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[54] **BIDIRECTIONAL ELECTROMAGNETIC PICKUP DEVICE FOR STRINGED MUSICAL INSTRUMENTS**
12 Claims, 4 Drawing Figs.

[52] **U.S. Cl.** **84/1.15,** 84/1.16
[51] **Int. Cl.** **G10h 3/08**
[50] **Field of Search** 84/1.14, 1.15, 1.16; 310/25

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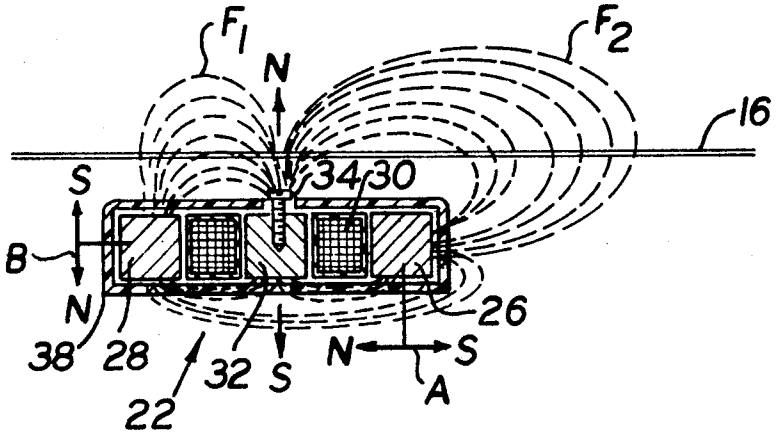
ABSTRACT: A pickup device for a stringed instrument or the like having vibratable elements, comprising a coil adapted for connection to a current amplifier and magnetic means for generating a bidirectional flux pattern having one component extending essentially longitudinally of the elements and a second component essentially vertically of the elements.



