United States Patent

Carlson et al.

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[54] **ACOUSTIC TRANSDUCER HAVING DIAPHRAGM PIVOTED IN ITS SURROUND**

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[21] Appl. No.: **157,023**

Related U.S. Application Data

[63] Continuation of Ser. No. 748,272, July 29, 1968, abandoned.

[52] **U.S. Cl.** .....**179/181 R,** 179/110 A, 181/32 R

[51] **Int. Cl.**.....**H04r 7/22,** H04r 17/02

[58] **Field of Search** .....179/110 A, 181 R, 114 R, 179/115 R; 181/32 R

[56] **References Cited**

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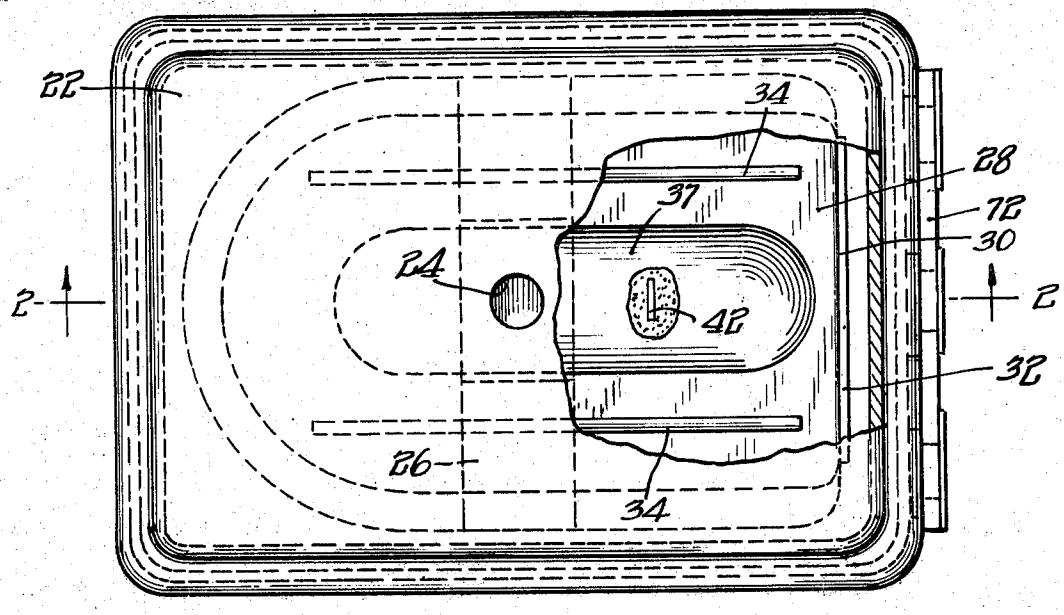
[57] **ABSTRACT**

An electronic appliance particularly adapted for converting acoustical energy to electrical energy. The appliance includes a carrier having an elongated piezoelectric element mounted in cantilever fashion on said carrier and a hinged diaphragm mounted on the carrier and connected to the piezoelectric element. The hinged portion of the diaphragm being spaced away from the fixed end of the piezoelectric element. An audio frequency amplification circuit is connected to the piezoelectric element. Components of the circuit are mounted on the carrier and selected components are encapsulated.

2 Claims, 5 Drawing Figures



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SHEET 1 OF 2

Fig. 1.

