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[54] **PIEZOELECTRIC MICROPHONE WITH BIASING MEANS**
6 Claims, 4 Drawing Figs.

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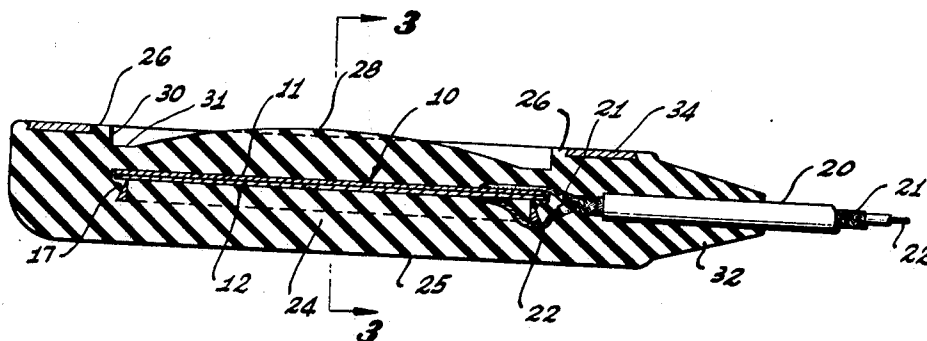
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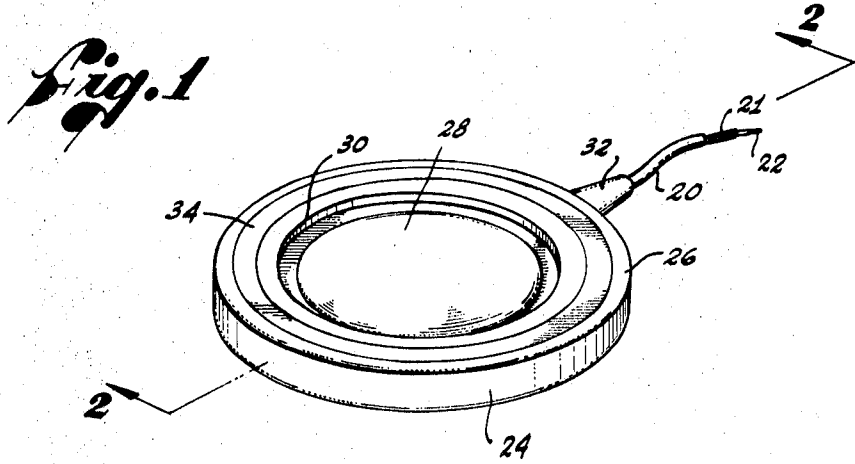
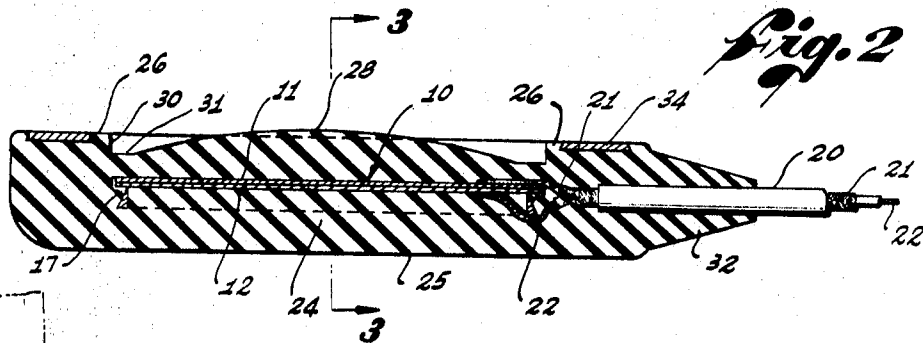
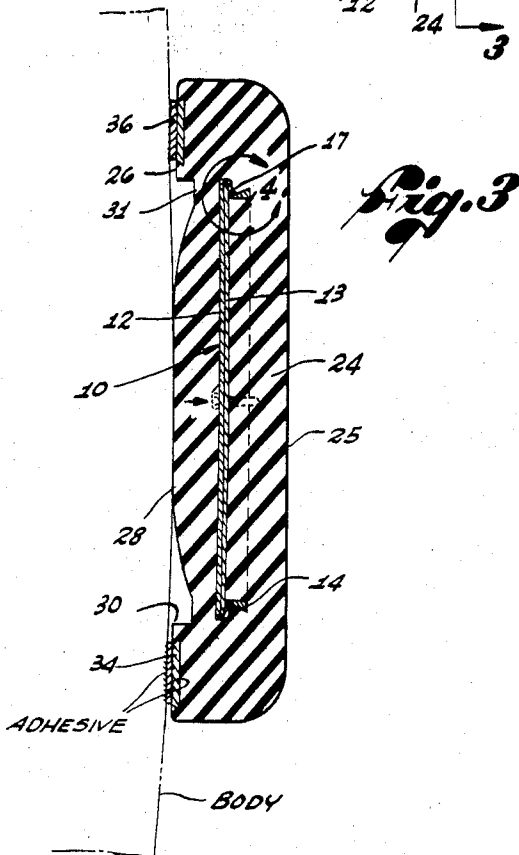
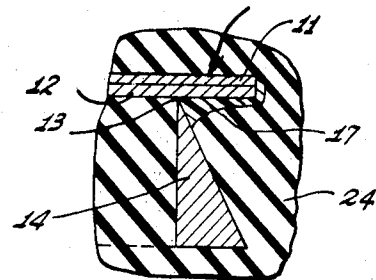
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ABSTRACT: A cardio-microphone comprising a piezoelectric crystal disc, mounted on a knife edge on a supporting ring, and embedded in a generally disc-shaped silicone rubber housing that has a dome on one side surrounded by an annular seating surface to be seated against the body of a patient. The dome projects beyond the seating surface, and, when it and the annular seating surface engage the body of the patient, the crystal disc on the inside receives center pressure which forces it into a dish-shaped shape and thereby provides it with a preliminary bias.





