

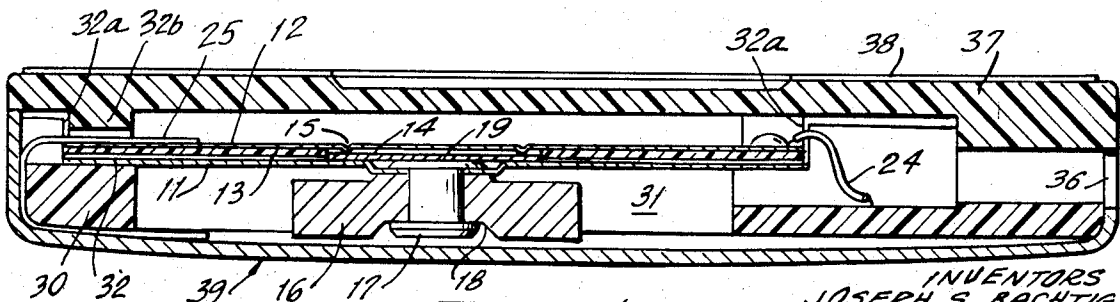
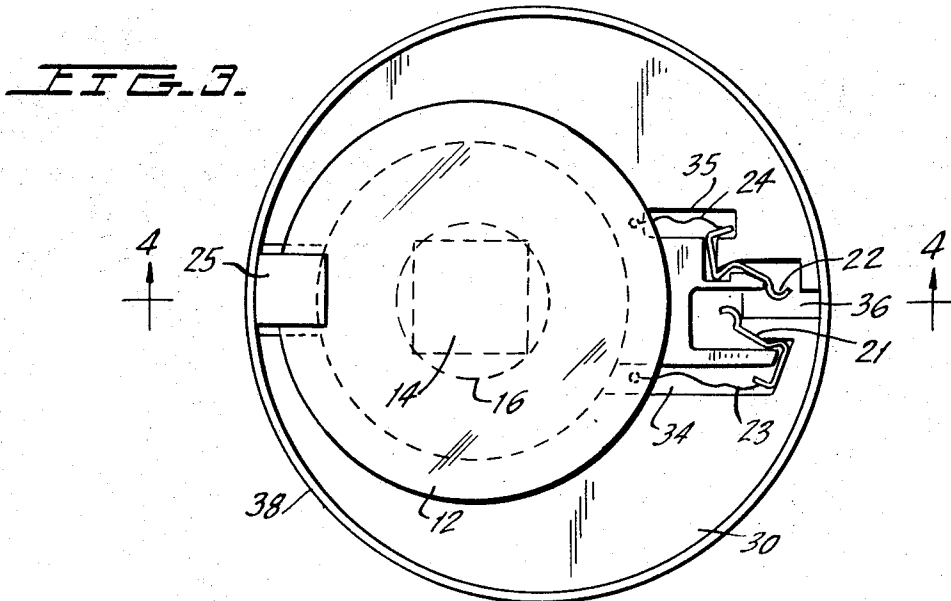
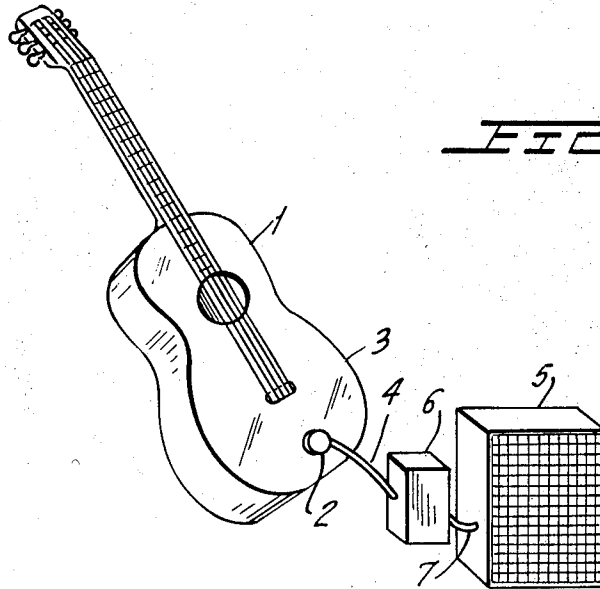
Nov. 3, 1970