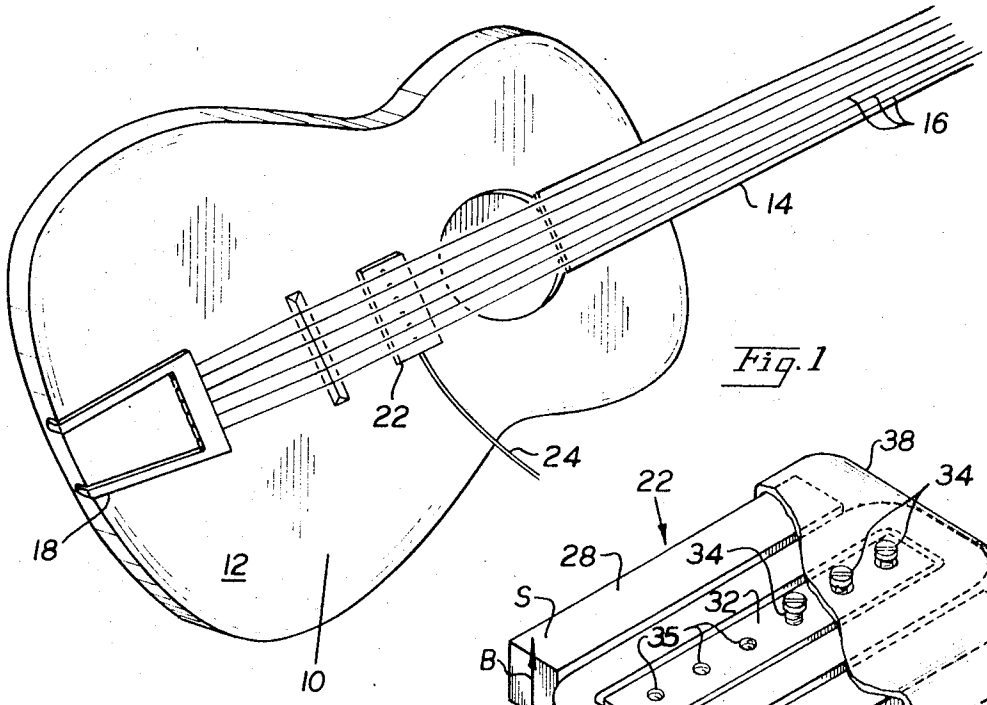


Fig. 1

Fig. 2

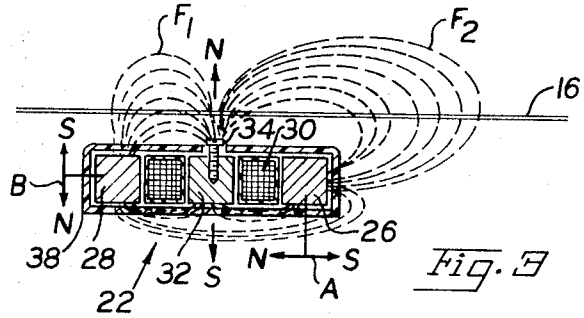


Fig. 3

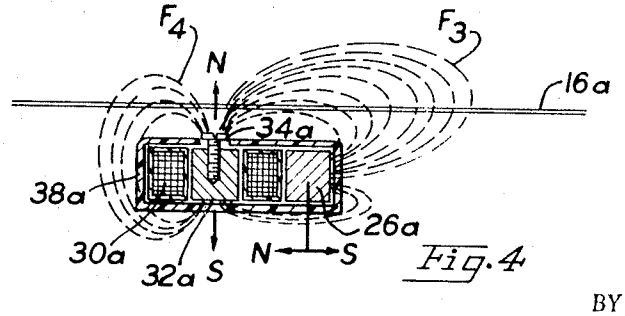


Fig. 4

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BIDIRECTIONAL ELECTROMAGNETIC PICKUP DEVICE FOR STRINGED MUSICAL INSTRUMENTS

BRIEF SUMMARY OF THE INVENTION

The present invention relates to apparatus for converting the vibrations of a string instrument or like percussive instruments having vibratable elements into an electrical current and, in particular, to an electromagnetic pickup device for use with metallic stringed instruments such as the steel or Spanish guitar, a vibraphone, xylophone or the like.

As is well known, taut strings, when plucked or bowed, or certain percussive elements when vibrated produce a fundamental sound wave (the nominal tone) and also a plurality of harmonic sound waves (overtones). It is the fundamental wave which gives the string or vibrating element its characteristic sound and it is the overtone waves which give it its richness and depth. Hence, for the full and faithful reproduction and amplification of the sound of a stringed or percussive instrument, it is desirous to capture the harmonic sound waves or overtones as well as that of the fundamental tone. For example, when reproducing the sound of a "steel guitar" it is not just desirous to pick up all the sound waves but it is essential to capture all of them since the steel strings and nonresonant body have little musicality even in fundamental sound.

Generally, present pickup devices for instruments having vibrating elements provide a magnetic flux pattern adapted to encompass the waves produced by the vibrating element, the reluctance of which is then translated into electrical current responsive to and variable in direct relation to the form and amplitude of the vibrations. Little problem has been encountered in encompassing the vibration creating the fundamental note since it has a relatively large and substantially fixed amplitude and frequency. On the other hand, more difficulty has been encountered in intercepting the overtones since they are produced of waves of much lesser amplitude and are defined by varying frequencies having nonuniform nodal positions along the length of the vibratable element.

Furthermore, because of variances in the structure of individual vibratable elements, (i.e., their thickness, weight, etc.) adjacent vibratable elements have noncorresponding or different frequency nodal positions. Thus, a pickup device designed for maximum effect with one vibratable element is often not as effective and may, in fact, be unsuitable for use with another vibratable element. Particularly is this the case when a full range of harmonic overtones is desired in addition to the few basic fundamental tones of several vibratable elements.

Various special devices have been suggested in an attempt to capture both fundamental and harmonic waves. In practice, however, each of the suggested devices was designed to produce a magnetic flux primarily configured to pickup or intercept one form of wave at the expense of the other. For example, there are devices which produce a field of substantial vertical height relative to the vibratable element which is hoped to be sufficient to intercept substantially all the intense and high amplitude of the fundamental sound wave and incidentally some of the harmonic waves. On the other hand, there are devices which produce an elongated field of obviously lesser amplitude extending longitudinally of the vibratable element so as to intercept a substantial number of the harmonic frequencies and at least a part of the fundamental wave.

It will be easily seen that the former sacrifices the harmonic sound for the sake of the fundamental tone while the latter sacrifices the fundamental tone to obtain the harmonics. The first pickup is "tinny" but basic while the second is rich but distorted. To overcome this defect, it has been the practice to use two or more pickup devices on a single instrument whereby it is hoped that by electronically combining their output, reception of all waves is obtained and the distortion precluding faithful performance is provided.