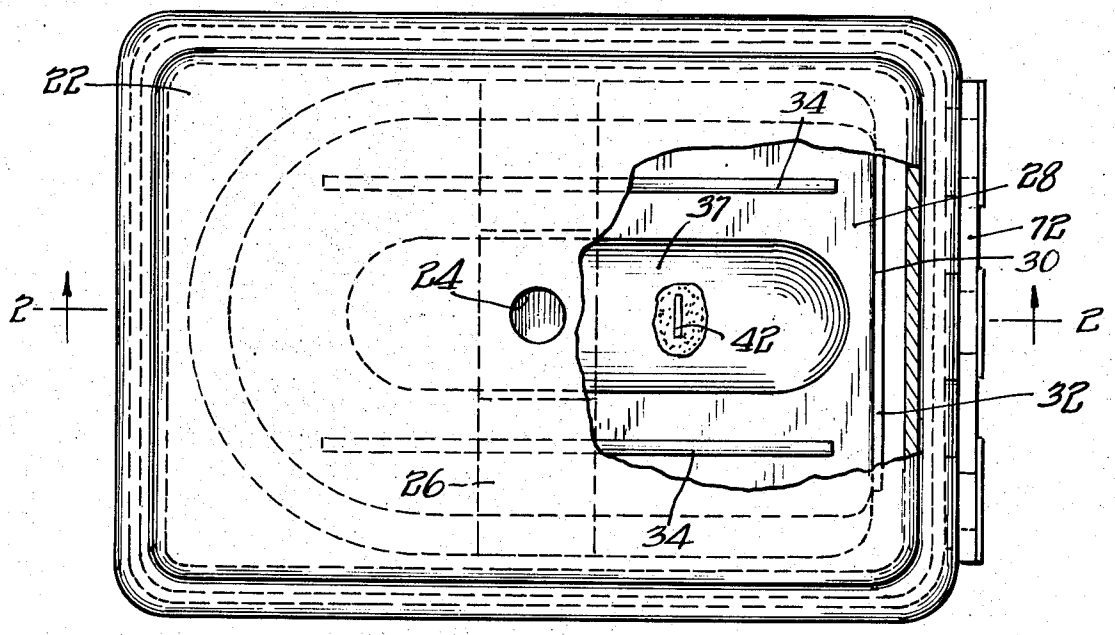
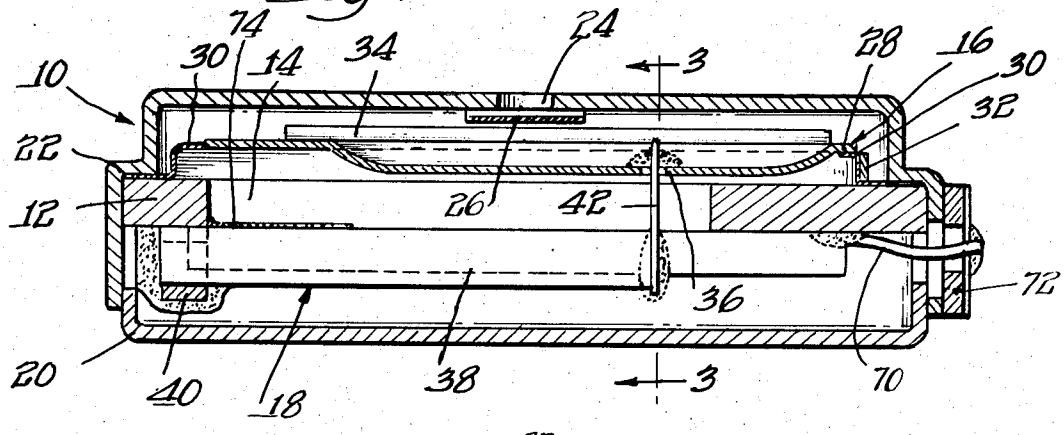


Fig. 2.



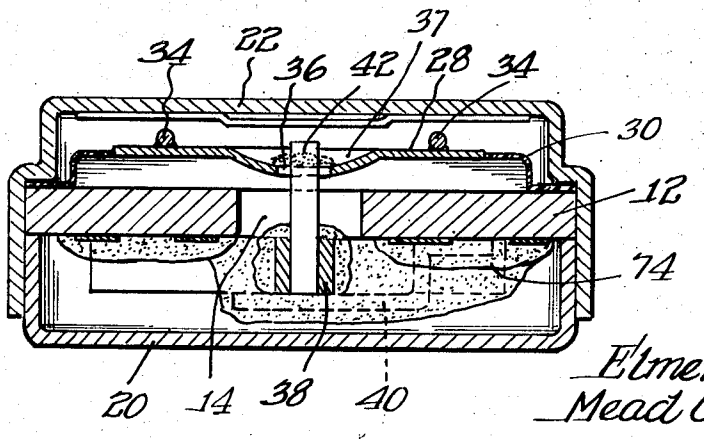


Fig. 3.

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Fig. 4.