J. S. BACHTIG ET AL
MUSICAL INSTRUMENT AND PIEZOELECTRIC PICKUP WITH
DIAPHRAGMS AND INERTIAL MASS

3,538,232

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3 Sheets-Sheet 1



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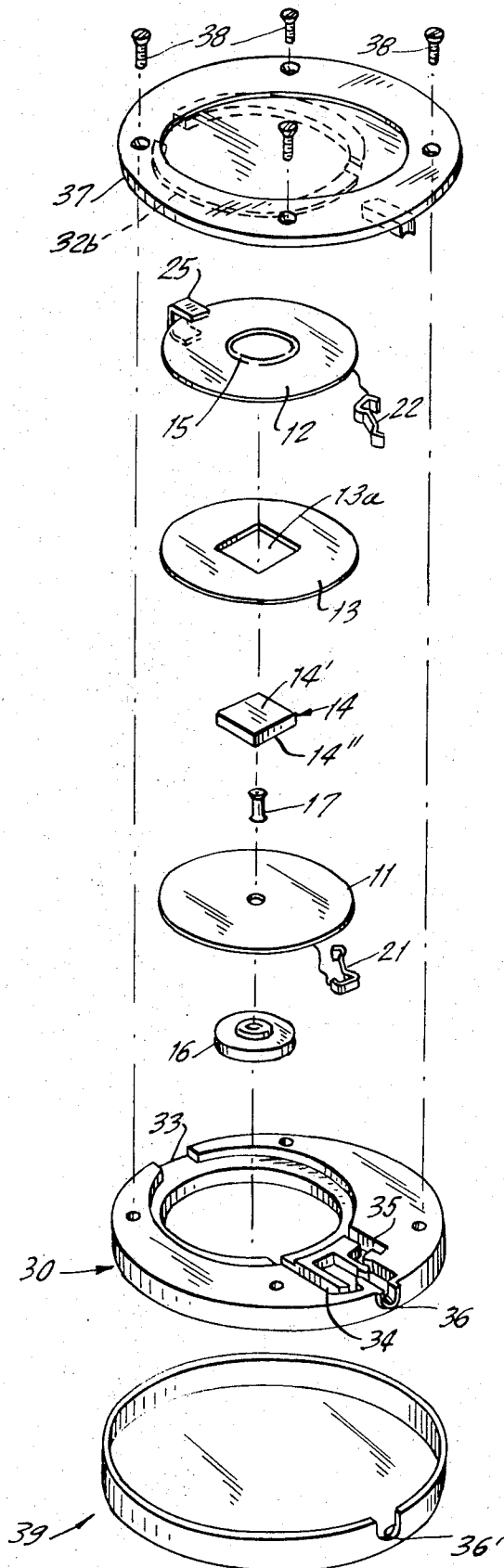


FIG. 2.

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FIG. 6.