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PIEZOELECTRIC MICROPHONE WITH BIASING MEANS

This invention relates generally to crystal microphones, particularly of a type adapted to use as an improved cardiomicrophone.

Objects of the invention include the provision of a small, light, rugged, crystal microphone, of low profile, easily attached to the body, with a frequency response of for example 1 c.p.s. to 1,000 c.p.s., and with no measurable noise characteristics in typical phono-cardiography, vibro-cardiography, pulse pickup and carotoid pulse pickup applications.

The invention provides a bimorphic crystal disc, made up of two thin piezoelectric crystal discs in contact. This disc is engaged on one side, near its periphery, by a sharp-edged mounting ring, the latter being connected to the crystal by a nonconductive epoxy, which also coats the edges of the crystal to reduce the possibility of lowered output impedance by a moisture induced leakage path over the edge. A coaxial cable has its conductive shield electrically connected to the "body" side of the crystal, i.e., the side applied to the body of a patient, and its central conductor to the opposite side of the disc. This assembly is encapsulated in a silicone rubber disc. A feature of the microphone is that the "body" or "application" side of this disc has a peripheral annulus, inside of which is a depression; and rising from the plane of this depression is a dome whose center normally projects outside the peripheral annulus by a dimension of the order of 0.150 inch. When the microphone is pressed down against the body of the patient, this dome engages the body surface first, and is depressed slightly as the microphone is pressed down tight. The dome is thus deflected, as is the crystal. When the microphone is pressed down into operative position, the crystal is prestressed, or biased, and operates from this position as a mean. In other words, the crystal vibrates on one side and then the other of the bias position described. The device thus has the obvious advantage of avoidance of passing through a neutral or relaxed center position.

The invention will be further understood from the following detailed description of a present illustrative embodiment thereof, reference being had to the accompanying drawings, in which:

FIG. 1 is a perspective view of a microphone in accordance with the invention;

FIG. 2 is a transverse section taken on line 2-2 of FIG. 1;

FIG. 3 is a view taken on line 3-3 of FIG. 2, showing the microphone applied to the body of a patient; and

FIG. 4 is an enlarged detail of the area shown within the circular arrow 4 in FIG. 3.

The drawings show the microphone enlarged about three times. The crystal, designated at 10, is disc-shaped, and made up of two thin disc-shaped piezoelectric crystals 11 and 12, in a common bimorphic structure. The crystal 10 is mounted on the peripheral sharp or knife edge 13 of a rigid mounting ring 14, which engages one side of the crystal at a small spacing distance from the periphery of the crystal. The crystal will then deflect when a force is applied to its center, i.e., inside the ring. The knife edge mounting assures minimum resistance to vibration of the crystal in the normal mode.