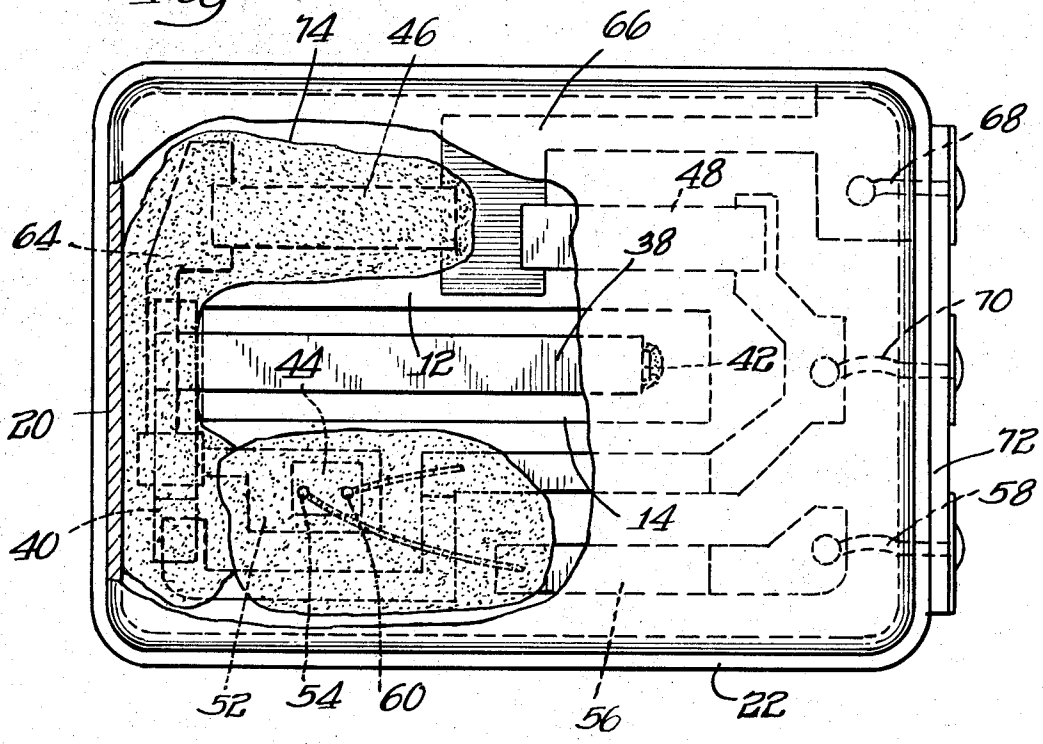
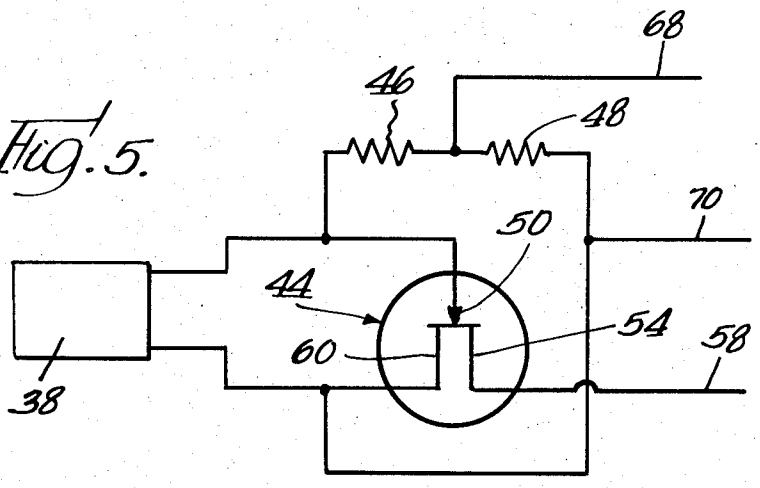


Fig. 5.



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ACOUSTIC TRANSDUCER HAVING DIAPHRAGM PIVOTED IN ITS SURROUND

This application is a continuation of application, Ser. No. 748,272, filed July 29, 1968, and now abandoned.

BACKGROUND OF THE INVENTION

Electronic appliances which convert acoustic energy to electrical energy have many and varied uses which include applications as microphones as parts of hearing aids. In order to provide the necessary cosmetic effect in hearing aids, it is particularly desirable to make the components of the hearing aid as small as possible, including the microphone and associated elements. One of the types of devices which perform the function of a microphone in a hearing aid includes the class of miniature transducers which utilize a piezoelectric element. Piezoelectric elements for transducers may take many forms. One form of piezoelectric element is supported at three points and a fourth point is connected to an acoustic device for distorting the element. Another form of piezoelectric element is one which has the element fixed at one end in a cantilever fashion and the free end is fixed to the acoustic device for distorting the piezoelectric element. The acoustic device for distorting the piezoelectric element is a diaphragm. The ordinary construction of a diaphragm is like a piston, that is, a diaphragm is either supported by a surround which provides for mechanical support for the diaphragm but allows the piston operation of the diaphragm to respond to a stimulus, or the diaphragm is a formed shape of elastic material designed to deflect at its center when a pressure differential is applied on opposite sides of its surfaces. The ordinary connection of the diaphragm to the piezoelectric element has been at the center of the diaphragm. The piezoelectric element has been conventionally located within a cavity behind the diaphragm.