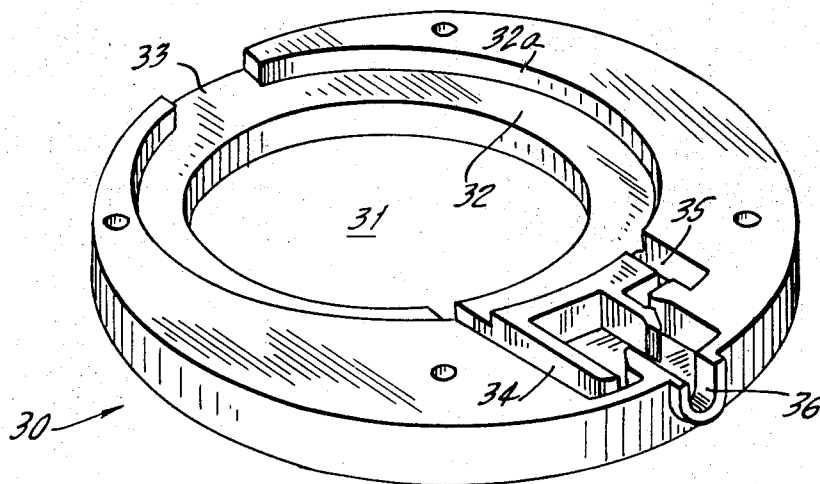


FIG. 5.

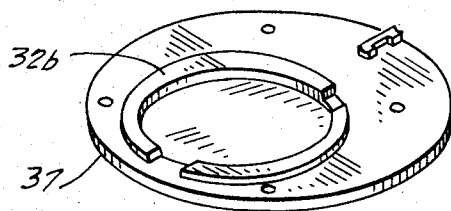
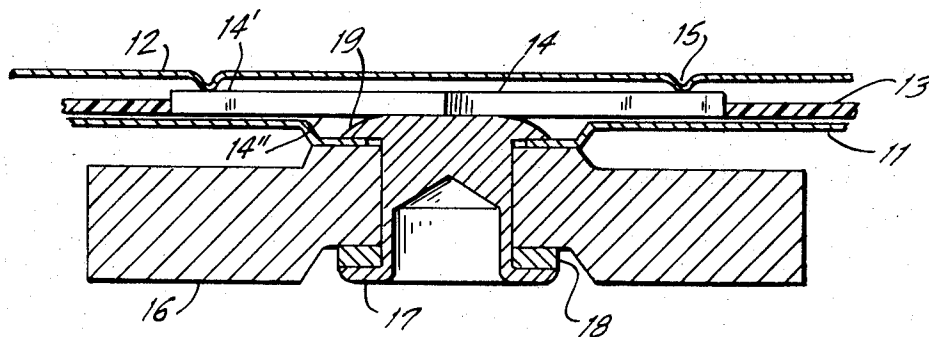


FIG. 7.

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MUSICAL INSTRUMENT AND PIEZOELECTRIC PICKUP WITH DIAPHRAGMS AND INERTIAL MASS

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10 Claims

ABSTRACT OF THE DISCLOSURE

An inertia type pickup device for utilization in conjunction with a musical instrument, such as a guitar. The pickup device is of the piezoelectric type and includes a piezoelectric element centrally retained between a pair of diaphragms. The diaphragms have their peripheries supported by the rigid housing of the device. A weight is attached to the center of one of the diaphragms to increase the mass inertia of the transducer system. When subjected to a vibration input the peripheries of the diaphragms move relative to their centers, causing flexure of the piezoelectric element and production of electrical signals corresponding to the mechanical vibrations. The device may be simply attached to the musical instrument by a double-faced adhesive member.

BACKGROUND OF THE INVENTION

This invention relates to transducers and more particularly relates to transducers for use with musical instruments to provide electrical amplification of the vibration accompanying the sound produced by these instruments.

Typical electrical amplification systems for use with musical instruments such as guitars, violins, pianos, etc., include the instrument, a pickup device for converting the mechanical vibrations from the instrument, an electrical signal, an electrical amplifier for amplifying the electrical signals and a loud speaker for converting the amplified electrical signal to acoustic energy. It is noted that while the instant invention will be described with reference to a guitar system, this invention may be used with numerous other musical instruments having suitable vibratile members as will be apparent to those of ordinary skill in the art.

In musical systems of the above type and especially where the musical instrument is a guitar or violin, it is of great advantage to provide versatility of the instrument so that it may be used both with and without electrical amplification. It is also of advantage to be able to vary the location on an instrument of a transducer, when the instrument is used with an electrical amplifier, so that it may be positioned as best suits the individual. These qualities have not been attainable by the prior art without great sacrifice in the fidelity of electrical amplification.

