Feb. 22, 1966 C. L. FENDER 3,236,930

ELECTROMAGNETIC PICKUP FOR ELECTRICAL MUSICAL INSTRUMENTS

Filed May 11, 1962

Fig. 1.

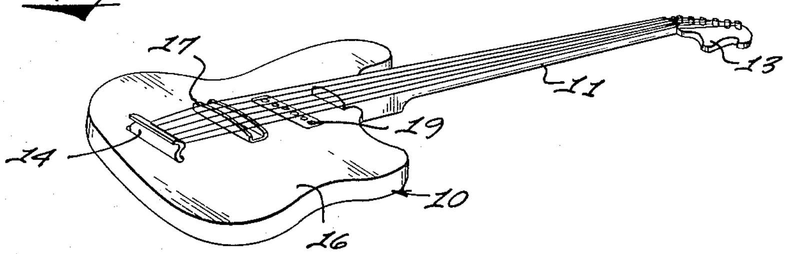


Fig. 3.

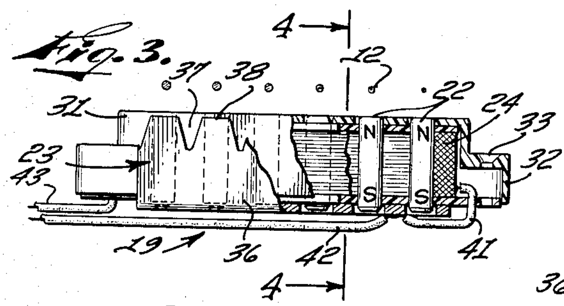
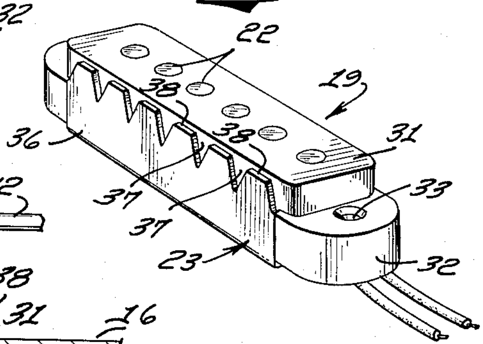


Fig. 2.



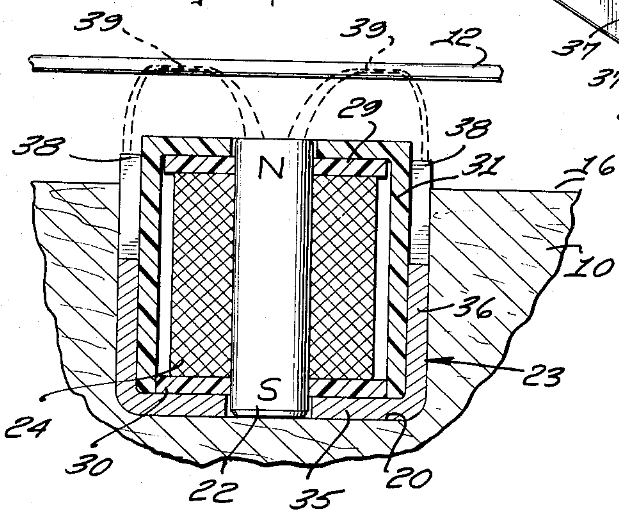
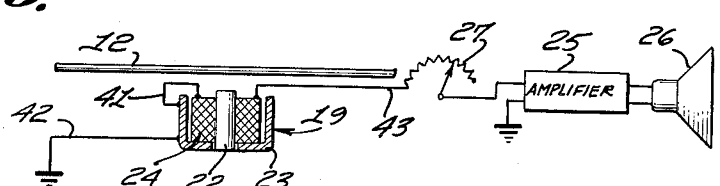


Fig. 4.

Fig. 5.



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ELECTROMAGNETIC PICKUP FOR ELECTRICAL MUSICAL INSTRUMENTS

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4 Claims. (Cl. 84—1.15)

This invention relates to pickups, or mechanical-electrical transducers, for electrical musical instruments, particularly stringed instruments such as electric guitars. The invention further relates to an electric guitar incorporating such pickup.

