Jan. 17, 1961 C. L. FENDER **2,968,204**

ELECTROMAGNETIC PICKUP FOR LUTE-TYPE MUSICAL INSTRUMENT

Filed Aug. 13, 1957

Fig. 1.

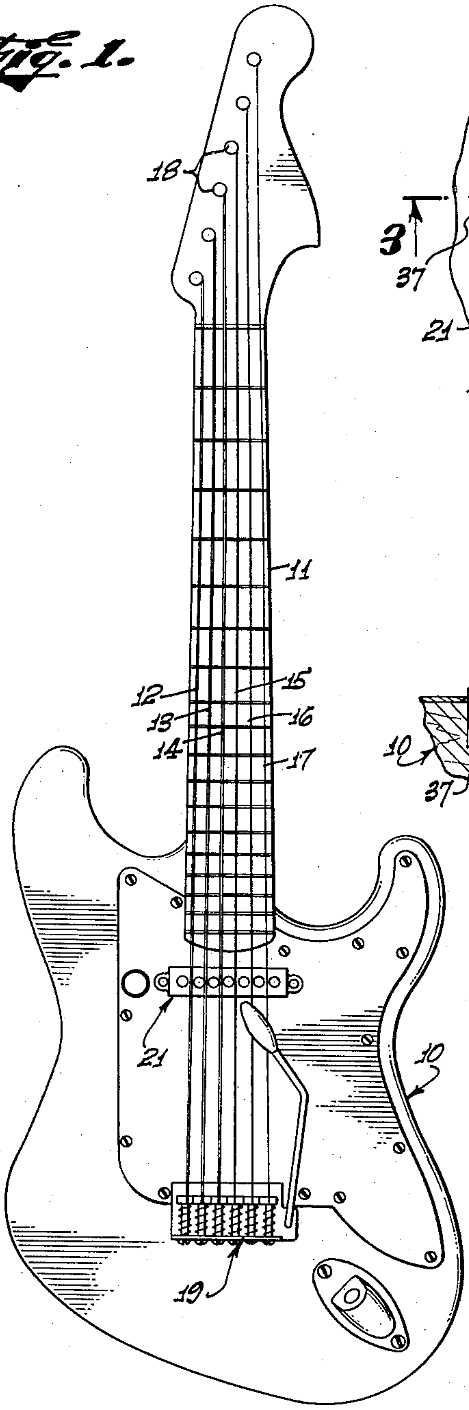


Fig. 2.

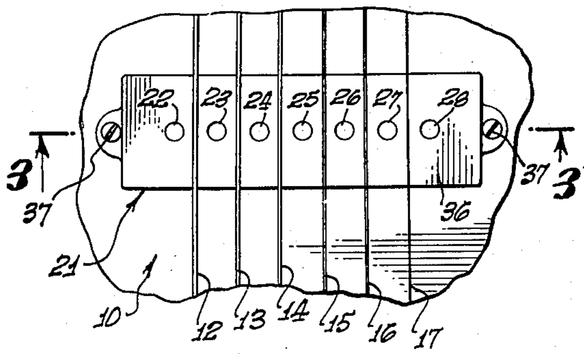


Fig. 3.

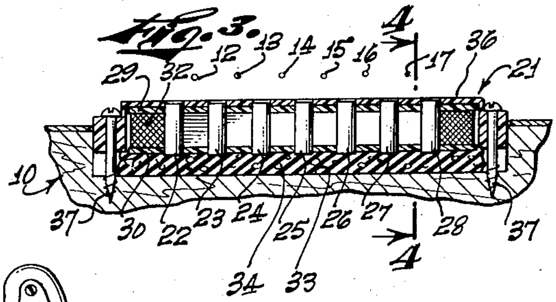
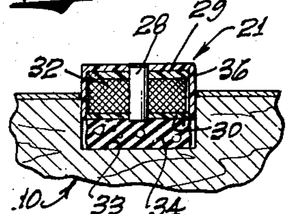


Fig. 4.



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1

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ELECTROMAGNETIC PICKUP FOR LUTE-TYPE MUSICAL INSTRUMENT

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12 Claims. (Cl. 84—1.16)

This invention relates to an electrical musical instrument of the lute type, and more particularly to an electromagnetic pickup means therefor. The invention is particularly applicable to an electric guitar or similar musical instrument in which vibration of stretched strings is effected by plucking or picking the same.