Previous types of pickup devices for providing electrical amplification of the sound of a musical instrument have included such devices as microphones, magnetic type pickups, piezoelectric devices and capacitance type devices. Each of the above pickups has suffered drawbacks of one kind or another.

The use of microphones for electrically amplifying the sound of a musical instrument has proved undesirable in many situations. Microphones have a great susceptibility to pickup extraneous sounds and echoes and amplify them with the music to be amplified. As a result the quality of the sound is often poor. In addition, there is a tendency for the amplified music to be fed back through the microphones producing oscillations (squeal).

The magnetic type devices usually consist of a magnetic coil which picks up the vibrations of the steel strings of a guitar. Such pickups, however, are unsuitable where the strings are other than steel. In addition, these pickups are also very susceptible to extraneous interference from stray electromagnetic fields.

Previous piezoelectric and capacitance type transducers have also had their drawbacks. In particular, the mechanical characteristics of the previous transducers of these types are such that they required secure and permanent affixing to a vibratile member of the musical instrument in order to produce electrical oscillations precisely corresponding to the mechanical vibrations. These transducers were usually secured to a musical instrument such as the guitar at the bridge of the instrument, for direct actuation by the strings of the instrument. In addition, in order to obtain the greatest fidelity, it was necessary to eliminate the sound box of the instrument to prevent the vibrations of the sound box from affecting the piezoelectric or capacitance transducers. As a result of the characteristics of the previous transducers of these types, the versatility of the instruments on which they were used was limited since an instrument without a sound box could only be used in combination with an electrical amplifier. In addition, the location of the transducers at the bridge of the instrument limited access to these transducers for maintenance purposes. The fixed location of the transducers also made it impossible for the individual to adjust the location upon the instrument of the connection cable from the electrical amplifier according to his personal desires and comfort, or for best musical effect.

One method of apparently eliminating some of the disadvantages of the previous transducers mentioned above would be to provide the transducers with suitable securing means such as adhesive backing whereby the transducer could be placed at any position on the instrument without permanent fastening and damaging of the instrument. Thereby, the transducer may be moved to any desired position comfortable and/or pleasing to the individual user of the instrument. This method has not been successfully employed with prior transducers because of the failure of such securing means to provide suitable mechanical coupling between the vibratile member of the instrument and the vibration responsive elements of the transducer. In particular, the adhesive backing acts as a damper and is not capable of providing the rigid mechanical coupling necessary to cause the vibration of conventional transducer elements so as to produce electrical oscillations in correspondence to the mechanical vibrations of the musical instrument. As a result, use of such adhesive backing with the previously existing transducer produces a very poor quality music amplification.

The instant invention overcomes the above problems existing in the field of electrical amplification for musical instruments. In the illustrated preferred embodiment of the invention, a novel reaction-type piezoelectric transducer is provided with inertial reaction means enabling the securement of the transducer to a musical instrument by means of an adhesive backing on the transducer while insuring high fidelity electrical amplification of the music. The transducer device consists generally of a piezoelectric element or transducer member carried along a vibratory portion of a diaphragm plate and having a weight of substantial inertia attached thereto. The weight operates as an inertia-reaction body resisting mechanical vibrations relative to the remoter portions of its supporting plate which are affixed to the housing. The housing also carries a biasing structure, for instance, a further vibratory plate, which has biasing elements such as a ridge or several protrusions, which engage portions of the piezoelectric

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transducer with a stressing force and subjects it to strains corresponding to the housing vibrations thereby causing it to deliver a corresponding electric signal output, as is known to the art. Both vibratory plates are electrically conductive and provide electrical contacts to the opposite sides of the piezoelectric element. An exterior surface of the transducer device may include an adhesive surface for affixing the transducer to a vibratory wall surface of a musical instrument.

It is, therefore, one object of the instant invention to provide a transducer which may be readily secured to a musical instrument, such as a guitar.