In the ordinary prior art construction of a microphone for use in a hearing aid the microphone has been provided as a single unit and the remainder of the elements which constitute the audio frequency amplification circuitry have been mounted exteriorly of the microphone. In utilizing components exteriorly of the transducer element, the various parts were in many instances left open to the atmosphere so that environmental changes often had an effect on the components, thereby affecting the efficiency of the circuit. As aging of insulating of the parts progresses, there has been a change in the operation of the circuit which requires replacement or repair of the parts or a replacement of the entire hearing aid.

Furthermore, it is particularly desirable to maintain a definite mechanical relationship of certain component parts of a hearing aid so that there is a high degree of stability, thereby eliminating any change in electrostatic effect between the parts, such as capacitance which may produce unwanted signals in an audio amplification circuit.

SUMMARY OF THE INVENTION

The present invention relates to an improved electronic appliance and in particular, a miniature microphone, which microphone includes a construction which allows certain components of electrical circuitry to be mounted within a housing to achieve immunity from interference from the environment and from mechanical instability.

The present microphone construction utilizes a diaphragm which is hinged along one edge so that the diaphragm operates as a flapper diaphragm. An elongated piezoelectric element is mounted in a cantilever fashion and has its fixed end on the edge opposite to the edge at which the flapper diaphragm is hinged. The selection of the length of the piezoelectric element and the point of connection of the piezoelectric element with the diaphragm is optimized for efficient operation of the transducer.

The arrangement of the piezoelectric element beneath the diaphragm permits an apportionment of the elements of the microphone for optimum transfer of energy of the sound wave to an audio amplification circuit. The diaphragm, which has a contained volume of air on one side thereof, operates as a bellows on the air in the chamber and compression or rarification of this air operates as a spring upon the diaphragm. The elongated piezoelectric element also has a resilience which also operates as a spring and optimum balance of the spring of the diaphragm and the piezoelectric element is achieved. It is, therefore, a principal object of the instant invention to provide an improved miniature microphone which effects optimum transfer of energy from the diaphragm to the piezoelectric element.

In order to provide a conservation of space of a hearing aid, the present electronic appliance includes a plurality of electronic components mounted within a transducer housing and interconnected by printed circuitry. It is another object of this invention to provide an electronic appliance in which the space within a transducer housing is utilized for elements of electronic circuitry used in connection with the piezoelectric element to provide an amplification of the electric signal generated within the piezoelectric element.

It is a still further object of the present invention to provide an improved construction for an electronic appliance wherein selected electronic components are protected from mechanical damage, and critical components are encapsulated in a material to protect the critical components from environmental changes and to retard the loss of insulation qualities due to aging.

It is another object of the herein-disclosed invention to provide an improved electronic appliance wherein a transducer and associated circuitry may be conveniently mounted and then easily positioned in a housing.

It is still another object of this invention to enclose the most sensitive portions of an audio amplification circuit entirely within an electrostatic shield to prevent the introduction of noise into the amplification circuit by electric fields.

It is still a further object of the instant invention to encapsulate sensitive elements of an audio amplification circuit to hold the elements rigid relative to each other and to other parts of the electronic appliance to prevent the introduction of noise into the amplification system as a result of vibration of components, which noise would be created by electrostatic induction.

It is a further object of this invention to provide an improved electronic appliance wherein a portion of an audio amplification circuit is mounted immediately adjacent to a piezoelectric element in order to amplify a signal from the element without appreciable impression of noise onto the signal prior to amplification.