An object of the invention is to provide a highly simple and economical electromagnetic pickup which produces in an associated loudspeaker a markedly superior sound or tone in comparison to that produced by prior-art pickups.

Another object is to provide a pickup which is relatively insensitive to rotation of the plane of vibration of the vibrating string, so that a relatively smooth and uniform sound is generated in the associated loud speaker.

Another object is to provide a pickup which is capable of generating a usable voltage for a much longer period of time, subsequent to picking of the string, than a conventional pickup.

Another object is to provide an electromagnetic pickup which produces extremely realistic and natural sounds, such sounds being substantially free of certain undesirable characteristics which were previously regarded as inherent in electrical musical instruments as distinguished from acoustic instruments.

An additional object is to provide an electric guitar incorporating a pickup which generates a relatively high current and voltage in comparison to prior-art pickups, and which is relatively insensitive to extraneous electromagnetic fields so that the amount of noise generated in the pickup and associated circuitry is minimized.

A further object is to provide a pickup which is highly superior in its ability to respond to bass vibrations.

Another object is to provide an electromagnetic pickup which is very powerful in its ability to transduce string vibrations into electric signals, yet is extremely compact and simple in construction and manufacture.

These and other objects and advantages of the invention will be more fully set forth in the following specification and claims, considered in connection with the attached drawing to which they relate.

In the drawing:

FIGURE 1 is a perspective view of an electric guitar incorporating an electromagnetic pickup constructed in accordance with the present invention;

FIGURE 2 is an enlarged perspective view illustrating only the pickup;

FIGURE 3 is a view, partly in side elevation and partly in longitudinal central section, illustrating the electromagnetic pickup of the invention;

FIGURE 4 is an enlarged transverse sectional view of the pickup and an associated string, taken on line 4—4 of FIGURE 3, representative lines of magnetic force or flux being illustrated; and

FIGURE 5 is a schematic circuit diagram illustrating the manner in which the pickup may be associated with an amplifier and loudspeaker.

The electric guitar in which the pickup is incorporated is shown in FIGURE 1 as comprising a body **10** having a neck **11** projecting from one end thereof. A plurality of magnetizable strings **12**, illustrated as six in number, are mounted in tensioned relationship over the body **10** and neck **11**. Each string extends from a suitable tuning screw on the head **13** to a support or connector **14** which may form part of a vibrato or tremolo device.

The six strings **12** are mounted in spaced-parallel relationship relative to each other, such strings lying generally in a plane which is parallel to the plane of the face **16** of body **10**. By the use of the word "plane," it is not meant to exclude conventional constructions wherein the strings actually lie on the surface of a large-diameter imaginary cylinder. The various strings are supported, at a suitable point intermediate the connector element **14** and head **13**, on a bridge means **17** which rests upon face **16**.

An electromagnetic pickup **19** is mounted in body **10** at one or more points between the bridge means **17** and head **13**, one such pickup being shown in FIGURE 4 as nested in a suitable recess **20** in body **10**. The illustrated body is of the solid wooden type, although it is to be understood that hollow bodies may also be employed.

Stated generally, pickup **19** comprises permanent magnet means **22**, and magnetic circuit means **23** adapted to cause the lines of force generated by magnet means **22** to pass longitudinally through portions of strings **12** whereby such strings act as magnetic keepers or armatures. Coil means **24** are operatively associated with the means **22** and **23** in such manner that the variations in magnetic flux caused by vibration of strings **12** generate in the coil means an electrical signal corresponding to the sound produced by the vibrating strings. As indicated schematically in FIGURE 5, the coil means **24** is connected to a suitable amplifier **25** and loudspeaker **26**, there being a control resistor **27** interposed in the circuit to vary the volume of the resulting sound.

The permanent magnet means **22** is illustrated to comprise a plurality of corresponding elongated cylindrical elements formed of a magnetized permanent magnet alloy such as Alnico. Each of the magnets **22** is perpendicular to the common plane of strings **12**, the illustrated relationship being such that each magnet is directly beneath an associated string **12** so that an extended axis of the magnet will intersect the string at a right angle. All of the magnets are arranged with corresponding poles adjacent the strings **12**, for example all north poles being relatively adjacent the strings and all south poles being remote therefrom. The poles which are relatively adjacent the strings are spaced sufficiently far therefrom to permit playing of the instrument without danger that a string will engage a pole or any other portion of the pickup.