Another object of the instant invention is to provide a transducer which may be attached to a musical instrument without damaging the musical instrument and without leaving any permanent holes or attachments to the musical instrument.

A further object of the instant invention is to provide an improved transducer device of the piezoelectric type which operates on the inertial reaction principle.

An additional object of the instant invention is to provide such a piezoelectric transducer device which may be easily secured to a musical instrument as by an adhesive backed member or clamp.

Still another object of the invention is to provide a piezoelectric transducer device having a piezoelectric element retained between a pair of vibratory plates, which are responsive to mechanical vibrations to flex the piezoelectric element thereby causing the production of electrical signals corresponding in amplitude and frequency to the mechanical vibrations.

The aforementioned objects and features, along with additional objects and features of the instant invention will become apparent from a reading of the description of the invention in conjunction with the drawings, as follows:

FIG. 1 is a perspective view of an electric guitar system with the instant invention incorporated therein;

FIG. 2 is an exploded perspective view of the pickup device of the instant invention;

FIG. 3 is a plan view of the pickup device of the instant invention with its housing cover removed;

FIG. 4 is a cross-sectional view of the pickup device of the instant invention taken along line 3—3 of FIG. 2, and including the housing cover;

FIG. 5 is an enlarged partial view of the diaphragm and transducer assembly of the pickup device of the instant invention in the vicinity of the piezoelectric armature and weight;

FIG. 6 is a perspective view of the housing removed from its metal shell;

FIG. 7 is a perspective view of the housing cover showing the underside which mates with the housing when the cover is secured to the housing.

Referring first to FIG. 1, there is shown a musical system including a guitar 1, amplifier 6 and a loudspeaker 5. The system further includes the transducer device 2 of the instant invention on the vibratory sounding board 3 of the guitar 1. The transducer device 2 converts the vibratory motion of the guitar to an electrical signal for presentment to amplifier 6. The transducer device 2 is therefore connected by an electric cable 4 to a suitable audio amplifier 6 generally shown. The output of amplifier 6 is in turn, connected to the loudspeaker 5 by means of electric cable 7. The electrical circuitry of the amplifier and loud speaker circuit are not shown in detail since they form no part of the instant invention and may consist of typical circuitry well known in the art for use with piezoelectric transducers. It is to be understood that while the instrument shown in FIG. 1 is a guitar, and while the transducer device is located on the sounding board of the guitar, the transducer device of the instant invention may be used on a variety of musical instruments and it may be located at any one of a number of suitable locations on the instruments, as will be apparent to those skilled in the art.

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Referring now to FIGS. 2 through 7, transducer 2 includes external casing members 30 and 37 held together by screw means 38 or other appropriate securement means. The internal region of main housing section 30 includes a cylindrical cavity opening 31 bounded by ridge 33. Cavity 31 includes a diaphragm assembly of thin conductive plates 11, 12, sandwiching between them a thin square shaped piezoelectric element or transducer member 14. The transducer 14 which generates a voltage output corresponding to the imposed mechanical strain may be any type of known piezoelectric or piezoresistive material. It is shown as a thin piezoelectric planar member having a square shape. However, other configurations may be utilized (e.g. circular or rectangular). Transducer 14 may typically be a bilaminate and has two outer exterior metallic electrode surfaces for electrical connection to the external circuits. These opposed electrode surfaces are in good electrical engagement with the metallic diaphragm for providing the external circuit connection (via 21, 22).

The piezoelectric transducer 14 is seated within the square cutout section 13A of the lesser thickness insulating spacer 13. The insulator sheet 13 is coextensive with the two diaphragm plates 11, 12 and may be of polyethylene or other suitable plastic sheet material. The plates 11 and 12 and the insulator 13 are concentric with the piezoelectric transducer 14. As can be seen clearly in FIG. 5, the diaphragm plate 12 has protruding straining means shown, for example, as an annular depression 15 which engages the corner portions along the upper surface 14' of the square piezoelectric transducer disc 14 for imparting thereto strains corresponding to the vibrations imparted to the main casing member 37. Alternatively, annular protrusion 15 may be replaced with a plurality of appropriately positioned dimples. This straining means prestresses the diaphragm plates 11 and 12 and the piezoelectric transducer member 14 to assure that the piezoelectric transducer member 14 is forced to remain in substantial contact with nearby portions of vibratory plates 11 and 12 while the peripheral portions of the plates 11 and 12 move relative to its central portion in response to imparted mechanical vibrations.

