

[54] **MICROPHONE HAVING IMPROVED
PIEZOELECTRIC TRANSDUCER
SUPPORTS**

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[51] Int. Cl. **H04r 17/02**
[58] Field of Search **179/110 A; 310/8.2, 8.3, 8.5,**
310/8.6

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[57] **ABSTRACT**

A microphone assembly in which a piezoelectric transducer beam is attached at one end to a flexible diaphragm and is supported at the other end by simply resting upon an electrical contact without being connected thereto. The transducer beam is pressed against the supporting contact by a second electrical contact that is shaped to support the transducer beam near its center and to apply a rotary force thereto. The second electrical contact has a rectangular opening formed in an end portion thereof for receiving and supporting the transducer beam and the end portion of the electrical contact beyond the rectangular opening is rolled over to form a spring for applying rotary force to the transducer beam.

10 Claims, 5 Drawing Figures

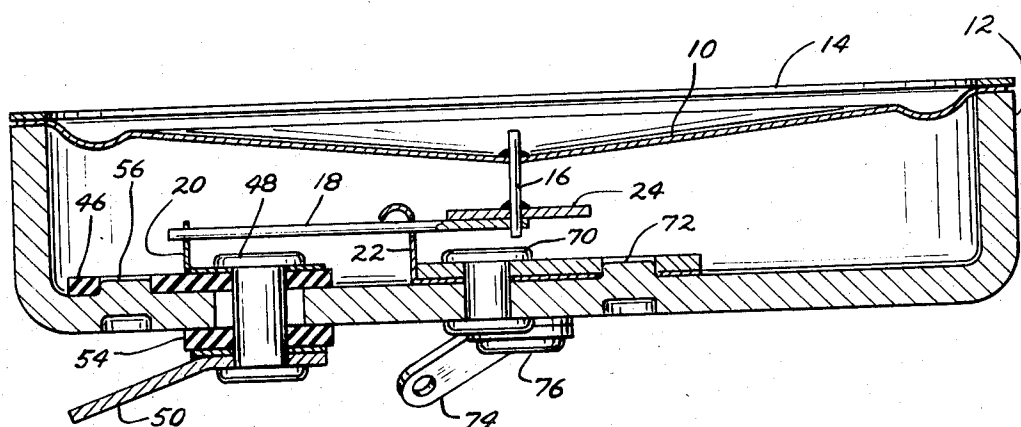


FIG. 1

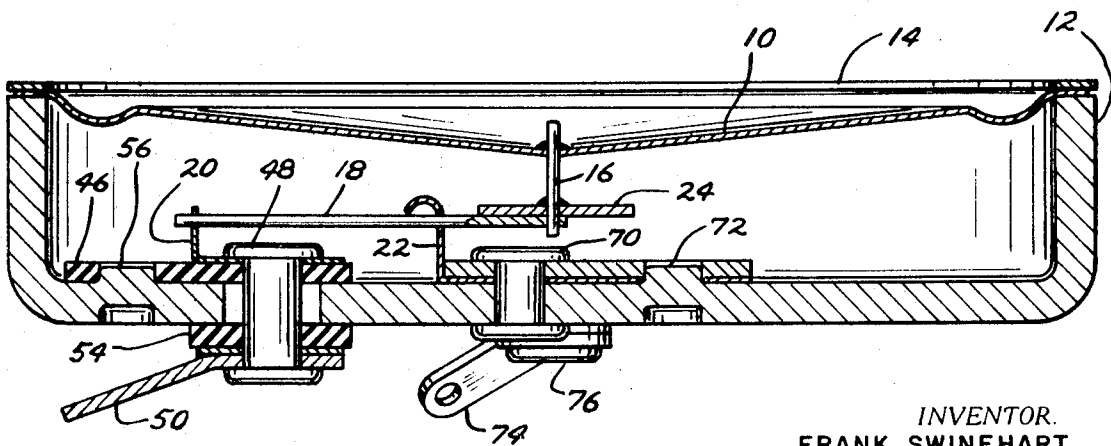
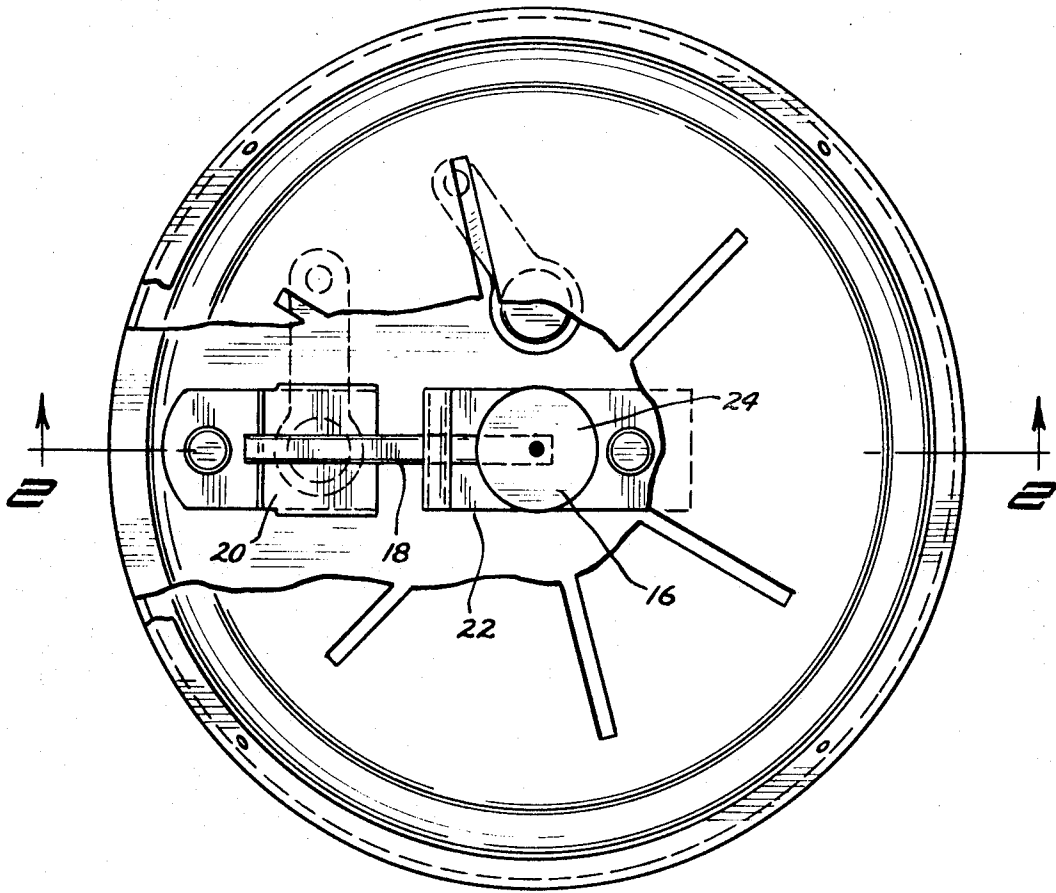


