woven gauze 5 of about 100 mesh, and typically nylon gauze, extending transversely across the inside of the cylinder 2 and peripherally fas-

tened thereto. With this gauze mounting, the acoustic leakage between the edge of the transducer element 1 and the inside surface of the hollow cylinder 2 is of low acoustic impedance.

5 Instead of gauze a thin rubber-like solid membrane may be used.

The transducer element 1 is very sensitive to mechanical vibration, and the two alternative mounting arrangements described above provide good attenuation of mechanical vibrations between the mounting cylinder and the transducer element.

10 In the construction shown in FIG. 3, the hollow cylinder 7 is of the same length as in the previous two constructions, but of an increased diameter, typically 1 inch for the 0.23 inches diameter transducer element. A centrally mounted second responsive diaphragm 6 peripherally fastened to the inside surface of the cylinder 2 has the transducer element 1 attached to the central region thereof by a drive member 7 fastened at one end thereof to the diaphragm 6 and at the other end thereof is a major surface of the element 1.

The sensitivity of the construction shown in FIG. 3 is increased for speech when an edge weight-loading 18 is added. The transducer element itself has a resonant frequency, for its small size, which is above speech frequency, and this resonant frequency is lowered to the top end of the speech frequency range by the addition of a suitable weight-loading.

In each of the constructions shown in FIGS. 1, 2 and 3 leads 8 from the transducer element are taken to terminals 9 extending through the wall of the cylinder 2 for external connection.

The transducer element 1 has three alternative constructions and these are shown in FIGS. 4, 5 and 6.

35 Referring to FIG. 4, a thin disc 10 of piezoelectric ceramic material (a mixture of lead titanate and zirconium titanate) has electrodes 11 and 12 applied as by evaporation to the major surfaces thereof. The material of the electrodes 11 and 12 is typically gold, nichrome or silver and in intimate contact with the disc surface. After application of the electrodes, the disc is polarized by subjection to a voltage via the electrodes of the order of 25KV per cm through the thickness of the disc, so that a voltage difference will appear between the electrodes when the disc is stretched radially.

45 The electrodes 11 and 12 cover the whole of the respective major surface of the disc almost to the periphery thereof, and after attachment of lead wires 8a and 8b, the disc is mechanically bonded, typically by an epoxy resin, face to face with a thin flexible metal disc 13 typically of aluminum, brass or nickel iron, e.g., Permalloy D, about equal in thickness (0.0022 inches) to the piezoelectric disc 10 and having an acoustic stiffness equal to the acoustic stiffness of the disc 10. The latter disc 10 is as thin as can conveniently be made, about 0.002 inches to 0.0025 inches.

55 The composite disc 10, 13 together with electrodes 11 and 12 and lead wires 8a and 8b, constitute the piezoelectric disc transducer element of the microphone.

60 Instead of a metal disc bonded to an electroded polarized piezoelectric disc 10, a second electroded polarized piezoelectric disc is bonded to the disc 10, the two discs being of about equal thickness and of equal acoustic stiffness.

This element is shown in FIG. 5. The second disc 14 of piezoelectric ceramic material (a mixture of lead ti-

tanate and zirconium titanate) has electrodes 15 and 16 applied as by evaporation to the major surfaces thereof. The material of the electrodes is typically gold, nichrome or silver and in intimate contact with the disc surface. After application of the electrodes 15 and 16, the disc 14 is polarized by subjection to a voltage via the electrodes 15 and 16 of the order of 25 KV per cm. through the thickness of the disc 14.

The polarized disc 14 is bonded face to face with the disc 10 so that the adjacent electrodes, one on each disc, are conductively joined. The disc 14 may be bonded to the disc 10 so that the respective polarities are opposite (FIG. 5) in which case two lead wires 8a and 8b for external connection are taken one from each of the two outer electrodes.

Alternatively the disc 14 may be bonded to the disc 10 so that the respective polarities are the same (FIG. 6) in which case there are three lead wires 8a (from electrode 11), 8b (from common electrodes 12 and 16) and 8c (from electrode 15), the lead wires 8a and 8c being joined for external connection.

