Jan. 15, 1963 C. R. EVANS 3,073,203

CONVERSION OF MECHANICAL VIBRATIONS INTO ELECTRICAL OSCILLATIONS

Filed May 12, 1960 2 Sheets-Sheet 1

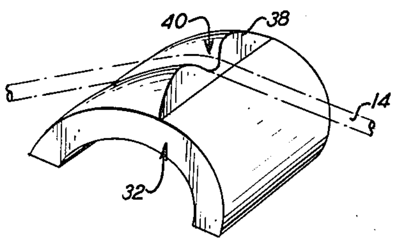

Fig. 7

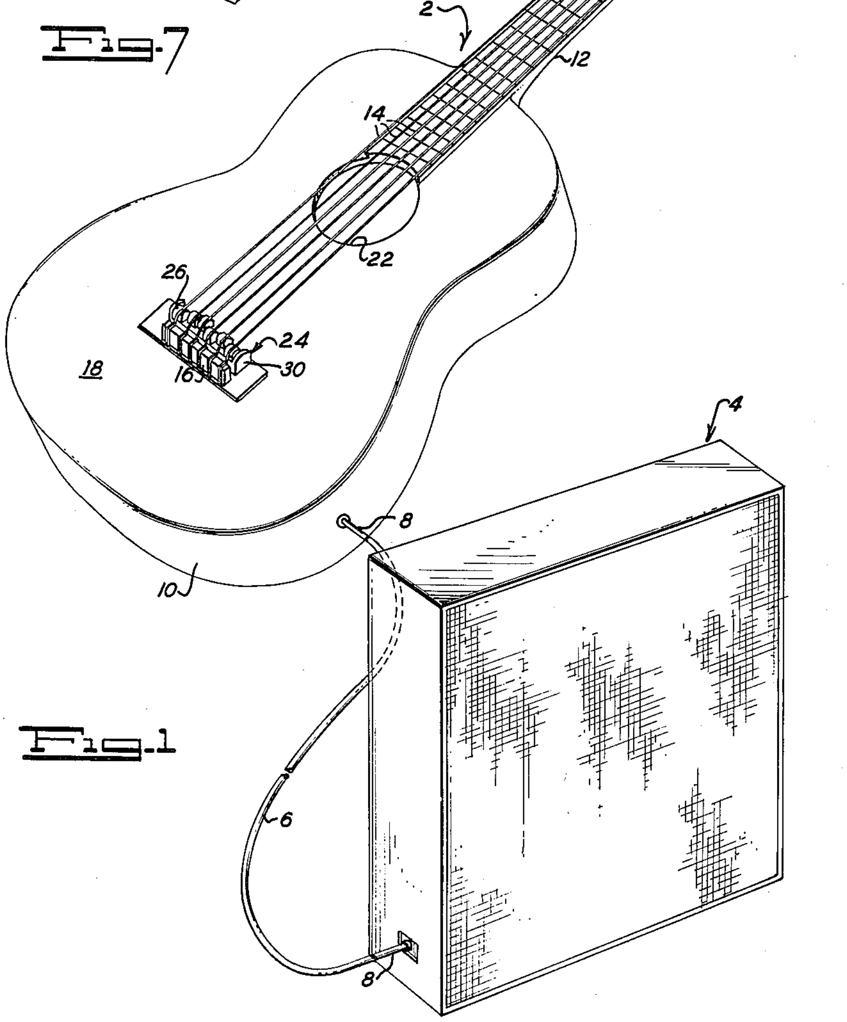

Fig. 1

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2 Sheets-Sheet 2

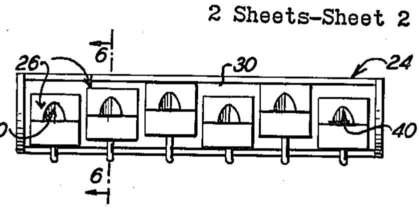

Fig. 5

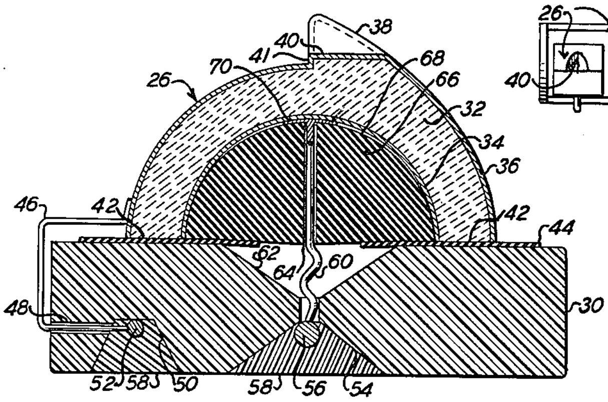

Fig. 6

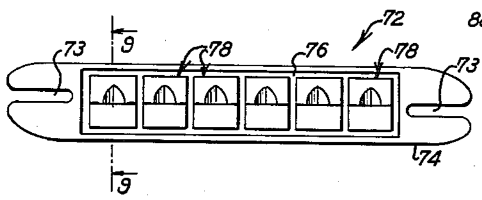

Fig. 8

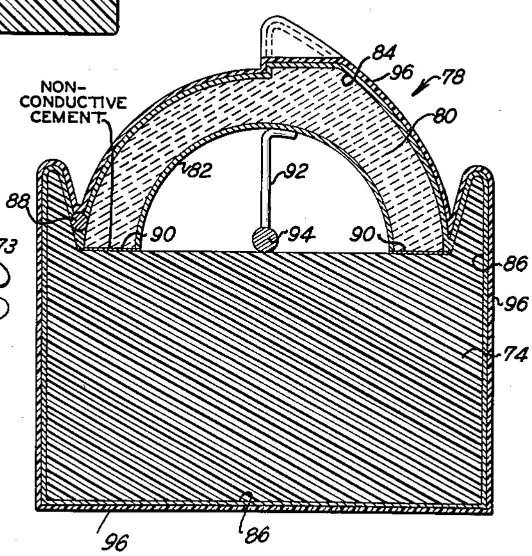

Fig. 9

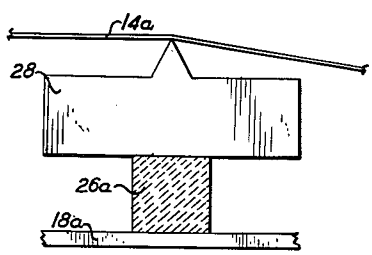

Fig. 2

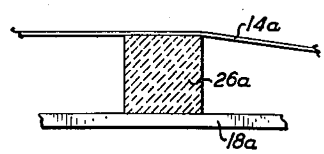

Fig. 3

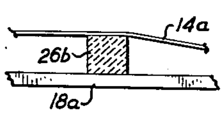

Fig. 4

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CONVERSION OF MECHANICAL VIBRATIONS INTO ELECTRICAL OSCILLATIONS

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Filed May 12, 1960, Ser. No. 28,567
12 Claims. (Cl. 84—1.16)

This invention relates to the conversion of mechanical vibrations into electrical oscillations, and more particularly, to piezoelectric apparatus for converting mechanical vibrations generated in musical instruments into electrical signals that may be supplied to loudspeakers. Although certain features of the invention have applicability to various musical instruments, it will be convenient to describe the invention in connection with electric guitar apparatus. Having gained an understanding of this form of the invention, persons skilled in the art will appreciate the manner in which the invention may be applied in other instruments.

A typical electric guitar system includes a guitar instrument, a pickup for converting mechanical vibrations from the guitar into electrical oscillations, means for amplifying the electrical oscillations, and loudspeaker apparatus for converting the amplified electrical signals into acoustic energy. These systems have wide utility, and they have been used extensively heretofore.

It will be apparent that the quality of the music produced by such systems is determined in large part by the nature of the electrical oscillations delivered by the pickup means. Unless the pickup can convert the vibrations of the strings into electrical oscillations without losing important components and without introducing objectionable extraneous signals, the quality of the music will suffer.

Many different types and designs of pickups have been proposed heretofore. Piezoelectric and capacitance type pickups were suggested at one time, but these did not come into extensive use. Some artists prefer an acoustic coupling, and they achieve this by placing a microphone close to an acoustic guitar. Finally, there is the magnetic type of pickup that has been adopted and used on a wide scale.