A member or weight 16, having substantial mass or inertia is connected to the intermediate vibratory mass of the diaphragm assembly. The weight 16 is shown connected by a rivet 17, including an upturned region 19 in contact engagement with the central region of the lower transducer surface 14''.

The plates 11 and 12 are connected to a pair of contact springs 21 and 22, via fine conductor wires 23, 24, respectively. The two contact springs 21 and 22 have exposed terminal sections for connection to cable 4 leading to the amplifier 6. The contact spring 22 may be connected to the ground of the amplifier circuit. Hence, a grounding strap 25 is also shown connected to diaphragm plate 12.

The diaphragm assembly above described is mounted in the interior cavity 31 of the plastic or epoxy main housing body 30. The cavity 31 has a smaller diameter than the plates 11, 12, so that the peripheries of plates 11, 12 and 13 rest upon underlying circular housing shoulder 32. The shoulder 32 is surrounded by an upstanding wall 32a of the housing 30, having a diameter substantially corresponding to the diameter of the plates 11 and 12. The housing member 30 has a passage 33 through which the grounding strap 25 passes and further includes housing passages 34 and 35 in which the terminal spring contacts 21 and 22 are located. These housing passages 34, 35, lead to a common recess 36 for permitting the insertion of a two-conductor plug (not shown) to make contact with the spring contacts 21 and 22, respectively.

As seen in FIGS. 4 and 7, the housing has a complementary cover member, preferably constructed of the same material as housing member 30. The cover 37 has a circular shoulder 32b which will closely confront hous-

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ing cavity walls 32 and 32a to securably locate the diaphragm and transducer assembly (11, 12, 13, 14) in operative position, and prevent relative movement between the peripheries of the plates 11 and 12 and the housing sections 30, 37.

The bottom side of housing member 30 is surrounded by a metal shell 39. This shell includes an opening 36' in registry with 36 for permitting the entrance of a plug for contact with the contact springs 21 and 22. The housing 30 is secured within the metal shell 39 so as to provide grounded contact between the metal shell and the grounding strap 25 on plate 12. The grounding of the metal shell 39 and the plate 12 form a complete electrical shield against extraneous electrical interference since the shell 39 and plate 12 completely surround the piezoelectric transducer member 14 and the ungrounded plate 11.

In operation, the transducer device of the instant invention is placed upon a vibratory wall of the musical instrument by a double faced adhesive member 38 (FIG. 4) of appropriate clamp. When the instrument is played, the housing 30 and its cover 37 vibrate with the musical instrument at substantially the same amplitude as the portion of the instrument upon which the transducer device is secured. Since the peripheries of plates 11 and 12 are rigidly mounted on the housing ridge 32, these peripheries also move as a result of the mechanical vibrations. However, the relatively large mass provides by weight 16 at the center of the vibrating plate 11 resists displacement because of its inertial reaction to such movement. Since the piezoelectric transducer member 14 is biased against the plate 11 by the annular ridge 15, the piezoelectric transducer member is flexed by the relative motion between the central regions of plates 11 and 12. The periphery of plate 11 moves relative to its center, thereby causing stresses and strains on the piezoelectric transducer member 14 and these stresses and strains are transduced to proportional voltages corresponding to the mechanical vibrations. These voltages are then transmitted to the amplifier 6 through plates 11 and 12 and contacts 21 and 22. The amplified signal is reconverted to acoustic energy by loudspeaker 5.