Other objects and uses of the present invention will become readily apparent to those skilled in the art upon a perusal of the following specification in light of the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a plan view of an electronic appliance embodying the herein-disclosed invention with a portion of a cover broken away in order to show the construction of a diaphragm;

FIG. 2 is a cross-sectional side-elevational view taken on Line 2—2 of FIG. 1 showing the interior construction of the electronic appliance shown in FIG. 1;

FIG. 3 is a cross-sectional end-elevational view taken on Line 3—3 of FIG. 2 showing the interior construction of the electronic appliance of FIG. 1;

FIG. 4 is a bottom view of the electronic appliance shown in FIG. 2, but with the bottom shown partially broken away in order to show the interior construction; and

FIG. 5 is a schematic of a circuit diagram of the electronic circuitry for the electronic appliance shown in FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings and especially to FIG. 2, an electronic appliance embodying the hereindisclosed invention is generally indicated by numeral **10**. The electronic appliance **10** generally consists of two parts; namely, a transducer, which in this instance is a microphone, and a portion of an audio amplification circuit, which are electronic circuit elements and are connected as shown in FIG. 5.

Referring first to FIG. 2 which shows portions of the microphone, it may be seen that the microphone includes a carrier **12** which is generally plate-like, and has an aperture **14** contained therein. Mounted on one side of carrier **12** is a diaphragm assembly **16** and a converter assembly **18** is mounted on the other side of the carrier. The carrier is mounted in a housing **20** which has a cover **22** in engagement therewith, and the cover also encloses the diaphragm assembly. The cover **22** includes an aperture **24** which has a baffle plate **26** mounted interiorly of the cover adjacent to the aperture.

The diaphragm assembly includes a substantially rigid diaphragm piston **28** which is supported by a flexible surround **30**. Adhesively fixed to one side of surround **30** is a rigid metal strip **32**, which strip prevents the surround from deflecting at the region to which the strip is connected. The remainder of the surround is flexible so that the diaphragm piston **28** when displaced at an appropriate force pivots about the strip so that a portion of the surround, between the strip and the edge of the piston, acts as a hinge and the diaphragm operates as a flapper diaphragm. It should be noted that any convenient means for making the portion of the surround rigid may be used. It has been found that even a large mass of adhesive may be applied to the portion of the surround to reduce its flexibility and thereby produce a hinge effect. The diaphragm assembly includes re-enforcing rods **34** fixed to the piston and a welt **35** in piston **28** which cooperate to reduce the deflection of the diaphragm piston during normal operation of the piston. The diaphragm piston has a drive element aperture **36** positioned closer to its hinged edge than to its free edge.

The converter assembly **18** includes an elongated piezoelectric element **38** which has one end fixed to the carrier **12** by means of electrically conductive clip **40**, which has one end in contact with the piezoelectric element and the other end is fixed to the carrier. The moving end of the piezoelectric element has a drive element **42** secured thereon, and the drive element extends through the aperture **36** and is secured to the diaphragm piston.

It is important to note that the overall height of the electronic appliance is determined by the thickness of the housing and cover and the space required by the diaphragm, the carrier, and the piezoelectric element. The free length of piezoelectric element **38** is entirely under the diaphragm assembly.

In order to have an optimum transfer of energy from the diaphragm to the piezoelectric element, the distance from the hinged edge of the diaphragm piston to the drive element is less than the distance from the free end of the diaphragm to the drive element and is also less than the free length of the piezoelectric element. It may be appreciated that if the piezoelectric element were lengthened so that the drive element were connected to the diaphragm piston adjacent to the hinged edge, a high force would be transmitted; however, the deflection would be quite small so there would be very little effect upon piezoelectric element **38**. On the other hand, if the piezoelectric element were quite short so that the drive element **42** were connected adjacent to the free end of the diaphragm piston, there would be a relatively small force available. However, a large deflection would be available, thereby requiring the short piezoelectric element to deflect a substantial amount. The optimum operation is determined by the optimum transfer of energy from the diaphragm to the piezoelectric element and must be determined individually for each specific piezoelectric element and diaphragm assembly. In the present preferred embodiment, optimum transfer of energy is achieved when the distance from the hinge connection between the diaphragm and the carrier and the connection between the drive element and the diaphragm is less than the distance from the fixed end of the piezoelectric element to the connection of the piezoelectric element to the drive element.

In order to utilize the space available in the present electronic appliance, certain electronic components which are used in the circuitry for amplification of a signal from the piezoelectric element are included within the housing. The proximity of the elements to the piezoelectric element allows the weak signal from the piezoelectric element to be protected by encapsulation until it is amplified by appropriate component parts so that no appreciable noise or other distortion is added to the signal prior to amplification. Furthermore, any relative motion between circuit components is prevented so that the likelihood of induction of spurious signals due to the incidental mechanical vibrations and unwanted electrostatic fields in certain electronic components of the amplification circuit is eliminated.