The magnetic type of pickup includes an electric coil that sets up a magnetic field in the vicinity of a steel string on the guitar. When the string vibrates, the field is disturbed or altered in such a way as to give an electrical reflection of the mechanical vibrations. These pickups have a number of limitations and disadvantages. One of these is that they are operable only in connection with steel strings; the gut and nylon strings preferred by many artists do not have the magnetic qualities required for actuating pickups of this type.

Another very serious limitation encountered in the use of pickups of the magnetic type is that extraneous signals are inevitably introduced. The electric coils have some of the characteristics of loop antennae, and it has been found that the pickups are subject to all kinds of stray radiation. Neon signs, for example, may produce very pronounced and very objectionable hum signals in the output of an electric guitar system embodying a magnetic pickup. Acoustic feedback also is a very serious problem.

It is a general object of the present invention to overcome the objections and disadvantages noted above and to provide pickup means capable of accurately converting mechanical vibrations into electrical oscillations.

Another object of the invention is to provide a pickup that will be insensitive to stray radiation effects and to atmospheric conditions.

2

Another object of the invention is to provide a string instrument with a pickup that will have maximum sensitivity with respect to vibrations of the strings and minimum sensitivity with respect to vibrations of other parts.

Yet another object of the invention is to provide a piezoelectric pickup for a string in which the relationship between the string and the piezoelectric body is such that the piezoelectric body reflects vibrations of the string even though the string may vibrate in various planes.

A more specific object of the invention is to provide a practical piezoelectric bridge construction for a string instrument wherein relatively movable string supports provide a means for making fine adjustments in the vibrating lengths of the individual strings for tuning purposes.

Still another object of the invention is to provide an instrument having electrically conductive strings with means for electrically grounding such strings, so that any stray radiation received by these strings will not interfere with the development of signals accurately reflecting the mechanical vibrations of the strings themselves.

The foregoing objects may be realized, according to a preferred embodiment of the invention, by the provision of a guitar having a novel bridge unit. The bridge unit includes a base member of some suitable non-conducting material adapted to be carried by the body of the guitar. On its upper surface, the base carries a plurality of piezoelectric transducers. Each of these transducers has a small mass and is adapted to contact directly a string of the guitar.

The arrangement is such that each string bears downwardly upon a piezoelectric transducer, pressing it against the base member. When the string is set into vibration, as by plucking, the pressure with which the string urges the transducer against the base will vary in accordance with the frequency and amplitude of the vibrations. The piezoelectric material converts these pressure fluctuations directly into electrical oscillations.

It has been discovered that minimization of the mass of the individual piezoelectric transducers is of critical importance. The base of the bridge must be mounted upon a part of the guitar body, with the result that it moves in response to vibrations of the guitar body. Such movements will result in significant pressures in the piezoelectric bodies if the individual bodies have substantial masses and therefore a substantial inertia to motion. In general, the mass of an individual transducer should not exceed about 10 grams, and it is preferred that the mass be much less. Transducers having a mass of 1.5 grams have been found to be very satisfactory.

It is important also that each string bear directly against a transducer. If a member is interposed between the piezoelectric material and the string, the mass of this member must be added to the mass of the piezoelectric body in determining the inertial characteristics of the structure. If the combined mass is large, the inertia tending to prevent movement of the piezoelectric body in sympathy with the vibrating guitar body will be sufficient to cause signal-generating pressure variations in the piezoelectric material.

In the preferred form of the invention, each piezoelectric body is semi-cylindrical and its external surface is shaped so as to provide a notch for receiving a string of the instrument. The string contacts the bottom and also portions of the side walls of the notch. This particular arrangement makes the piezoelectric transducer sensitive to vibrations of the string in various planes.

The terminals of each transducer may be formed by conductive coatings on the inner and outer cylindrical faces thereof. These may be left exposed or they may be covered by plastic coatings to protect them against abrasion and moisture.

Normally it is preferred that the transducers be wired so that their external terminals are grounded. This arrangement results in a shielding effect, protecting the interior terminals and the signal-carrying leads against stray radiation. It also makes it possible to ground the strings of a steel string guitar by bringing the strings directly into contact with the grounded transducer terminals.