The crystal disc is secured to the knife edge by a nonconductive epoxy adhesive, as at 17, and the periphery of the discs 11 and 12 are coated therewith to reduce possibility of lowered output impedance by a moisture induced leakage path over the edge.

Electrical connections are made to the two outer crystal faces by means of a coaxial cable 20, the metallic shield 21 being connected to that side of the crystal that is to face the body of the patient, while the center conductor 22 is connected to the opposite crystal face, as shown.

A low noise characteristic is aided through use of a coaxial cable incorporating a conductive "dust" in the shield. It is important that the shield be connected to the body side of the crystal to further reduce noise, since the body acts as an antenna. It is significant that no measurable noise can be attributed to the presently designed sensor in typical phono-cardiography, vibro-cardiography, pulse pickup and carotoid pulse pickup applications.

The crystal assembly as thus described is finally encapsulated in a dislike cover or housing 24 composed preferably of silicone rubber. Preferably, prior to "potting" with the silicone rubber, the crystal assembly is coated with a "primer" according to known practice.

The silicone cover or housing 24 is then molded on, and adheres quite strongly so that moisture cannot effect operation. The silicone rubber is preferably somewhat soft, e.g., something of the order of, or a little harder than, the rubber erasing tip on a lead pencil. This housing may be flat on one side, as at 25, while the other side is characterized by a flat peripheral annulus 26, parallel to the plane of the disc 10, and by a relatively flat dome or promontory 28 inside thereof which projects, in the center, slightly above or beyond the plane of the annulus 26. The projection distance may be, e.g., 0.015 inch in the actual sized device. In the embodiment here shown, the annulus 26 is at the top of an annular shoulder 30, which rises from a depressed annular surface 31 also parallel to the plane of the disc 10, and the aforementioned dome 28 rises from the inner margin of this depressed surface 31.

The silicone rubber housing 24 has molded on one of its edges a tapered and bored projection 32 which passes the coaxial cable.

To aid in securing the microphone to the body of the patient, a metallic ring 34 is set into the annulus 26 in a flush position, and a double-coated adhesive ring 36 is applied to this ring and to the body, as in FIG. 3. The dome 28 is thereby flattened and compressed, and exerts pressure on the center of the crystal disc causing it to be stressed and to assume a slightly disc'd form and position. The crystal is thus biased to this stress and shape when the microphone is attached to the body, and vibrates on its knife edge support in one direction and then the other about this bias position. A more stable vibration, and corresponding output, is obtained in this way than if the crystal were to vibrate from a relaxed or unstressed neutral position.

The metallic ring 34 also has the beneficial effect of adding rigidity to the assembly, so that nonelectrical noise arising from such sources as body movement are minimized.

A present illustrative embodiment of the invention has now been described, but it will be understood that the details of this embodiment are for illustrative purposes only, and that various changes in design, structure and arrangement may be made without departing from the spirit and scope of the appended claims.

I claim:

1. A microphone comprising:

a generally circular, normally flat crystal disc;

a substantially rigid annular ring having an annular knife-edge at one end thereof facing in a direction parallel to the axis of said ring, said knife-edge engaging one face of said crystal disc adjacent its periphery;

cementitious material rigidly securing said ring to said disc to fixedly hold said knife-edge thereagainst; and

a flexible rubber body having said disc and ring completely embedded therein, said rubber body having an outer surface, outwardly of said one face of said disc adapted to engage a patient's body and transmit vibrations therefrom to said disc.

2. A microphone as defined in claim 1 wherein said cementitious material extends outwardly from said ring to cover the outer face portion of said disc and the peripheral edge thereof.

3. A microphone as defined in claim 1 wherein said outer surface of said rubber body is shaped to define a projection substantially centrally of said disc whereby external pressure applied to said projection causes said disc to bow slightly, away therefrom.

4. A microphone as defined in claim 1 wherein said outer surface of said rubber body is provided with a flat annular surface portion, defining a plane substantially parallel to the plane of said disc, and surrounding said projection; said projection extending outwardly beyond the plane of said annular surface portion whereby said annular surface portion serves to engage a patient's body and thereby limit the bowing of said disc.

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5. A microphone as defined in claim 3 wherein the portion of said outer surface between said projection and said annular surface portion is nearer said disc than said annular surface

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portion.
6. A microphone as defined in claim 3 including a metal ring having a surface flush with said annular surface portion.

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