Anyone of the above transducer element constructions may be incorporated in any one of the microphones of FIGS. 1, 2 and 3, and the element may be attached at either major surface to the supporting gauze, membrane or diaphragm.

The microphone of FIGS. 1, 2 or 3 is to be used very near the mouth and normal air blasts of speech will produce turbulent flow round the cylinder housing. The noises of turbulence, blasting are greatly reduced by the provision of a fine gauze cover 17 at each end of the cylinder 2. This has a two fold effect: firstly the gauze cover reduces the unidirectional air flow impinging directly on the element (or diaphragm), and secondly it reduces the sharp edges which generate turbulence.

The transducer element of FIGS. 1 and 2, and the diaphragm of FIG. 3, is driven by the pressure difference between its two faces. Sound waves arriving at some distance greater than 1 foot produce very little pressure difference across the disc, or diaphragm, at frequencies where the wavelength is large compared to the distance between back and front surfaces i.e., for all frequencies up to about 5,000 Hz. When used very near the lips, however, the microphone is in the region of spherical wave propagation from the mouth and the well known base boost effect comes into operation, whereby the pressure gradient increases with decreasing frequency below 5,000 Hz.

In these constructions, the disc (of FIG. 1 or 2), or diaphragm-disc assembly (of FIG. 3) should have its first resonant mode in the upper range of the speech band, between 3,500 Hz and 6,000 Hz to give a smooth response over the whole speech band. Also to maintain good noise reduction up to about 6,000 Hz the back to front distance between faces should be small, not much greater than one tenth wavelength of 4,000 Hz. These requirements are achieved by the dimensions already given.

It is to be understood that the foregoing description of specific examples of this invention is made by way of example only and is not to be considered as a limitation on its scope.

We claim:

1. A pressure gradient microphone comprising:
a hollow cylinder having two open ends of equal di-

ameter;

a piezoelectric disc transducer; and
means for mounting said disc transducer within said cylinder such that the major surfaces of said disc transducer are normal to the longitudinal axis of the cylinder, said means for mounting including a foraminated membrane peripherally fastened to the inside surface of said cylinder, with said disc having one major surface thereof centrally arranged relative to said foraminated membrane and directly attached thereto;

said disc transducer when mounted in said cylinder by said means for mounting forming two empty chambers within said cylinder, each of said two chambers providing unrestricted air flow therein.

2. A pressure gradient microphone according to claim 1 further including a gauze cover over each end of said cylinder.

3. A pressure gradient microphone according to claim 1 wherein the combination of said foraminated membrane and said transducer is centrally positioned relative to the ends of said cylinder.

4. A pressure gradient microphone according to claim 3 wherein said transducer has a pair of leads extending therefrom, and wherein the wall of said hollow cylinder proximate said transducer is adapted to permit said leads to extend out of the cylinder interior.

5. A pressure gradient microphone according to claim 1 wherein said foraminated membrane is a taut woven gauze membrane.

6. A pressure gradient microphone according to claim 1 wherein said transducer comprises:

- a first piezoelectric disc;
- a first electrode attached to one major surface of said first piezoelectric disc;
- a second electrode attached to the other major surface of said first piezoelectric disc; and
- a second disc having equal acoustic stiffness as said first piezoelectric disc attached face to face with said piezoelectric disc.

7. A pressure gradient microphone according to claim 6 wherein said second disc is a flexible metal disc.

8. A pressure gradient microphone according to claim 6 wherein said second disc includes:

- a second piezoelectric disc;
- a third electrode attached to one major surface of said second piezoelectric disc; and
- a fourth electrode attached to the other major surface of said second piezoelectric disc.

9. A pressure gradient microphone according to claim 8 further including two leads connected one to each of the outer electrodes and wherein said first and second piezoelectric discs are polarized in opposite directions.

10. A pressure gradient microphone according to claim 8 further including two leads connected one to both of the outer electrodes and the other to both of the center electrodes and wherein said first and second piezoelectric discs are polarized in like directions.

11. A pressure gradient microphone according to claim 8 wherein said first and second piezoelectric discs are made of piezoelectric ceramic material.

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