When the invention is utilized in connection with classic guitars, it is desirable that the individual piezoelectric transducers be mounted upon the base member of the bridge in such a way as to permit individual adjustment of the positions thereof along the lengths of the strings. This permits the artist to tune the strings accurately. In order to allow this tuning movement, without reducing the reliability of the piezoelectric pickup, applicant has provided a number of novel constructional features.

One such feature is the use of a thin strip of compliant material, such as a polyethylene film, between the upper surface of the base member and the lower surfaces of the piezoelectric bodies. The presence of this strip entirely eliminates any possibility of a rocking action that might arise from irregularities in the surfaces of the components. In this connection, it will be apparent that if the piezoelectric bodies are to move relative to the base, they cannot be fixed to it, and that they must merely rest upon it. With this type of a construction, the danger of a rocking contact is particularly acute.

The requirement of movability also introduces problems in establishing secure electrical connections with the terminals on the surfaces of the piezoelectric bodies. These problems have been solved by the present invention through the use of flexible wire leads associated with the piezoelectric bodies in a particularly advantageous way.

The external terminal for each transducer is connected directly to the end of a flexible lead wire of sufficient length to permit some movements of the transducer. A similar arrangement may be provided for the interior terminal of the transducer, but it has been found that greater reliability may be obtained by establishing pressure contacts with the interior terminals of the devices.

A more complete understanding of these and other features of the invention will be gained from a consideration of the following description of certain embodiments illustrated in the accompanying drawings, in which:

FIG. 1 is a perspective view of electric guitar apparatus embodying the invention;

FIGS. 2, 3 and 4 constitute a series of diagrams provided to facilitate explanation of the significance of certain aspects of the invention;

FIG. 5 is an enlarged plan view of a bridge assembly of the type shown in FIG. 1;

FIG. 6 is a further enlarged transverse cross sectional view taken along the line 6—6 in FIG. 5;

FIG. 7 is a perspective view of a single transducer member illustrating the manner in which a string of the guitar cooperates therewith;

FIG. 8 is a plan view of another form of guitar bridge embodying features of the present invention; and

FIG. 9 is an enlarged transverse cross section view taken along the line 9—9 in FIG. 8.

The electric guitar apparatus shown in FIG. 1 includes a guitar **2**, a loudspeaker assembly **4**, and an electric cable **6** provided with jacks on its ends for detachable connection with the guitar **2** and the loudspeaker assembly **4**. Mechanical vibrations generated upon actuation of the guitar **2** are converted into electrical oscillations. These are passed through the cable **6** to the loudspeaker enclosure **4** where they are amplified and then converted into acoustic energy. The present invention is concerned primarily with the manner in which the mechanical vibrations are converted into electrical oscillations.

The overall configuration of the guitar **2** may be conventional. As illustrated, it includes a hollow body **10**, an elongated neck **12**, and a plurality of strings **14**. Strings **14** are secured at their lower ends to a member **16** fixed to the top panel **18** of the body **10**, and they extend upwardly along the fretted surface of the neck **12** to string-tensioning apparatus **20** of conventional construction.

The drawing shows the guitar body **10** as being hollow. In acoustic guitars as conventionally constructed, the top panel or sounding board **18** of the body **10** is provided with a circular opening, such as that designated **22**, immediately below the strings **14** of the instrument. The opening **22** then serves as the aperture for a resonating air chamber. Moreover, various parts of the body **10**, such as the panel **18**, vibrate in response to mechanical excitation by the strings **14** and in response to acoustic excitation through the surrounding air. The secondary vibrations from the resonating air chamber and from the wooden parts of the guitar have been responsible for the distinctive tone qualities produced in the acoustic guitars.

However, the present invention minimizes the significance of these secondary vibrations. The electrical signals obtained from the guitar **2** are those derived directly from the vibrations of the strings **14**. The strings **14** pass over a bridge assembly **24** adjacent the member **16**, and, as it passes over the assembly **24**, each string **14** bears downwardly against the upper surface of a piezoelectric transducer **26** forming part of the assembly **24**. When the strings **14** are vibrated, pressure variations will occur in the piezoelectric bodies **26**. These pressure variations will generate electrical oscillations that can be amplified and converted into acoustic energy in the loudspeaker unit **4**.