The coil means **24** is illustrated to comprise a single coil which closely encompasses all of the magnets **22**, the coil being formed of a very large number of turns of fine insulated wire. Upper and lower insulators **29** and **30**, for example, formed of a suitable fibrous material, are mounted adjacent the upper and lower surfaces of the coil **24**. Each of the insulators **29** and **30** has a plurality of openings therein adapted to receive, in close-fitting relationship, the associated ends of the cylindrical magnets **22**. An open-bottomed plastic casing or housing **31** is mounted over the insulators **29** and **30** and the coil means

24 contained therebetween, such casing also having a plurality of openings adapted to receive the respective magnets 22. The lower edge or rim of casing 31 terminates in the same plane as the lower insulator 30, both the casing and the lower insulator being substantially longer than the upper insulator 29 whereby protuberant or end portions 32 are formed as illustrated best in FIGURE 2. Such portions are provided with openings 33 to receive the screws (not shown) which mount the pickup 19 to body 10.

The magnetic circuit means 23 is illustrated to comprise a generally channel-shaped element formed of magnetizable material such as steel or soft iron, having a web 35 which is disposed between the lower insulator 30 and the bottom wall of recess 20. The web is formed with a plurality of openings each of which receives the lower end of a magnet 22, such end protruding a short distance below the lower insulator and being substantially flush with the lower surface of the web. The web openings have such sizes that little or no air gaps are provided between the web and the lower ends of the various magnets.

The channel-shaped magnetic circuit element 23 further comprises integral sides or flanges 36 which extend upwardly adjacent the outer surfaces of casing 31, the upper edges of the flanges lying generally in the same plane as the upper ends of the various magnets. The upper edge portions of the flanges are provided with a plurality of notches or gaps 37, illustrated as being V-shaped, and which form between them a plurality of teeth 38.

The locations of the notches 37 are such that the respective teeth are adjacent the magnets 22. Thus, when the pickup 19 is disposed in perpendicular relationship relative to strings 12, as illustrated, one magnet 22 and the adjacent two teeth 38 will lie directly beneath each string 12. In instruments wherein the pickup is not perpendicular to the strings but is oblique thereto, the teeth 38 should be somewhat staggered or offset in such manner that there will be (as in the illustrated arrangement) two teeth directly beneath each string 12, and a magnet directly beneath such string and directly between such two teeth. The two teeth beneath each string are, in each instance, on opposite sides of the magnet which is beneath such string.

It is emphasized that the entire pickup 19 is disposed on only one side of the common plane of strings 12, all portions of the pickup being spaced from such common plane a sufficient distance that there will be no substantial interference with playing of the instrument.

It is important to the invention that the spacing between the pickup and the plane of strings 12, the distance longitudinally of the instrument between each magnet 22 and the two associated teeth 38, and the lengths of the magnets 22, be correlated to each other in a certain manner. As will next be described, the manner of correlation is such that at least a large number of the lines of magnetic force will, when traveling between the upper ends of the magnets and the adjacent teeth, pass longitudinally through substantial portions of the associated strings 12.

Referring particularly to FIGURE 4, the situation will be described relative to a single string 12, and the two teeth 38 and single magnet 22 which are directly therebeneath. Lines of magnetic force pass upwardly into the string 12 from the north pole of the magnet, then pass downwardly from the string to the teeth 38 on opposite sides of the magnet, and then pass downwardly through the magnetic circuit element or channel 23 to the south pole. It follows that substantial sections of the lines of force pass longitudinally through portions of the string 12, such longitudinally-extending sections being indicated at 39 in FIGURE 4. Stated in another manner, each string 12 acts as a keeper or armature for the double magnet formed by the element 22 and the associated two teeth 38. The term "double magnet" is employed since the teeth may be regarded, in the illustrated example, as south poles to which the lines of force extend (via string 12) from the north pole therebetween.