Electric guitars, and similar electrical musical instruments, are conventionally provided with an electromagnetic pickup comprising a number of permanent magnet elements associated with a conductive coil. One such magnet element is disposed directly beneath each string of the instrument, and there are the same number of magnet elements as there are strings. Vibration of each string causes a disturbance in the magnetic field of the associated magnet. This has the effect of generating a voltage in the conductive coil, which voltage is suitably amplified and transmitted to a loudspeaker.

With the above-described electromagnetic pickup construction, and with the described relationship between the magnet elements and the vibrating strings, a number of effects result which are undesirable in many situations. Such effects include, firstly, a strong, and relatively harsh, twang or percussive sound followed by a very rapid decay or attenuation to a much lower sound level. Such effects also include, secondly, a slow beating or tremolo effect, caused by rotation of the plane of vibration of the string. It is a well known principle of physics that a stretched wire first vibrates in the plane in which it is deflected, but that the plane of vibration then commences to rotate.

With relation to the first of these effects, it is pointed out that upon release of the pick or finger from the string being plucked there is a loud percussive attack sound which decays substantially instantaneously into a very much softer average sustained note. While the twang or percussive sound may be desirable for some types of music, for example rural music, it is frequently undesirable in that it is unduly harsh instead of sweet.

With relation to the second of the above-mentioned effects, it is pointed out that the slow tremolo or beating sound, caused by the rotation of the plane of vibration, is generally not desired. It will be understood that even where a tremolo is desired, it should be under the control of the musician and should not result from an uncontrollable rotation of the plane of vibration.

In addition to the above-discussed type of pickup in which a single permanent magnet is disposed directly beneath each string, there exist other types of conventional pickups. These include types in which there is a single relatively large bar magnet associated with the coil, and either with or without magnetizable pole pieces associated with the individual strings. Such pickups, however, have substantial defects which include a poor response to the high frequencies. It will be understood that where a relatively thin magnetizable wire is vibrating in the field of a large bar magnet, the amount of disturbance of such field, with consequent voltage generation in the associated coil, is small. The eddy current, capacity, inertia and other effects are particularly undesirable where large magnets

2

are employed, and the results of such effects are most apparent in the high frequency response.

In view of the above and other factors characteristic of electrical lute-type instruments, and electromagnetic pickup means therefor, it is an object of the present invention to provide a lute-type musical instrument incorporating a novel electromagnetic pickup construction and a novel relationship between the strings of the instrument and the magnet elements of the pickup.

A further object is to provide a pickup, for electric guitars and the like, which produces in a loudspeaker a note which is much sweeter, more sustained without initial extreme percussive effect and rapid decay or attenuation, and much more free of beats or tremolo than in the case of a note produced in the loudspeaker by a conventional pickup device.

A further object is to provide an electromagnetic pickup means having an excellent high and low frequency response, and characterized by relative freedom from undesired tremolo effects and from harsh drumming or twanging effects.

A further object is to provide an electromagnetic pickup construction in which the level of the sustained note is relatively high in comparison to the level of the initial sound, yet in which the high frequency response is excellent.

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 plan view of an electric guitar constructed in accordance with the present invention;

Figure 2 is an enlarged fragmentary plan view of the pickup region of the guitar illustrated in Figure 1;

Figure 3 is a section on line 3—3 of Figure 2; and

Figure 4 is a section taken on line 4—4 of Figure 3.

Referring to the drawing, and particularly to Figure 1, the invention is illustrated as incorporated in an electric guitar having a body 10 and a neck 11, the latter being provided with a conventional fretted fingerboard. Extended over the fingerboard and over a portion of the body 10 are a plurality of strings, numbered 12–17 inclusive, which lie in a single plane parallel to the face of the body. The strings 12–17 may extend between conventional tuning pegs 18 and a suitable anchoring device on the body 10. For example, the strings may extend to a tremolo device 19 such as is illustrated in my Patent No. 2,741,146, for a Tremolo Device for Stringed Instruments, issued April 10, 1956.

The strings 12–17 are constructed of a magnetizable substance, such as steel, and are graduated in diameter in a conventional manner. The strings being magnetizable, they may be associated with an electromagnetic pickup device 21 which forms the primary subject matter of the present application and which will be described in detail below. It is pointed out that the strings may be of conventional construction and not special magnet alloys.