FIG. 2

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FIG. 3

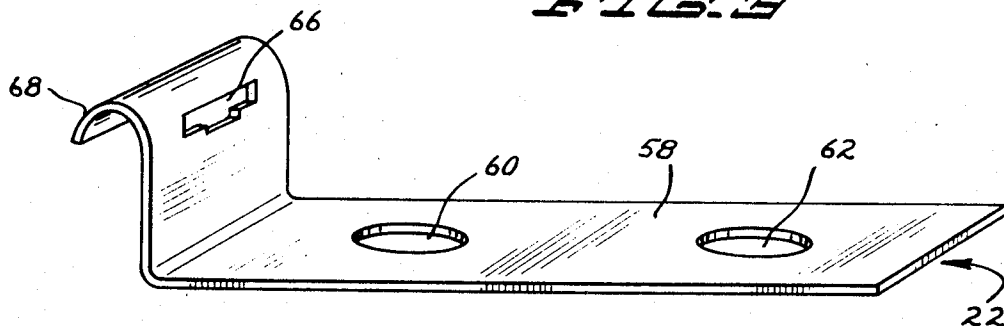


FIG. 4

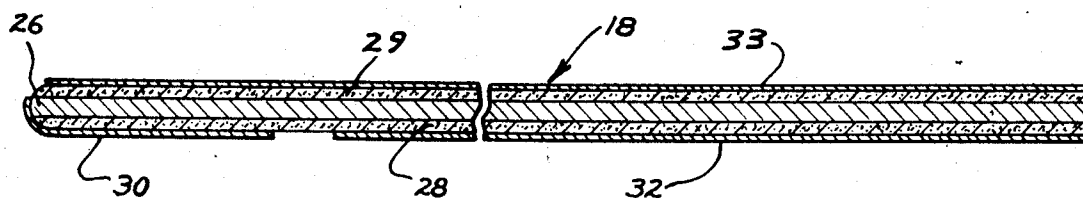
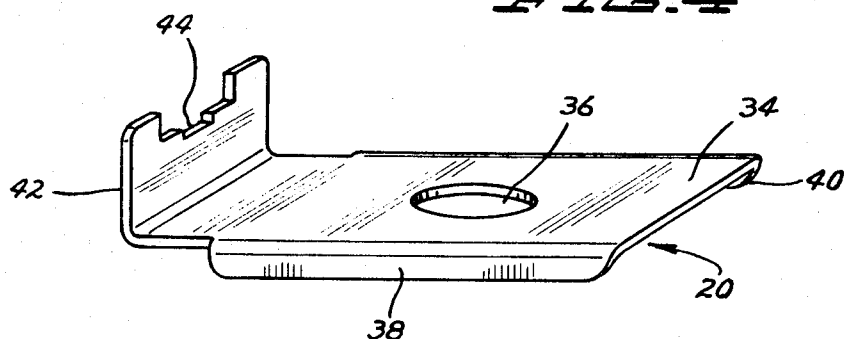


FIG. 5

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MICROPHONE HAVING IMPROVED PIEZOELECTRIC TRANSDUCER SUPPORTS

BACKGROUND OF THE INVENTION

This invention relates to improvements in microphone assemblies that utilize piezoelectric transducer beams. These transducer beams are relatively slender, laminated structures containing two thin layers of piezoelectric ceramic such as lead zirconate titanate or the like which are joined to opposite sides of a metal core. A layer of electrically conductive metal such as nickel or silver is deposited on both sides of the piezoelectric ceramic layers to act as electrical contacts. When the beam is bent, an electrical potential corresponding to the amount of bending is developed between the metal core and the outer metallic coating of both piezoelectric ceramic layers. The potential developed across the two piezoelectric ceramic layers can be connected either in series or in parallel by appropriate polarization of the ceramic layer. Although the basic concept of this invention is applicable to both the series and parallel connections, the disclosed embodiment is particularly adapted for use with parallel connections.

In parallel transducer beams, the outer metallic coating of the two piezoelectric ceramic layers are normally connected together at one end of the beam, but simplified and less expensive transducer beams are available in which the two outer metallic coatings are separated. With the simplified transducer beams, it has been customary in the past to provide an external jumper circuit for connecting the two outer metallic coatings together.

In a microphone assembly, the transducer beam is attached at one end to a flexible diaphragm that vibrates in response to sound and is clamped to the microphone housing in such a way that the vibrations of the diaphragm will induce corresponding bending vibrations in the beam. The voltage induced in the transducer beam by such bending is picked off by means of two electrical contacts, one of which is positioned to make contact with the outer metallic coating of the piezoelectric ceramic layers, and the other of which is positioned to make contact with the metal core thereof. For convenience in making contact with the metal core, a portion of the outer metallic coating at one end of the lower piezoelectric ceramic layer is usually insulated from the rest of the metallic coating and joined instead to the metal core where it is exposed at the end of the transducer beam so that electrical contact can be made with the metal core via the outer surface of the beam.