It is pointed out that if the spacing longitudinally of the instrument between the north pole and each tooth were excessive, for example substantially greater than the length of magnet 22, the lines of force would not travel from the north pole to the teeth but would instead travel downwardly through coil 24 and directly to the south pole. Such an arrangement is the same as in conventional pickups wherein the magnetic circuit means 23 is not employed. In such an arrangement, large numbers of the lines of force do not reach the region of string 12 at all, instead extending downwardly through the coil to the south pole.

If each tooth were disposed close to the north pole, excessive numbers of the lines of force would travel directly from the north pole to the teeth without reaching the string 12. This condition is also not desired, it being important that the maximum number of lines of force be caused to pass through the string 12 longitudinally thereof.

As a specific example, the distance between each north pole and each of the adjacent teeth may be on the order of one-half the length of each magnet 22, and may be generally equal to or greater than the spacing between each north pole and the string 12 thereabove.

The provision of the notches 37 and associated teeth 38 is also important to the forcing of the lines of force through strings 12. If the upper edges of the flanges 36 were merely straight, the lines of force from the various poles would fan out to various undetermined positions along such edges, which would reduce the tendency of the lines of force to pass through the strings 12. Since the upper flange edges are formed with teeth, all of such teeth are of the same polarity (for example south in the present illustration). The teeth being of the same polarity, they repel each other and cause the lines of force to bunch or hump up until large numbers thereof pass through the strings. The desired magnetic keeper action is thus achieved.

The bunching or concentrating of the lines of magnetic force along paths which extend directly between the opposed teeth 38 is also highly important to the elimination of undesirable effects caused by rotation of the plane of vibration of string 12. The response of the pickup is relatively great when the string vibrates in a vertical plane, since the string is then moving toward and away from the magnet 22. In the present pickup a generally corresponding and relatively high response is achieved when the string is vibrating in a horizontal plane, so that there is relatively little difference in sound between the condition when the string is vibrating horizontally and the condition when the string is vibrating vertically. The reason there is such a high response when the string is vibrating horizontally is that the string is then moving toward and away from (and through) the bunched lines of magnetic force which extend between and teeth as set forth in the preceding paragraph. If there were no teeth the lines of force would not be bunched, and the response to vibration in the horizontal plane would be much less.

Referring to FIGURE 5, one end of the coil 24 is shown as connected through a lead 41 to the magnetizable channel 23, such channel being connected through a lead 42 to ground. The other end of the coil is connected through a lead 43 to the variable control resistor 27. Such resistor feeds into the input of the amplifier 25 and loudspeaker 26, one input terminal of the amplifier being grounded.

Operation

In the operation of the electrical musical instrument and the pickup portion 19 thereof, the various strings 12 are plucked or picked by the guitarist in the usual manner. The strings are formed of magnetizable material and act as magnetic keepers or armatures for the magnet portions 22 and 38 of the pickup 19, as described in detail above.

As each string vibrates, it effects a corresponding variation in the magnetic field which passes through the string, through the magnetic circuit means 23, and through the magnet 22. Such variation in the magnetic field produces a corresponding voltage in the coil 24. The voltage thus generated is fed through the control resistor 27 to the amplifier 25 and loudspeaker 26 so that a corresponding sound is produced in the loudspeaker.

It is to be noted that in the described arrangement each string 12 acts, along with the channel-shaped magnetizable elements, as part of the magnetic circuit means 23. In such magnetic circuit, which is somewhat in the nature of a three-legged transformer, there are variable air gaps between the teeth 38 and the string portion directly thereabove, and a variable air gap between the north pole of magnet 22 and the string portion thereabove.

In the present pickup, the generation of voltage in coil 24 results primarily from the lines of force which pass externally of the coil through the above-described magnetic circuit. Particularly since large numbers of lines of force are caused to bunch or congregate at 39 in the string 12, passing longitudinally of the string sections, the effect created in the coil 24 due to string vibration is very powerful.

It is emphasized that the present magnetic circuit means concentrates the magnetic field generated by magnet 22, and accordingly results in a greater response. If there were not element 23, the generated magnetic field would be very diffuse and would be weak at critical areas, with resulting relatively poor response to string vibration.