Briefly, the present invention provides a pickup device simply comprising a coil adapted for connection to a current amplifier, and magnetic means for generating a bidirectional flux pattern about the coil having one component extending essentially longitudinally of the vibratable elements and a second component extending essentially vertically of the vibratable elements. The flux pattern encompassing substantially all of the vibrations of the vibratable element which then induce a single integrated current in the coil.

The object of this invention is to provide a single device of simple construction which will faithfully and truly respond to both fundamental tone waves and harmonic overtone waves.

It is an object of this invention to provide a single pickup device capable of intercepting divergent wave patterns produced by one or more vibrating elements. It being a further and specific object of this invention to provide a pickup device of the described type wherein there is obtained a single output signal characteristic however of multiple and divergent wave patterns.

It is another object of this invention to provide a device which establishes at least a bidirectional magnetic field. One component of this bidirectional field being of sufficient amplitude to encompass the fundamental sound wave and another component extending for a substantial distance along the length of the vibratable elements to encompass a number of nonuniform harmonic frequencies.

It is another object of this invention to provide an electromagnetic pickup device producing a bidirectional magnetic field in which one component extends substantially vertically of vibratable elements intersecting it normally thereto while its other field extends longitudinally essentially parallel to the vibratable elements.

It is still another object of this invention to produce a pickup device producing full quality, natural sound at low cost.

These and other objects and advantages will become apparent from the following description wherein reference is made to the accompanying drawing. In the drawings:

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a guitar embodying the pickup device of the present invention;

FIG. 2 is an enlarged perspective view of the pickup device alone and with its covering shell removed;

FIG. 3 is a sectional view vertically through the device and longitudinally of a vibratable element illustrating the bidirectional flux path, and;

FIG. 4 is a view similar to that of FIG. 3 showing a modified pickup structure.

DETAILED DESCRIPTION

Turning now to FIGS. 1—3, showing the preferred form of the present invention, there is to be seen a guitar generally identified by numeral **10** representative of the Spanish or electric variety having a nonvibrating body **12**, a neck or a finger board **14** over which is tensioned a plurality of vibratable elements **16**. The elements **16** are secured at their forward end in adjustable turning keys (not shown) and at their rearward end in an anchoring device **18**. A bridge **20** is located between the anchor **18** and the neck **14** to further tension the vibratable elements and remove them from the surface of the body **12** in order that they may be vibrated freely thereover.

A pickup device generally identified **22** is adapted to be mounted on the body **12** between the neck **14** and the bridge **20** adjacent to but preferrably below the element **16**. In outward appearance, the pickup device **22** resembles those commonly in present use, and is furnished with an extension cord **24** which is connected to a suitable electronic circuit, controls and a speaker amplifier system (not shown). Electronic amplifier and speaker systems are so well known and so many commercial units are available, anyone of which may be easily employed with the novel pickup herein shown, that their detailed description here is unnecessary and is therefore omitted for the sake of brevity.

Referring specifically to FIGS. **2** and **3**, the pickup **22** comprises a pair of elongated solid block magnets **26** and **28**

disposed in spaced coplanar relation and substantial parallel longitudinal alignment with each other on either side of an elongated wire coil member **30**. The coil member **30**, being a winding or wire, lies with its major axes coplanar with the magnets. The magnets are preferably of the transverse polar bar type wherein, for reasons more fully explained later, their polar axes A and B extend from side to side transverse to their longitudinal axes.

Centrally of the coil **30** is a core **32** within the face of which is located a plurality of upright adjusting screws **34** mounted in suitable threaded apertures **35**. The screws **34** are of soft iron to enable a flux pattern to be created therethrough. If the core **32** is of nonmagnetic material a mellow, less treble sound will be obtained while if it is of soft iron a high treble sound can be produced. The number of screws **34** are equal at least to the number of vibratable elements and are spaced along the core **32** accordingly. A plastic insulating sheet or sheets **36** are provided to cover the coil **30** and a protective outer housing **38** also of plastic is provided to hold all the elements in relatively fixed positions and to locate the unit properly adjacent to or below the vibratable elements. The outer covering **38** may conveniently be molded over current various parts of the device or provided as a separate element such as a packet or box within which the parts may be placed.