The above described type of microphone assembly has proven to be highly successful in practice with regard to its electrical characteristics, but several serious difficulties have been encountered with regard to the mechanical construction and assembly of such microphones. One particular difficulty relates to the mechanical mounting structure and electrical contact structure for making contact with the piezoelectric transducer beam. It will be understood by those skilled in the art that the position of the beam and the tension applied to the beam are critical factors with regard to the ultimate electrical performance of the transducer in translating vibrations of the diaphragm into corresponding electrical vibrations. Accordingly, in the

past, it has been necessary to provide relatively complex mounting structures and electrical contacts for receiving and holding the transducer beam in its proper position. With regard to assembly of the microphone, the problem posed by such relatively complex mechanical supports and electrical contacts for the transducer beam are compounded by the relatively small size of the beam, which makes it difficult and time-consuming to properly position the beam in its housing. Accordingly, the principal object of this invention is to provide a simplified mechanical mounting structure and electrical contact assembly for a piezoelectric microphone whereby the transducer beam can be accurately placed in position very quickly through the use of simple components.

In addition, in the past it has been necessary to provide an external jumper circuit when simplified transducer beams are used in the microphone structure. A further object of this invention is to provide a mechanical mounting structure of the above noted type where contact is made to both sides of the transducer beam without requiring a separate external jumper circuit.

SUMMARY OF THE INVENTION

In accordance with this invention, the above noted objects are achieved by providing a first electrical contact which is bent and shaped so as to slidably receive the piezoelectric transducer beam and apply a rotary force to the central portion of the beam and a second electrical contact which is shaped and positioned to support the end of the beam against the rotary pressure and to make electrical contact with the beam without being connected thereto. The first electrical contact has a rectangular opening formed in an end portion thereof for receiving and supporting one side of the transducer beam, with the end portion of the electrical contact beyond the rectangular opening being rolled over to form a spring for applying rotary pressure to the other side of the transducer beam to force it against the other electrical contact which is located at the end of the beam. In addition to combining the mechanical support and electrical contact functions, this novel electrical contact also has the advantage of making electrical contact with both the upper and lower surface of the metallic coating on the transducer beam without requiring a separate jumper circuit. Other novel features of the invention for simplifying and expediting the assembly of the transducer beam include locating bosses provided in the bottom of the microphone housing and recesses in the two electrical contacts for engaging the locating bosses to accurately position the contacts for attachment to the microphone housing. The above noted and other novel features of the invention are described in detail below in connection with one specific embodiment of the invention which is illustrated in the attached drawings.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front view of one illustrative embodiment of the invention.

FIG. 2 is an axial cross sectional view taken along the plane 2—2 of FIG. 1.

FIG. 3 is a perspective view of one electrical contact of this invention.

FIG. 4 is a perspective view of the other electrical contact of this invention.

FIG. 5 is a cross sectional view of the piezoelectric transducer beam utilized in the above noted embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring to FIGS. 1 and 2, one illustrative embodiment of this invention contains a flexible metallic diaphragm 10 which is mounted at its peripheral edges on a hollow metallic case 12 and covered by a radially slotted cover plate 14. Diaphragm 10 is attached at its center by means of a drive pin 16 to one end of a piezoelectric transducer beam 18 which is supported at its other end by an electrical contact 20 and in its central portion by another electrical contact 22. Drive pin 16 is attached to diaphragm 10 and to the end of transducer beam 18 by cement. A small weight 24 is attached to the end of transducer beam 18 for adjusting the mechanical resonance of the system to the desired frequency. The detailed construction of piezoelectric transducer beam 18, electrical contact 20, and electrical contact 22 is shown more clearly in FIGS. 3, 4 and 5. As shown in FIG. 5, transducer beam 18 contains a brass core 26 upon which two layers of piezoelectric ceramic material such as lead zirconate titanate or the like are sandwiched. The piezoelectric ceramic layers are indicated by reference numerals 28 and 29. A coating of electrically conductive metallic material 30 such as nickel or silver is deposited on top of the piezoelectric ceramic 28 near one end of the transducer beam 18 to make contact with the brass core 26. A second metallic coating 32 is spaced from coating 30 and covers the entire balance of the piezoelectric ceramic layer 28. A third metallic coating 33 is deposited on top of piezoelectric ceramic layer 29. When the transducer beam 18 is bent by vibrations of the diaphragm 10, corresponding electric potentials are developed between the inner and outer surface of the piezoelectric ceramic, thereby producing corresponding potentials between metallic coating 30 and metallic coatings 32 and 33. These potential differences are picked off by the two electrical contacts 20 and 22, one of which is adapted to contact the metallic coating 30 and the other of which is adapted to contact the metallic coatings 32 and 33.