Applicant has found that the mass of the transducers **26** and the physical relationships between these transducers **26** and the strings **14** are matters of importance in the production of electrical oscillations that reflect accurately the mechanical vibrations of the strings **14**. The significance of these factors can be explained conveniently by reference to the diagrams designated FIGS. 2, 3 and 4 in the drawings.

FIG. 2 depicts a piezoelectric body **26*a*** supported upon a vibratable panel **18*a***. A vibratable string **14*a*** is arranged so as to apply pressure to the piezoelectric body **26*a***, but there is interposed between the string **14*a*** and the body **26*a*** a string-supporting member **28** having a substantial mass. The arrangement shown in FIG. 2 is essentially the same as that which has been proposed heretofore in connection with piezoelectric pickups for string instruments.

If the panel **18*a*** were perfectly rigid, the pressure variations applied to the piezoelectric body **26*a*** in response to the vibrations of the string **14** would be very much like the string vibrations. However, this condition never exists in actual instruments, and we must consider the effects produced by vibration of the supporting panel **18*a***. When the panel **18*a*** moves, the piezoelectric body **26*a*** and the string-supporting member **28** must move with it. Yet, it is readily apparent that the combined mass of the piezoelectric body **26*a*** and the string-supporting member **28** is substantial. This means that there will be a substantial inertia or resistance to acceleration on the part of these members. The inertia is in turn reflected in pressure changes on the piezoelectric body **26*a*** corresponding to the vibrations of the support panel **18*a***.

In FIG. 2, the string-supporting member **28** has been depicted as a member of substantial thickness. This illustration makes it easy to realize that, under certain circumstances, a string-supporting member interposed between a string of the instrument and the piezoelectric body may have so large an inertia as to cause nearly all of the vibrations of the support panel **18*a*** to be reflected in pressure changes on the piezoelectric body. Of course, such a result would be undesirable, because the electrical signals developed by the piezoelectric material would not reflect accurately the vibrations of the string of the instrument.

FIG. 3 represents a situation in which a piezoelectric body **26a** of the same size as the one shown in FIG. 2 is contacted directly by a vibratable string **14a**. In this case, there would be less resistance to motion of the piezoelectric body **26a** in sympathy with the vibrations of the supporting panel **18a**. However, the mass of the piezoelectric body **26a** still is substantial, and, as a result, the body **26a** will have a substantial inertia. Again, the pressure fluctuations resulting from the inertia of the body **26a** to movements with the panel **18a** will produce undesirable electrical signals.

Turning now to FIG. 4, it will be observed that the piezoelectric body **26b** shown in this view is very much smaller than the piezoelectric body **26a** shown in FIGS. 2 and 3. It should be assumed that its mass has been reduced also. When this has been reduced enough, the magnitude of any noise signal resulting from the inertial characteristics of the piezoelectric body **26b** will be so small as not to interfere with the desired signals resulting from vibration of the string **14a**.

Thus, it will be seen that the mass of each individual transducer component and any member that may be interposed between the transducer and its string, is a factor of critical importance. It is believed that the mass should not exceed about 10 grams for any one unit, and it is preferred that the mass be much lower where practical. For example, a transducer having a mass of 1.5 grams has been found to be very satisfactory. A similar transducer having a mass of 5 grams was found to be noticeably less good than the 1.5 gram transducer.

The classic guitar bridge construction shown in detail in FIGS. 5 and 6 of the drawings takes these factors into account, and it also embodies unique structural features of importance. The assembly **24** includes a non-conductive base member **30** that may be fixed directly to the body **10** of the guitar **2**. This base member **30** preferably is molded from some suitable resinous plastic material. An individual transducer **26** is provided for each of the strings **14** of the guitar **2** and all of these transducers **26** rest upon the base **30** of the assembly **24**.

Each of the transducers **26** is of hollow, tunnel-shaped, configuration and is made up of a body **32** of a ceramic piezoelectric material. Barium titanate has been found to be a suitable material for this purpose. As illustrated, each body **32** is semi-cylindrical in shape and has a generally semi-cylindrical internal surface bearing a coating **34** of a conductive material such as silver. The coating **34** forms one of the terminals or contacts for the transducer **26**.