As will be seen from FIG. **1**, the device is placed transversely across adjacent to and beneath the elements **16** so that each adjustment screw **34** is positioned immediately under a corresponding element **16**. The structure of the present device is completed by providing the coil **30** with a pair of leads **40** and **42** which are connected via cord **24** to a current amplifier (not shown). It will, or course, be understood, without any further detail, that as the magnetic flux pattern created by the magnetic elements is modulated and its reluctance varied by the vibration of the vibratable elements, a current is induced within the coil **30** which is transmitted via the cord **24** to the electronic circuitry of the amplifier system.

As mentioned previously the magnets **26** and **28**, while of the bar type, have their polar axes directed transversely relative to their length. Further, in accordance with the present invention, the magnets are located about their longitudinal axes so that their specific corresponding poles are, in fact, also offset 90° from each other. Particularly, the down string magnet **26** (nearest the neck **14**) has its polar axis A extending parallel to the elements **16** with its S-pole looking toward the neck **14**. The upstring magnet **28** (nearest the bridge **20**) on the other hand has its polar axis B extending vertically of the elements **16** with its corresponding S-pole linking upwardly through the vibratable element. Consequently, as will be seen from FIG. **3**, a bidirectional magnetic flux pattern (dotted lines) is composed of substantially independent magnetic fields of forces enveloping the coil **30**.

The bidirectional flux pattern is composed of two separate force fields each of which has itself directional components. One force field, indicated F_1, is created by the upstring magnet **28**, and circuits from its south pole upwardly to the series of adjustment screws **34** and thence returning through the central core **32** below the coil **30** to its north pole. The other force field indicated F_2 is created by the down string magnet **26** and circuits from its south pole also through the series of adjustment screws **34** thence to return below the coil **30** to its north pole. The first field F_1 extends essentially vertically of the vibratable elements from the face of the body **12** to a level above the vibratable elements dependent on the strength of the magnet **28**. The field F_2, unlike the former field, extends essentially longitudinal of and parallel to the elements **16**.

As a direct consequence of positioning the down string magnet **26** with its axis A parallel to the elements **16**, the lines of magnetic force extending from the south pole of magnet **26** project forwardly down string some substantial distance before being reversed to collect at the adjustment screws **34**. As a result, the combined flux pattern has a first major independent component, Field F_1, which is substantially offset about 90° from a second major independent component field F_2. Each of the component force fields, of course, extends for the length of the entire pickup device **22** and envelopes the entire coil **30** and encompasses all of the elements **16**. The upstring field F_1 does, by its nature, have a great degree of vertical component but because of the proximity of its source magnet **28** to the core **32** and the upstring magnet **26**, its field also includes a lesser component parallel to the string. Field F_2 also includes a lesser component that is vertical to the vibratable elements even though its primary component is lengthwise in the direction of the vibratable elements.

Field F_2 similarly is dependent on the adjustment screws **34** for its circuit, which is dependent upon their vertical adjustment. This provides this second field F_2 with a lesser vertical component that extends about and intersects the vibratable element. Of course, the divergent components of both fields are variable as a function of the adjustment screw height and there is therefore enabled individual adjustment of the fields for a respective vibratable element, taking into account variation in string construction configuration and vibration. Consequently, the resultant flux pattern as it encompasses all of the string vibration wave patterns diverges angularly from the central core. Thus, it is also able to encompass both the extent of the amplitude as well as the entire length of a plural number of waves.

It can now be appreciated that the magnetic flux pattern produced by the present device **22** is capable of capturing and intercepting the diverse wave forms produced by the vibrating elements. The present device distinguishes from the pickup devices known in the prior art by the arrangement of the magnet elements and the common coil which insures generation and maintenance of lines of force in the noted divergent directions and in that the changes and modulations of their patterns are instantly and simultaneously integrated into a single common signal.

By generating magnetic lines of force in the lengthwise or horizontal direction parallel to vibratable elements, the present device **22** is able to cover an elongated length of each vibratable element thereby insuring that during vibration of the element, the lines of forces will encompass primarily a plurality of harmonic wave forms including waves at their crest and at their null points. Thus, the present single device performs the same function as a plurality of conventional pickup devices spaced along the length of the vibratable element. The import of the present device, however, is its ability also to simultaneously encompass or intercept primarily the fundamental tone wave. The capture of the higher amplitude fundamental tone wave is assured by its independent creation of a vertical component.