Referring to FIG. 2, the metallic coatings 32 and 33 are contacted by the upper and lower abutting edges of contact 22, which also applies a rotary counterclockwise force to the transducer beam 18, and the metallic coating 30 is contacted by electrical contact 20. The electrical contact 22 serves several functions in this structure. In the first place, it provides a fulcrum point for translating the vibrations received from the diaphragm 10 into bending movements of transducer beam 18. Secondly, by applying a counterclockwise rotary force to the beam, it presses the beam against electrical contact 20 to ensure positive electrical connection between the contact 20 and the metallic coating 30 of the beam without being attached thereto. It will be appreciated by those skilled in the art that if the transducer beam 18 were soldered to the electrical contact 20, the heat developed in such a soldering operation would tend to be destructive to the delicate coatings on the beam and furthermore that such a connection would be very difficult to make in a closed housing. Also, the use of mechanical clamps in connection with electrical contact 20 is equally undesirable due to the

increase in cost and complexity, not to mention the added time requirements in assembling. Accordingly, one advantage of the novel transducer beam mounting structure of this invention is that it eliminates such clamp members by applying a strong enough rotary force to the transducer beam 18 to hold the metallic coating 30 in positive electrical contact with the electrical contact 20 without any mechanical connection.

The simple structure of electrical contact 20 can be better appreciated with reference to FIG. 4. As shown in FIG. 4, this contact comprises a base plate 34 having an opening 36 formed therein, two downwardly depending skirts 38 and 40, and an upstanding abutment member 42 having a recessed portion 44 for receiving the transducer beam 18. Referring to FIG. 2 the downwardly depending skirts 38 and 40 are adapted to position the electrical contact 20 on top of an insulating pad 46 to insulate it from the metallic housing 12. Electrical contact 20 and insulating pad 46 are secured to the bottom of housing 12 by means of an electrically conducting rivet 48 which extends through the opening 36 in contact 20 and through a matching opening in the bottom of housing 12. An electrical contact member 50 for receiving a wire connection is secured to rivet 48 on the other side of housing 12, and the entire assembly is insulated from the housing 12 by a second insulator block 54. For alignment purposes, a locating boss 56 projects upwardly from the bottom of housing 12 and engages a corresponding opening in insulator block 46. The locating boss 56 is formed by a stamping operation that raises a cylindrical portion of the bottom of housing 12. Locating boss 56 makes it possible to precisely locate the electrical contact 20 when it is assembled and to mount it in place with a minimum of time and effort.

The detailed construction of electrical contact 22 is shown most clearly in FIG. 3. Referring to FIG. 3, electrical contact 22 comprises a base portion 58 which has two openings 60 and 62 formed therein. Opening 60 is for receiving a rivet for fastening the electrical contact to the bottom of housing 12, and opening 62 is for engaging a locating boss formed in the bottom of housing 12 to correctly align the electrical contact when it is mounted in place. Electrical contact 22 further comprises an upstanding abutment portion 64 containing a rectangular opening 66 and a rolled over lip portion 68 that constitutes a spring. Rectangular opening 66 is larger than the transducer beam 18 in width for easy insertion thereof and is notched at its bottom at approximately the width of the transducer beam 18 to securely hold the transducer beam therein. The rolled lip portion 68 extends below the level of rectangular opening 66 so as to apply a positive downward pressure to the transducer beam 18. As shown in FIG. 1, electrical contact 22 is held in place by a rivet 70 extending through the opening 60 and a matching opening in the bottom of housing 12. The contact is aligned by means of a locating boss 72 which projects upwardly from the bottom of housing 12 and engages opening 62 of electrical contact 22.