The outer surface of the piezoelectric body **32** also is provided with a conductive coating **36**, such as a silver coating, to form the other contact or terminal for the transducer and to serve as electrically conducting shielding means covering the outer surface of the transducer. The shape of the exterior surface of the body **32** is essentially that of a half cylinder to which there has been added a bulging zone **38** (FIGS. 6 and 7). In it there is formed a string receiving notch **40** at the top of the transducer. The individual strings **14** of the instrument contact the bottoms and the sloping sides of these slots **40** and bear downwardly upon the transducers **26**. A small shoulder **41** at the front of each slot **40** assures freedom of movement of the vibrating length of the string **14** associated therewith.

From FIG. 6 it will be observed that the half round shape of the piezoelectric body **32** results in a relatively large hollow space in the center of the unit. This reduces considerably the overall mass of the transducer **26** and thereby improves the response characteristics thereof. Note also that the string of the instrument may bear directly against the transducer, without the interposition of inactive mechanical components of the type which have been proposed heretofore.

The supported surfaces of the piezoelectric body **32** are the radial edge surfaces **42** at the ends of the two legs of the body **32**, and it will be observed that these surfaces do not bear the conductive coatings **34** and **36**. In ordinary commercial operations, it usually is not feasible to form the parts with such precision that there will be no irregularities in the radial edge surfaces **42** of the piezoelectric bodies **32** or in the upper faces of the base members **30**. In order that such irregularities will not produce rocking contacts between the piezoelectric bodies **32** and the supports **30**, a film **44** of compliant material is interposed between the elements. A thin strip of polyethylene is suitable for this purpose. It may be laid upon the top of the base **30** without the provision of any cementing means between it and the base, or between it and the piezoelectric body **32**.

In FIGS. 1 and 5, the several transducers **26** are not disposed in a straight line along the base **30**. In order to obtain perfect tuning of the individual strings **14**, it is desirable that the apparatus include some provisions for changing slightly the vibrating length of each string when necessary. Since the shoulder **41** at the front edge of a groove **40** in a transducer element **26** will determine for practical purposes the end of the vibrating length of the string passing through such groove **40**, the length may be varied by shifting the transducer **26** backward or forward on its support **30**. The irregular alignment of the several transducers **26** illustrated in FIGS. 1 and 5 is intended to suggest that such adjustments have been made.

In order to permit movements of the piezoelectric bodies **32** relative to the base **30**, there must be no rigid coupling between the base and the several transducers. The outer contact **36** of each piezoelectric body **32** has cemented thereto an end of a flexible lead wire **46** that passes through an aperture **48** in the front surface of the base **30**. The aperture **48** permits the lead **46** to extend into a longitudinal groove **50** in the bottom surface of the base **30**, where it is connected to a ground wire or cable **52**. The length of the flexible lead **46** is sufficient to permit the piezoelectric body **32** to be moved backwardly and forwardly when desired. After the required adjustments have been made in the position of a transducer **26**, the downward pressure of the string **14** on it serves to clamp it in position, so that no further securing means is required.

Another groove **54** is provided in the bottom surface of the base **30** for the reception of a signal-carrying wire or cable **56**. This cable **56** is coupled electrically to a fitting for receiving one of the jacks **8** shown in FIG. 1. After the device has been assembled, plastic material **58** may be used to fill the the grooves **50** and **54** so as to hold the respective cables **52** and **56** therein.

A branch wire or lead **60** extends upwardly from the signal-carrying cable **56** at the location of each of the piezoelectric bodies **32**. Each branch lead **60** passes through an aperture **62** in the base **30** and then through an aperture or passageway **64** in a body **66** of flexible resilient material such as rubber. The rubber body **66** preferably is about as long as the piezoelectric body **32** with which it is to cooperate, and its exterior cylindrical surface **68** preferably has the same radius as the interior cylindrical surface of the piezoelectric body **32**.

The passageway **64** through the rubber body **66** may be round in horizontal cross section. It need not be materially larger than the lead **60** passing therethrough. As the lead **60** emerges from the top of the passageway **64**, it is splayed out so as to leave exposed wire ends **70** above the upper face **68** of the rubber body **66**. These wire ends **70** therefore form a pressure contact with the coating **34** on the interior face of the piezoelectric body **32**, so that the voltages developed across the piezoelectric material **32** will be transmitted to the main cable **56** of the assembly.