This is accomplished by producing a lesser vertical component within the lengthwise or horizontal field F_2 which vertically intersects the vibratable elements as explained, and secondly by positioning a magnetic element **28** with its polar axis extending in a direction vertically of the vibratable elements with its corresponding poles rotated 90° out of phase with the poles of the horizontally disposed magnetic element **26**. Consequently, the fields of the two elements cooperate with each other to encompass the movements of the vibratable elements. The resultant electrical signal produced by the coil **30** is therefore more representative of the true wave patterns produced by a plurality of vibratable elements and the sound reproduced is more natural, full and realistic.

By placing the coil **30** coplanar with the magnets **26** and **28**, and providing that it be the common denominator between the two and each of the fields of the flux pattern, the present device **22** distinguishes over the conventional pickups. Thus, it produces a single electrical output which integrates in a changing magnetic reluctance, variations of a plurality of sonic vibrations. Devices employing multiple output signals which must be later electronically combined are avoided.

The arrangement of the magnets is further functionally reinforced by the structure of the present device which itself distinguishes over the prior conventional devices. It is well known that conventional devices employ polar pieces or other

metallic fastening means for holding the magnetic elements. These extraneous metallic pieces distort the magnetic flux pattern or, in fact, short circuit its path to such a degree that polar axes of the magnetic elements act entirely different from and opposed to that which was intended. The present device being without metallic fasteners, polar pieces or any other distorting means and arranged in coplanar relationship insures faithful and true magnetic polar axis direction, preserving the independency and divergency of the bidirectional force fields produced.

Various changes and modifications to the preferred structure may be made without departing from the concept of the present invention or without changing its mode of operation. For example, the employment of the S-pole as the norm or standard for establishing the direction of the polar axes is by convention only. The N-pole could just as significantly be employed in this manner. Because it is conventional to the place the pickup device nearer to the bridge of the instrument, the pickup shown creating its horizontal force field downstring. It will be apparent that should considerable distance be found between bridge and neck it may sometimes be advisable to interchange the two magnets and to reverse the vertical and horizontal force fields. To modify force field in either direction the strength of the magnet may be varied as may its position from the coil. Various other modifications to coil, core, and protective housing will readily come to mind. Any suitable element or component may be employed, all because of the simplicity of the present construction.

In FIG. **4**, there is shown one modification of the preferred form previously described. In the structure shown in FIG. **4**, a smaller and simpler pickup **22** is shown which employs one magnet **26***a* having essentially a horizontally directed polar axis similar to that of magnet **26** shown in connection with FIGS. **2** and **3**. The central core **32***a* is also magnetized and has its polar axis extending vertically with respect to that of the magnet **26***a*. Unlike the core **32** shown in FIGS. **2—3**, core **32***a* is a positive magnet producing a force field of its own. In this respect, it is more like the upstring magnet **28** of the preceding FIGS. The core **32***a*, however, has its poles rotated 270° out of phase with the poles of magnet **26***a* so that following the invention employed in FIG. **2** and **3**, if the S-pole of magnet **26***a* faces downstring then the N-pole of core **32***a* extends or is directed vertically upward through the vibratable elements **16***a*. The remaining structure, of course, with the exception of the upstring magnet **28** remains the same and have been given the same number with subscript *a* for easy identification.

It will be noted that the force field F_3 created by the magnet **26***a* and coil **30***a* is substantially the same as the field F_2 seen in FIG. **3**, and has a major horizontal component running essentially parallel to the elements **16** and a minor component vertically extending about and intersecting the elements **16**. However, the second field F_4 is created by the direct action of the magnetized core **32***a*. On creation of this field, the adjustment screw **34***a* becomes magnetized (N-pole, maintaining the invention) and the field extends about the upstring portion of the coil **30***a* to the lower surface of the core **32***a*. Consequently, this field F_4 has a major vertical component and a very weak minor horizontal component. This may be often advantageous when the distance between the bridge and neck is too small to require much upstring horizontal field or when the vibratable elements are nearly perfectly matched. The device shown in FIG. **4** distinguishes from the prior art in exactly the same functional and structural modes as the preferred form. Namely, the device produces bidirectional flux patterns capable of encompassing both fundamental and harmonic waves and does not employ polar pieces and other metallic parts. Consequently, its directional field forces are not short circuited or misdirected resulting in the production of wrong flux pattern.