It is to be understood that the pickup device 21 may be located at various longitudinal positions on the body 10, in accordance with the relationships it is desired to sense between the fundamental tones and the harmonics. The pickup may also be located on the neck 11, but this tends to eliminate some of the benefits achieved by the invention.

Throughout this specification, the sounds referred to are those which are produced in a suitable loudspeaker, indicated in Figure 2, to which the conductive coil of pickup device 21 is connected through suitable amplifying means. It is not the understanding of applicant that the pickup device 21 alters the actual, physical vibration of the strings 12–17, but instead alters, as compared to conventional pickup devices, the sounds generated in a loudspeaker as the result of vibration of the strings.

Pickup device 21 is illustrated to comprise a plurality of identical permanent magnet elements 22–28, inclusive, preferably formed of a permanent magnet alloy such as Alnico. The number of magnets is one greater than the number of strings, or seven in the present illustration. Magnets 22–28, which may also be referred to as magnetized pole elements, are illustrated as being cylindrical in shape, and are mounted in parallel relationship between a pair of plates 29 and 30 formed of fibreboard or other suitable non-conductive and non-magnetizable material. In the illustrated embodiment, the cylindrical magnets 22–28 are suitably mounted through rows of openings in plates 29 and 30.

A coil 32, formed of a large number of turns of fine conductive wire, is mounted around the group of magnets 22–28 between plates 29 and 30. The wire in coil 32 is insulated, such as with varnish or lacquer, and the entire assembly comprising the magnets, plates and coil is preferably dipped in a suitable varnish or lacquer. As previously indicated, the ends of the wire in coil 32 are connected through suitable amplifying means to a loudspeaker.

The pickup device 21 is illustrated as mounted in a suitable recess 33 in the wooden body 10, and is shown as supported on a sponge rubber cushion 34. A cap or cover 36, preferably formed of a suitable plastic such as nylon, is mounted over the upper plate 29 and is secured to the body 10 by means of screws 37. Tightening or loosening of the screws 37 effects downward or upward movement of the pickup device under the bias of cushion 34, in order to adjust the distance between the magnets 22–28 and strings 12–17. Cap or cover 36 is shown as being apertured to receive the upper end of each magnet 22–28.

According to the invention, the magnets 22–28 are mounted in straddling relationship relative to strings 12–17, by which it is meant that each string is disposed between two adjacent magnets. Particularly where the magnets are of equal strengths, each string should be located substantially midway between two adjacent magnets. This is to be contrasted with the above-indicated pickup constructions in which a magnet or pole element is disposed directly beneath, or in the same plane as, an associated string.

The magnets 22–28 are mounted parallel to each other, and perpendicular to the plane of the strings 12–17, in a row which extends transverse to the strings. The magnets are spaced equal distances apart, and the upper ends of the magnets lie in a plane which is parallel to and spaced below the plane of the strings. Imaginary extensions of the axes of the magnets pass substantially midway between the adjacent strings, so that each string lies substantially midway between the extended axes of two adjacent magnets. The centers of the magnets are spaced apart by distances substantially equal to the spacing between the strings and, as stated heretofore, the number of magnets is one greater than the number of strings.

Magnets 22–28 are so related that all of the north poles or all of the south poles are adjacent the strings 12–17. The upper ends of adjacent magnets being of like polarity, they tend to repel each other, but both attract the associated strings.

The theory of operation of the present pick-up string relationship is not readily provable. It is pointed out that the present patent application is primarily directed not to theory but instead to the practical working relationships and ensuing unexpected results, the value of which has been proved by numerous tests. The following represents applicant's best present understanding of the theory of operation.

Referring first to the prior art situation where a single bar magnet, without pole pieces, is employed for all strings, the high frequency response is poor because of the inertia, eddy current and capacitance effects previously mentioned. Furthermore, the tremolo or beat effect caused by rotation of the plane of vibration is especially bad. This is because a string, when initially plucked or deflected, momentarily remains generally in the plane of the strings or parallel to the bar magnet. While the string is thus vibrating parallel to the bar magnet it produces relatively little effect on the field of the magnet since the distance from the magnet remains constant. The voltage generated in the coil is thus small, and the sound is weak. When, however, the plane of vibration rotates until the string is vibrating perpendicularly to the magnet, the constant variation in the distance between the string and the magnet causes a large disturbance in the magnetic field with resultant relatively large induced voltage and loud sound. A distinct, uncontrollable tremolo thus is created, having a frequency determined by the speed of rotation of the plane of vibration of the string.