Since the rubber body **66** is flexible, and since it is not attached to the support **30**, it does not interfere materially with the movements of the piezoelectric body 32 during adjustments in the position thereof. Moreover, the resilience of the rubber body 66 assures good contact between the splayed wire ends 70 and the silver coating 34 on the interior surface of the body 32 in all positions of the transducer 26 relative to the base 30.

FIGS. 8 and 9 of the drawings illustrate another type of guitar bridge embodying features of the present invention. These views depict a bridge 72 particularly adapted for use on a jazz guitar. Such guitars ordinarily are provided with bridges of the general outline shown in FIG. 8. These bridges are mounted upon the top panel of the guitar body by screws passing through slots 73 in such a way as to permit some adjustments thereof, but the individual string mounts or fulcrums need not be movable relative to each other.

The bridge construction 72 includes a base or body member 74 that preferably is molded from some suitable resinous plastic material of a non-conductive character. The upper face of the body 74 is provided with an elongated trough 76 (FIG. 8) for receiving a plurality of transducer components 78. Each of these components 78 is intended to support a single string on the guitar.

As shown best in FIG. 9, each transducer component 78 is made up of a piezoelectric ceramic body 80 having a coating 82 of conductive material on its interior surface, and having a coating 84 of conductive material on its outer surface. The conductive coatings 82 and 84 may be silver coatings, for example. These coatings serve as electrical contacts or terminals for the transducer 78.

As the bridge 72 is normally wired for use, the exterior coating 84 on the piezoelectric body 80 is grounded. This result may be facilitated by bringing the coating 84 into contact with a similar conductive coating 86 on the exposed surfaces of the base 74. The entire extent of the coating 86 then becomes available as a charge accumulator or "ground." If an external connection is desired for the ground contacts 84 of the several piezoelectric bodies 80, this may be achieved by running a lead wire 88 along the space between the sides of the piezoelectric bodies 80 and the adjacent wall of the trough 76. This wire 88 should be in electrical contact with the external coating 84.

In this embodiment of the invention, the individual piezoelectric bodies 80 may be of exactly the same shape as the piezoelectric bodies 32 shown in FIG. 6. However, each piezoelectric body 80 is cemented to the body member or base 74 by a suitable non-conductive cement or adhesive 90.

A branch wire or lead 92 has an end portion thereof connected to the interior coating or terminal 82 on the piezoelectric body 80. This lead 92 then is connected at its opposite end portion to the main signal-carrying cable 94 of the bridge unit 72. The cable 94 extends longitudinally along the entire length of the trough 76 and is connected by branch leads 92 to the interior terminals 82 of the several piezoelectric bodies 80. The cable 94 then passes outwardly from the bridge 72 where it may be coupled to suitable means for delivering the electrical signals produced in the transducer 78 to amplifier apparatus and suitable loudspeakers.

The external surfaces of the bridge 72 may be encapsulated in some suitable non-conductive plastic material 96. This material serves to protect the conductive coatings 84 against moisture and abrasion.

It will be apparent that the bridge assembly 24 of FIGS. 5 and 6 also may be encapsulated in plastic, if desired, and that the plastic material 96 may be omitted from the bridge 72, if desired. When a bridge is to cooperate with steel strings, it is desirable to ground the string through the ground contacts of the transducers, and in these instances it is desirable to establish a conducting relationship between the strings and the silver coatings on the piezoelectric bodies.

Various other modifications and alterations will suggest themselves readily to persons skilled in the art. It is intended therefore that the foregoing be considered as exemplary only, and that the scope of the invention be ascertained from the following claims.

I claim:

1. A pickup for converting mechanical vibrations in a musical instrument into electrical oscillations comprising a hollow, tunnel-shaped, piezoelectric transducer having an inner surface and an outer surface and having at least two legs, means supporting such legs, said supporting means being on said instrument, an electric conductor electrically connected to the inner surface of said transducer, and electrically conducting shielding means covering said outer surface.

2. A pickup as defined in claim 1 wherein said transducer is of generally semi-cylindrical shape and wherein said shielding means includes a conductive coating on said outer surface of said transducer.