As can be seen from the above description of the instant invention, a small compact inexpensive transducer is provided having the features of being durable, rugged, and versatile, and at the same time providing high quality amplification for a musical instrument.

While the instant invention has been described with respect to one preferred embodiment thereof, many modifications and variations will now become apparent to those skilled in the art. It is, therefore, preferred that the scope of this invention not be limited by the specific disclosure herein, but only by the appended claims.

The embodiments of the invention in which an exclusive privilege or property is claimed are defined as follows:

1. In an acoustic transducer device for electrically reproducing the acoustic output of a musical instrument having a vibratory instrument wall,
 - a enclosure housing including a mounting portion for attachment to and vibration with the vibratory instrument wall;
 - said enclosure housing having an internal cavity containing two opposite vibratory diaphragms, both having their peripheral rims held by a nearby rigid region of the housing, and
 - a mechanoelectric transducer plate for supplying an electrical signal output corresponding to motion strains imparted to said transducer plate,
 - said transducer plate held with its opposite extended planar surfaces sandwiched between intermediate regions of said diaphragms, and radially spaced from said peripheral rims,
 - said transducer plate supported on the intermediate

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region of one of said diaphragms, said one diaphragm having a predeterminedly selected motion-resisting mass inertia for causing the central regions of diaphragms to undergo relative flexure when subjected to vibrations imparted to said housing mounting portion, imparting strains to said transducer plate and thereby supplying transducer signals corresponding to said imparted vibrations.

2. In an acoustic transducer as claimed in claim 1, including additional mass means operatively connected to the intermediate position of said one diaphragm for correspondingly increasing said mass inertia and the signal output of said transducer plate.
3. In an acoustic transducer as claimed in claim 1, said transducer plate having first and second opposite metallic surface electrodes along its exposed opposite surfaces,
 - said two diaphragms having metallic contact surfaces engaging under pressure said first and second surface electrodes and providing first and second external signal output connections from said transducer plate.
4. In an acoustic transducer as claimed in claim 1, an insulating layer disposed between said two diaphragms and holding said transducer plate between said opposite intermediate diaphragm regions.
5. In an acoustic transducer as claimed in claim 1, the other of said diaphragms having at least one protrusion engaging under predetermined pressure a certain region of said transducer plate and thereby causing such transducer plate to undergo strains corresponding to flexure of said one diaphragm.
6. In an acoustic transducer as claimed in claim 5, said transducer plate having a square shape, said protrusion of the other diaphragm being an annular depression engaging the far corner regions of said square shaped transducer plate.
7. In an acoustic transducer as claimed in claim 1, said one diaphragm engaging the central region of a first surface of said transducer plate and the other of said diaphragm having at least one protrusion engaging the peripheral portion of the opposed second surface of said transducer plate and thereby causing said transducer plate to undergo strains corresponding to flexure of said one diaphragm.
8. In an acoustic transducer as claimed in claim 7, said other diaphragm having an annular protrusion engaging symmetrically said peripheral portion of said transducer plate second surface.
9. In an acoustic transducer as claimed in claim 3, further including,
 - an insulating member disposed between said two diaphragms and including a central opening for snugly receiving said transducer plate and positioning said transducer plate between said opposite intermediate diaphragm regions.
10. In an acoustic transducer as claimed in claim 7, said transducer plate having first and second opposite metallic surface electrodes along its exposed opposite surfaces,
 - said two diaphragms having metallic contact surfaces engaging under pressure said first and second surface electrodes and providing first and second external signal output connections from said transducer plate,
 - including additional mass means operatively connected to the intermediate position of said one diaphragm for correspondingly increasing said mass inertia and the signal output of said transducer plate,
 - said additional mass means being a weight suspended from the surface of said one diaphragm opposite said contact surface,
 - securing means for attaching said weight to the intermediate region of said one diaphragm,
 - said securing means including a portion extending be-

yond said contact surface and providing said central engagement with the transducer plate first surface.

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