There will next be discussed the prior art situation in which an individual small magnet is located directly beneath each string. With such an arrangement (and with corresponding arrangements incorporating a large bar magnet having individual pole pieces located directly beneath each string), the initial percussive sound is harsh, the amount of initial decay is excessive, and tremolo or beating is pronounced. Again considering the situation in which a string is initially picked, it is pointed out that the pick or finger initially moves the string (in approximately the plane of the strings) from a position close to its associated magnet to a position relatively remote therefrom. Since each string is only substantially affected by the one magnet adjacent thereto, such initial movement results in demagnetization of the string. Also, such initial movement produces no sound since the speed of movement is much lower than an audible frequency.

Immediately upon release of the pick or finger from the string deflected as above stated, the demagnetized string moves very rapidly into a position closely adjacent the magnet. Such rapid movement, and consequent magnetization or charging of the previously demagnetized string, results in a great disturbance in the magnetic field. The result is the harsh hammer or drum sound above mentioned.

After the released string rushes into a position above the magnet, it begins, substantially instantaneously, to vibrate at its natural frequency and in the plane of the strings. The amplitude of such subsequent vibrations is relatively small as compared to the amplitude of the initial vibration, which means that the degree of string magnetization is not greatly altered by such subsequent vibrations. This, plus the fact that the vibrations (in the plane of the strings) do not appreciably alter the distance between the string and the magnet, mean that the degree of disturbance of the magnetic field is small and the sound is weak. The rate of initial decay or attenuation is thus high, it being pointed out that the sound volume a split second after release of the pick is a small fraction of the sound volume of the initial twang.

The plane of vibration of the vibrating string then rotates until the string is vibrating up and down, that is to say toward and away from the magnet. The constantly changing distance between string and magnet makes the sound louder, since the disturbance of the magnetic field is greater than when vibration is horizontal or in the plane of the strings. A pronounced beating effect therefore results as the plane of vibration rotates.

Proceeding next to the theory of operation of the present invention, let it again be assumed that a string is deflected by a pick or finger and in the plane of the strings. The string is thus moved, at a speed insufficiently great to produce a sound, from a position of relatively low magnetic field strength (between two magnets) to a position of relatively high field strength (above a magnet). The string thus becomes magnetized, or magnetically charged, without substantially disturbing the field of the magnet over which it is deflected. Upon release of the pick or finger, the string moves rapidly to a position (between two magnets) where the magnetic field is less. This, however, does not greatly disturb the field of the magnet over which it was initially deflected, since the movement of the magnetized or charged string produces a relatively small disturbance in the magnetic field. This is in contrast to the above-discussed situation in which an uncharged string moves rapidly into a strong magnetic field. The described operation of the present invention, upon initial release of the pick or finger from a string, greatly reduces the initial percussive sound and results in a much more pleasant sound than that produced by multipole equipment of the type discussed above.

After the finger or pick is initially released, the string commences to vibrate in the plane of the strings as stated heretofore. The string thus moves alternately toward and away from the magnets on both sides of it, becoming first charged by one magnet and then by the other. This produces a substantial field disturbance and consequent high sustained sound level in comparison to the initial sound level. The amount of initial decay is thus greatly reduced as compared to the above-described multi-magnet equipment.

When the plane of vibration rotates until the string is vibrating upwardly and downwardly, there is still a substantial field disturbance since the string is moving alternately toward and away from both of the adjacent magnets. The high sound level is thus maintained.

It has been found that the amount of magnetic field disturbance, and consequent sound level, is relatively uniform regardless of the plane in which the string is vibrating. Consequently, the undesired tremolo or beating effect is greatly reduced or eliminated.

It is an extremely important feature of the present invention that the sound which emanates from the loudspeaker, as the result of operation of the present pickup, is much more like the sound produced by an acoustic (non-electric) guitar than when prior-art pickups are employed. Thus, the present sound has much color, timbre, etc., and is relatively high-pitched as compared to the sound produced by a conventional electric guitar. According to applicant's best understanding, this is because one pulse is produced when a string (such as **12**) moves toward one adjacent magnet (such as **22**), and a second pulse is produced when the string moves toward the other adjacent magnet (such as **23**). The result is a double-frequency component much like that produced in the sounding board (face) of an acoustic guitar when a string thereof vibrates. It is pointed out that the string of an acoustic guitar becomes taut (relatively bowed) twice during each full cycle or vibration, and that an impulse is transmitted through the bridge to the sounding board each time the string becomes taut. Thus, an acoustic guitar produces a double-frequency component as does the present electric guitar.