3. A pickup as defined in claim 2 wherein said transducer is provided with a string-receiving notch in said outer surface extending transversely with respect to the longitudinal axis of the transducer.

4. A pickup for converting mechanical vibrations in a musical instrument into electrical oscillations comprising a hollow, tunnel-shaped, piezoelectric transducer having a mass of about 1.5 grams and having an inner surface and an outer surface and having at least two legs, means supporting such legs, said supporting means being on said instrument, an electric conductor electrically connected to the inner surface of said transducer, and electrically conducting shielding means covering said outer surface.

5. A bridge for a musical instrument comprising pickup means for converting mechanical vibrations into electrical oscillations, said pickup means including a plurality of tunnel-shaped, piezoelectric transducers each having an inner surface and an outer surface and each having at least two legs, means supporting such legs, said supporting means being on said instrument bridge, an electric conductor electrically connected to the inner surface of each of said transducers, and electrically conducting shielding means covering said outer surface of each of said transducers.

6. A musical instrument of the string type comprising a body; pickup means for converting mechanical string vibrations into electrical oscillations including a plurality of hollow, tunnel-shaped, piezoelectric transducers each having an inner surface and an outer surface with a notch therein and each having at least two legs, bridge means supporting such legs, said bridge means being on said instrument, an electric conductor electrically connected to the inner surface of each of said transducers, and shielding means including electrically conducting coatings covering the outer surface of each of said transducers and surfaces of said bridge means; and a plurality of vibratable strings mounted on said body with each string being received in a notch in the outer surface of a transducer.

7. A musical instrument comprising an instrument body; a pickup for converting mechanical vibrations into electrical oscillations including a hollow, tunnel-shaped, generally semi-cylindrical, piezoelectric transducer having an inner surface and an outer surface and having at least two legs, an electric conductor electrically connected to the inner surface of said transducer, shielding means in the form of an electrically conducting coating covering said outer surface and means for grounding said coating; means on said instrument body supporting said legs of said transducer; and a vibratable string mounted on said body and bearing against the outer surface of said transducer.

8. In a musical instrument of the type having a body and a vibratable string mounted on said body, the im-

provement which comprises a pickup for converting mechanical string vibrations into electrical oscillations, said pickup including a hollow, tunnel-shaped, piezoelectric transducer having a mass no greater than about 10 grams and having an inner surface and an outer surface and having at least two legs, means supporting such legs, said supporting means being on said instrument body in position to cause said vibratable string to bear against the outer surface of said transducer, an electric conductor electrically connected to the inner surface of said transducer, and electrically conducting shielding means covering said outer surface.

9. A bridge for a musical instrument of the string type comprising a base; pickup means for converting mechanical vibrations into electrical oscillations including a plurality of hollow, tunnel-shaped, piezoelectric transducers each having an inner surface and an outer surface and each having at least two legs supported on said bridge base, an electric conductor electrically connected to the inner surface of each of said transducers, electrically conducting shielding means covering said outer surface of each transducer; and a plastic film encapsulating said base and said transducers.

10. A bridge for a musical instrument of the string type comprising a base; pickup means for converting mechanical vibrations into electrical oscillations including a plurality of tunnel-shaped, piezoelectric transducers each having an inner surface and an outer surface and each having at least two legs supported by said bridge base, a plurality of electric conductors each being secured with respect to said bridge base and being electrically connected at its free end portion to the inner surface of one of said transducers, said conductors being long enough to permit limited relative movements between individual ones of said transducers and said bridge base, and electrically conducting shielding means covering the outer surface of each of said transducers.

11. A bridge as defined in claim 10 wherein a thin strip of compliant material is interposed between said legs and the adjacent surface of said bridge base.

12. A pickup for converting mechanical vibrations in a musical instrument into electrical oscillations comprising a hollow, tunnel-shaped, generally semi-cylindrical, piezoelectric transducer having an inner surface and an outer surface and having at least two legs, means supporting such legs, said supporting means being on said instrument, an electrically conductive coating on the inner surface of said transducer, a flexible resilient member on said supporting means adjacent the inner surface of said transducer, electrically conductive means on said resilient member in position to establish pressure contact with said coating on the inner surface of said transducer and electrically conducting shielding means covering said outer surface.

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