It will now be appreciated that each of the objects set forth in the introduction hereto have been fully met. The present device is simple in construction and use, captures the full range of string vibration and faithfully reproduces the same. Accordingly, it is intended that the present invention not be limited by the specified description but by the scope of the appended claims.

I claim:

1. A pickup device for a musical instrument having a plurality of magnetizable metallic vibratable elements between a forward end and a rearward end, said device comprising;

a pair of transverse polar magnets spaced parallel to each other for positioning adjacent the elements;

said magnets being arranged transversely of said elements with the polar axis of one horizontally parallel to said elements and the polar axis of the other vertically normal to said elements producing in combination a bidirectional flux pattern encompassing the elements;

a coil between said spaced magnets and within the flux pattern thereof; and

means for connecting said coil to a current amplifier system, whereby on vibration of the elements said flux pattern is modulated inducing within said coil a current directly responsive to said vibrations for transmission to said amplifier.

2. The pickup device according to claim **1** including a magnetically nonpermeable housing for fixing said magnets and coils relative to each other and for locating the same below said vibratable elements.

3. The pickup device according to claim **2** wherein said magnets are permanent bar-type magnets, with their polar axes running from side to side, said magnets being arranged with the polar axis of the one nearest the forward end of said instrument extending horizontally in that direction and with the polar axis of the other magnet rotated 90° out of phase therewith.

4. The device according to claim **3** wherein said coil is provided with a longitudinal central opening and is arranged between said magnets with its major axis lying coplanar therewith, said device further including a permeable core comprising a common element for the flux patterns of each of the magnets.

5. The pickup device according to claim **4** wherein said core is provided with a plurality of height adjustment means at least equal to the number of vibratable elements on the instrument, said adjustment means being variable to selectively increase or decrease the vertical extend of the flux pattern produced relative to each vibratable element.

6. The pickup device according to claim **3** wherein said coil is provided with a longitudinal central opening coplanar with said magnets, the rearmost of said magnets being located with said central opening comprising a core therefor.

7. The pickup device according to claim **6** wherein said core is provided with a plurality of height adjustment means at least equal to the number of vibratable elements on the instrument, said adjustment means being variable to selectively increase or decrease the vertical extent of the flux pattern produced relative to each vibratable element.

8. Apparatus for converting the vibration of magnetizable metallic vibratable elements of a musical instrument into an electrical current comprising a permeable coil, a pair of transverse polar elongated magnets, nonpermeable means for retaining said coil between said magnets in side by side relationship adjacent said vibratable elements, the first of said magnets being arranged to have its polar axis extending parallel to the length of said elements to generate an independent magnetic field essentially parallel to the elements, the second of said magnets being arranged to have its polar axis normal to the length of the elements to generate a second independent magnetic field essentially normal to the elements, said coil integrating said independent magnetic fields into a common flux pattern about the elements, said flux pattern encompassing vertical and longitudinal vibrations of the elements and being modified thereby to induce a current in said coil responsive directly to all of said vibrations.

9. Apparatus for use in reproducing the sound of a vibrating instrument having magnetizable metallic vibratable elements when positioned adjacent thereto comprising a coil adapted for connection to an amplifier system, magnetic means for generating a flux pattern about said coil to induce a current therein, said flux pattern having at least one component extending essentially parallel to and along a length of the vibratable elements for encompassing a plurality of harmonic waves produced by vibrating the element, and another component extending essentially vertically about the element for encompassing the fundamental wave produced by vibrating the element, whereby said induced current is modified in direct response to the variations in said harmonic and fundamental waves so as to produce in said amplifier a faithful reproduction of the sound of the instrument.

10. In a musical instrument having a plurality of magnetizable metallic, vibratable elements, a pickup device adapted to be located adjacent the elements for converting its vibrations into a modulated electrical current, comprising a coil having a permeable core, separable magnetic means positioned adjacent said coil for generating at least two magnetic fields, one of said fields being essentially vertical to and primarily responsive to the fundamental vibration of the elements and the other of said fields being horizontal to and primarily responsive to the full harmonic vibration of the elements, said fields combining with the core of said coil to produce a flux pattern about said coil, the vibration of said elements directly varying said flux pattern to induce a current in said coil that is responsive to said vibrations.

11. The device according to claim 10 including means for varying the extent of permeability of said core and consequently of said magnetic field.

12. The device according to claim 11 wherein said magnet means comprises a pair of spaced oriented permanent magnets having their polar axes divergent from said coil and with respect to each other.