Looking now to FIG. 4, the mechanical connection of various circuit components is shown therein. A field-

effect transistor **44** is mounted on one side of the carrier proximate the fixed end of the piezoelectric element. A bias impedance element **46** is mounted on the same side of the carrier with a load impedance element **48**. The field-effect transistor includes a gate electrode **50** which is connected to a printed circuit pad **52** on the carrier. The field-effect transistor has a drain electrode **54** which is connected to a printed circuit pad **56** on the carrier which is, in turn, connected to a lead **58**. A third electrode **60** of the field-effect transistor is a source electrode and is connected to a pad **62**. The bias impedance element **46** has one side connected to a printed circuit pad **64** which is connected to the gate electrode and to one side of the piezoelectric element **38**. The other side of the bias impedance element **46** is connected to a printed circuit pad **66**, which is connected to a lead **68**. One side of the load impedance element **48** is connected to the pad **66** and the other side is connected to pad **62**, which pad is connected to a lead **70**. The pad **62** extends to a connection with the clip **40** contacting one side of the piezoelectric element **38**. The leads **58**, **68**, and **70** are connected to a terminal **72** mounted exteriorly of the housing.

FIG. **5** shows the electrical interconnection of the various parts. It may be appreciated that a battery may be connected across leads **58** and **68** and a further amplification stage or receiver may be connected across leads **68** or **58** and **70**. For a full description of the operation of the circuit, reference is hereby made to Patent application entitled "Audio Frequency Amplification Circuit," Ser. No. 742,239, having a filing date of July 3, 1968.

The components, such as a field-effect transistor **44** and the bias impedance element **46** and an electrode of the piezoelectric element, are encapsulated in a suitable plastic material so that there is no surface leakage between these elements. The clip and the connection of the piezoelectric element with the other electronic elements is also encapsulated in plastic material **74** so that there is no opportunity for leakage across a surface from the bias impedance element or the field-effect transistor. Also, there is no opportunity for environmental change to have an effect on the operation of the bias impedance element or the field-effect transistor. It may be readily appreciated since all of these elements are encapsulated and are positioned adjacent to the piezoelectric element, there is little or negligible vibratory effect on these elements. Furthermore, there is little or no electrostatic effect on the relatively weak signal from the piezoelectric element before the signal is amplified in the audio amplification circuit.

From the foregoing description, it is evident that the present device may be easily and economically assembled. Substantially all of the parts may be mounted on the carrier and tested. The carrier with the parts mounted thereon is positioned in the housing and the cover is added to complete the assembly.

It may be readily appreciated that the instant microphone operates in the following manner; that is, a sound wave enters aperture **24** and impinges upon the diaphragm piston **28**. The vibrations are transmitted to piezoelectric element **38** through drive element **42**, and the piezoelectric element then converts the vibration to a signal which is amplified by the amplification circuit.

It may be seen that the above described electronic appliance is of a minimum size and the space within the housing is utilized by a portion of the electronic components which are utilized to amplify the signal generated by the piezoelectric element. The weak signal from the piezoelectric element is protected and amplified so that extraneous or spurious electrostatic fields are not impressed upon the signal prior to amplification.

Although a specific embodiment of the herein-disclosed invention has been shown and described in detail, it is readily apparent that those skilled in the art may make various modifications and changes in the subject construction without departing from the spirit and scope of the present invention. It is to be expressly understood that the instant invention is limited only by the appended claims.

We claim:

1. An acoustical transducer comprising, in combination, a housing, a carrier, an elongated rigid strip affixed along its length to said carrier, a flexible surround, a diaphragm piston mounted on the surround, said piston having an edge complementary to the rigid strip and adjacent thereto but spaced from the rigid strip by the surround, a portion of said surround being fastened to the elongated, rigid strip, a converter assembly positioned in the housing, and a drive pin connecting said assembly to the piston portion of the diaphragm.

2. An acoustical transducer comprising, in combination, a housing, an elongated rigid strip in the housing, a flexible surround, a diaphragm piston mounted on the surround, said piston having an edge adjacent to said rigid strip but spaced from said rigid strip, a portion of said surround being affixed to said strip, a converter assembly positioned in the housing and a drive pin connecting said assembly to the piston portion of the diaphragm, whereby said strip defines a linear hinge about which said diaphragm pivots.

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