Throughout this specification and claims it is to be understood that such phrases as "plane of the strings," "parallel to the plane of the strings," etc., should not be construed to mean that the strings must lie precisely in a plane. Thus, for example, the invention is equally applicable to a guitar in which the strings lie on the surface of one small section of an imaginary large diameter cylinder. With such guitars the upper ends of the magnets should lie along an arc generally parallel to the arc of the strings.

In the appended claims, the word "pick-up" is employed to denote the individual elements such as **22, 23, 24, 25, 26, 27** and **28**, for example, and does not denote the entire magnet and coil assembly.

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 string type, including a plurality of electromagnetic type pick-ups operatively associated with the strings of said instrument, said pick-ups lying in a plane spaced from the common plane of said strings, each of said strings being disposed in a plane extending through a space between two adjacent ones of said pick-ups.

2. The invention as claimed in claim 1, in which said last-mentioned planes respectively containing said strings are substantially perpendicular to said common plane of said strings.

3. The invention as claimed in claim 1 in which each of said pick-ups comprises a magnetized element, in which all portions of each of said magnetized elements lie on one side only of said common plane of said strings, and in which coil means are operatively associated with said magnetized elements for generation of an electrical signal in said coil means in response to disturbance of the fields of said magnetized elements.

4. The invention as claimed in claim 1, in which said pick-ups comprise a plurality of elongated permanent magnets disposed in laterally spaced relationship relative to each other, in which all portions of all of said magnets lie on one side only of said common plane of said strings, in which the extended longitudinal axis of each of said magnets passes between two adjacent ones of said strings, and in which coil means are inductively associated with said magnets for generation of signals in said coil means in response to disturbance of the fields of said magnets.

5. The invention as claimed in claim 4, in which said longitudinal axes of said magnets are substantially perpendicular to said common plane of said strings.

6. The invention as claimed in claim 4, in which like poles of those of said magnets which are associated with each one of said strings are disposed relatively adjacent said common plane of said strings.

7. The invention as claimed in claim 6, in which those of said magnets which are associated with each one of said strings are disposed sufficiently close together that the fields adjacent said like poles repel each other.

8. The invention as claimed in claim 4, in which said coil means includes a single coil of wire mounted around the magnets associated with at least two adjacent ones of said strings.

9. The invention as claimed in claim 4, in which the number of said magnets is one greater than the number of said strings.

10. The invention as claimed in claim 1, in which said pick-ups comprise a plurality of laterally-spaced permanent magnets disposed on one side only of said common plane of the magnetizable strings of said instrument, in which two adjacent ones of said magnets have like poles disposed sufficiently close to a single one of said strings that vibration of said single string disturbs the fields of said two adjacent magnets, in which a plane containing said single string and perpendicular to said common plane of said strings passes substantially midway between said like poles when said single string is at rest, and in which coil means are operatively associated with said magnets to sense disturbances in the fields thereof.

11. The invention as claimed in claim 1, in which said electrical musical instrument is an electric guitar including a body having a face; in which means are provided to mount said strings in tensioned relationship generally parallel to each other and generally in a plane parallel to said face and spaced thereabove, said strings being formed of magnetizable material, said strings being substantially equally spaced relative to each other; in which said pick-ups include a plurality of elongated permanent magnets disposed generally parallel to each other and generally perpendicular to said common plane of said strings, all portions of all of said magnets being

disposed on only one side of said common plane of said strings, the ends of said magnets which are nearest said common plane of said strings being spaced therefrom, said ends of said magnets being sufficiently close to said common plane of said strings that vibration of each of said strings disturbs the fields of two adjacent magnets, said magnets straddling said strings in such manner that extensions of the axes of the two magnets magnetically associated with each undeflected string pass on opposite sides of such string; and in which electric coil means are inductively associated with said magnets and in such manner that the voltages generated in the coil means for at least two strings due to vibrations of said two strings are in adding relationship, said coil means being adapted to be connected to a loudspeaker.

12. The invention as claimed in claim 11, in which the magnet ends adjacent said common plane of said strings and associated with at least two adjacent ones of said strings are of like polarity, and in which said coil means includes a single coil of wire encompassing all of the magnets associated with at least said two adjacent ones of said strings.

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