One important feature of this invention is that electrical contact 22, which is the ground contact, makes positive contact with both the lower metallic coating 32 and the upper metallic coating 33 on the simplified transducer beam 18. In the past it has been necessary to

use a separate jumper to effect the ground connection on both sides of the transducer beam but such jumpers are eliminated with the structure of this invention.

In the illustrated embodiment, the electrical lug for receiving the ground wire connection is not attached to the rivet 70 which holds electrical contact 22 in place but is rather secured to the bottom of housing 12 by another rivet. Referring to FIG. 2, the ground connection comprises a lug 74 which is secured to the bottom of housing 12 by rivet 76. It will be apparent, however, that the ground wire lug could be attached to rivet 70 if desired.

From the foregoing description, it will be apparent that this invention provides a simplified mechanical mounting structure and electrical contact assembly for the transducer beam of a piezoelectric microphone whereby the transducer beam can be accurately placed in position very quickly through the use of simple components. And although this invention has been described in connection with one specific embodiment thereof, it should be understood that the invention is by no means limited to the disclosed embodiment, since many modifications can be made in the disclosed structure without altering its basic principles of operation. Accordingly, this invention includes all modifications falling within the scope of the following claims:

I claim:

1. In a microphone assembly including a flexible diaphragm adapted to vibrate in response to sound waves, a piezoelectric transducer beam having first and second electrodes disposed on the surfaces thereof and being attached at one end to said diaphragm for translating the vibrations thereof into corresponding electrical signals, and two electrical contact elements for making electrical contact with respective electrodes on said transducer beam to receive said electrical signals, the improvement wherein the first electrical contact is connected to a first electrode and includes means for supporting a transducer beam at a first point and further means to apply a force to said beam so as to tend to cause rotation thereof about said first point, and wherein the second electrical contact is connected to a second electrode and shaped and positioned to support the transducer beam at a second point in opposition to said force.

2. The microphone assembly of claim 1 wherein said first electrical contact has an opening formed in one end portion thereof for receiving said transducer beam, said one end portion of said first electrical contact being rolled over to comprise a spring for applying the

force to said transducer beam when it is inserted in said opening.

3. The microphone assembly of claim 1 and further comprising a hollow, metallic housing adapted to support said flexible diaphragm at the periphery thereof, both of said electrical contacts being attached to the bottom of said housing, and said second contact being insulated from said housing.

4. The microphone assembly of claim 3 and further comprising two locating bosses formed in the bottom of said housing for indicating the correct location of said two electrical contacts and means associated with said electrical contacts for engaging said locating bosses to correctly position said contacts.

5. The microphone assembly of claim 4 and further comprising means attached to said second electrical contact for receiving a first electrical conductor and means attached to said housing for receiving a second electrical conductor.

6. The microphone assembly of claim 5 wherein said flexible diaphragm is attached to said one end of said transducer beam by means of a drive pin connected between said diaphragm and said transducer beam transverse to the surface of said diaphragm and said transducer beam.

7. The microphone assembly of claim 2 wherein said second electrical contact contains an upstanding end portion having a notch cut therein for receiving the end of said transverse beam and securing it against transverse motion.

8. The microphone assembly of claim 3 and further comprising a pair of downwardly depending edges on said second electrical contact and an insulator block adapted to fit between said downwardly depending edges to insulate said second electrical contact from said metallic housing.

9. The microphone assembly of claim 8 and further comprising two locating bosses formed in the bottom of said housing for indicating the correct location of said two electrical contacts, an opening formed in said insulator block for engaging one of said locating bosses to correctly position said second electrical connector, and an opening formed in said first electrical contact for engaging the other locating boss to correctly position said first electrical contact.

10. The microphone assembly of claim 9 and further comprising an opening formed in each of said first and second electrical contacts for receiving corresponding rivets to attach said first and second electrical contacts to the bottom of said housing.

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