The result of the described arrangement is that a relatively large current and voltage are generated, in comparison to prior-art structures. Furthermore, the reproduction of the string vibration is more faithful, and the bass frequencies in particular are reproduced in an extremely desirable manner. Since the generated current is relatively high, the sensitivity of the circuit means illustrated in FIGURE 5 to extraneous electromagnetic fields (such as created by fluorescent light) is reduced in comparison to prior-art systems.

The present pick-up and instrument are to be compared with conventional instruments, in which no magnetic circuit means 23 is provided. Only very minor portions of the lines of force, or small numbers of the lines of force, reach the vicinity of the strings 12. The lines which do reach the strings pass through only very small portions thereof, with small harmonic content, not substantial portions as in the present invention. The result is that a smaller current is generated, and the tone and response produced by the pickup are inferior to that produced by the present invention.

The present invention is also to be compared with a common prior-art situation wherein the string is disposed directly between the north and south poles of a magnet means, the string being transverse to a line between such north and south poles. In such arrangements, the lines of force do not pass longitudinally of the strings but instead cut tranversely therethrough. Furthermore, vibration of the strings causes the same to become alternately more south or more north, whereas in the present arrangement the string in vibrating toward and away from the pickup moves toward both the north and south poles simultaneously, or away from both the north and south poles simultaneously, it being understood that each tooth may be regarded as a south pole as previously stated.

The thickness of the metal forming element 23 should not be made too great. If a heavy gauge metal is used, and the magnet is too large in diameter, hysteresis effects reduce the high-frequency response of the pickup. As an example, the gauge of the metal forming the channel may be 18, and magnet diameter 3⁄16 inch.

It is pointed out that the mounting of the plastic casing 31 inwardly of the flange 36 results in a more compact arrangement than would be the case if the casing were disposed externally of the flanges 36.

In the accompanying claims, it is to be understood that all of the words "south" appearing in a particular claim may be changed to "north," in which event all of the words "north" in the same claim must be changed to "south." Thus, it makes no difference whether the north poles or south poles are relatively adjacent the strings, it being the orientation of the poles relative to the poles of adjacent magnets which is important.

Various embodiments of the present invention, in addition to what has been illustrated and described in detail, may be employed without departing from the scope of the accompanying claims.

I claim:

1. An electrical musical instrument of the guitar type, which comprises a body having a face, a plurality of magnetizable strings mounted in tensioned relationship over said face and disposed generally parallel to each other, said strings lying generally in a common plane which is generally parallel to said face and spaced thereabove, an electromagnetic pickup mounted on said body beneath said strings, said pickup comprising a plurality of elongated permanent magnet elements each of which is disposed generally perpendicular to said plane of said strings and is beneath one of said strings, said permanent magnet elements being disposed in a row generally parallel to each other and in spaced relationship relative to each other, said permanent magnet elements all having their north poles adjacent said plane of said strings, a generally channel-shaped magnetizable element mounted around said permanent magnet elements, said channel element having a web disposed adjacent the south poles of said permanent magnet elements, said channel element having side flanges disposed on opposite sides of said permanent magnet elements in spaced relationship therefrom and extending upwardly to edges which are generally flush with said north poles, said edges of said side flanges and said north poles being spaced distances from each other and from said plane of said strings which are such that lines of force from said north poles will pass longitudinally through substantial portions of the strings above said north poles and will then pass downwardly to said edges and thence to said south poles, said edges of said flanges being shaped as teeth, there being only two teeth opposite each of said north poles and respectively provided on the flanges on opposite sides of said magnet elements, said two teeth and the associated north pole therebetween being directly beneath one of said strings, and coil means mounted around all of said permanent magnet elements and adapted to generate electric signals corresponding to the variations in the magnetic field of said permanent magnet elements caused by vibrations of said strings.

2. The invention as claimed in claim 1, in which said two teeth are spaced from said north pole therebetween a distance on the order of one-half the length of said magnet element.

3. The invention as claimed in claim 2, in which said teeth and said north poles are each spaced from said plane of said strings a distance on the order of or less than the spacing between each of said teeth and the north pole nearest thereto.

4. The invention as claimed in claim 1, in which a casing element is mounted over said magnet elements and over said coil means, the sides of said casing element being nested between said flanges.

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