ABSTRACT: A variable reluctance guitar pickup system which provides six individual pickups for the six steel strings, each developing an output voltage with string movement which is substantially insensitive to the plane of string vibration. The pickups have a central post of one magnetic polarity and a U-shaped enclosing yoke of opposite polarity. The string passes centrally through the yoke such that displacement of the string in any direction changes the reluctance of the magnetic circuit to which a pickup coil is sensitive. The yokes, all of the same polarity, provide extremely high isolation of the individual magnetic circuits and sound signals. The organization provides for ease of assembly and ready removability and replacement of the individual pickups which are in cartridge form and interchangeable.
VARIABLE RELUCTANCE GUITAR PICKUP SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

Guitar pickups for steel string guitars or similar instruments which provide an electrical musical signal for each string independently by variation of the reluctance of a magnetic circuit which includes the playing string.

2. Description of the Prior Art

Pickups which provide an electrical musical signal for each of the strings, usually six, of a guitar or similar instrument by variation of the reluctance of a magnetic circuit with string vibration are not broadly new. In general they provide a pickup of one magnetic pole-magnet circuit than equal vibration in other planes. This has an effect upon the quality of the output which is important in some systems at least. The possible signal voltage is also reduced insofar as string vibration in some planes contributes only very little to the output. Another disadvantage which is sometimes highly important is that isolation as between the several magnetic circuits is not very good even if provided with an individual pickup coil for each string, with the result that vibration of a particular string may induce considerable crosstalk in more than one pickup coil. With the popular variety of transducer systems available a common coil embraces all of the magnetic posts, thus, output is a composite of all signals and crosstalks and no individual signal isolation is even attempted.

SUMMARY OF THE INVENTION

With the system of the present invention each of the separate pickups has an inverted U-shaped yoke which is maintained at one magnetic polarity and a central pole of opposite polarity. The end of the central pole is so positioned that a string passing through the yoke is equal or slightly less distant to the central pole than to the yoke throughout its 180° curved portion. The yoke is considerably longer than the central pole and projects beyond it in both directions. It, therefore, acts as an effective magnetic shield for the central pole. Furthermore, all of the yokes are of the same polarity and hence, an adjacent vibrating string for another pickup cannot appreciably change the reluctance of the magnetic circuit of a particular pickup. This is particularly true since each pickup has its own entirely independent magnetic circuit. The pickups are provided with an electrical connection to the output so that as the strings vibrate, they will develop a maximum angularity through the yoke which contributes to the output as will appear.

All of the individual pickup cartridges each of which includes the permanent magnets, the yoke, the central pole member and the signal coil, are identical and are fabricated separately and slid into place such that they make mechanical and electrical connections with a mounting member attached to the guitar body.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings

FIG. 1 is a perspective view of the pickup system associated with the contiguous portion of a guitar;

FIG. 2 is end elevation of the pickup which may be considered as taken in the direction of the arrows along the line 2-2 of FIG. 1;

FIG. 3 is a partial elevational view; a portion of the cover and base plate are in section, which is taken substantially along the line 3-3 of FIG. 1 in the direction indicated by the arrows;

FIG. 4 is a partial horizontal elevational view, looking downwardly as indicated by the arrows along the line 4-4 of FIG. 2 with a portion of the cover in section;

FIG. 5 is a vertical sectional view which may be considered as taken along the line 5-5 of FIG. 4 as indicated by the arrows; and

FIG. 6 is a transverse sectional view taken in the direction of the arrows along the line 6-6 of FIG. 5.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1, the pickup system 14 includes as principal elements, six pickup cartridges 16 through which the strings pass, together with appropriate mounting structure, a signal cord 18 having a connector 20 which plugs into a complementary fitting 22 on the pickup and a cover 24 which serves as both a protective element and also as an electrostatic shield and as a means for grounding electrostatic charges on the player. The bridge support which do not show in this view are beneath the cover 24.

The pickup system shown in the more detailed views comprises a base plate 26 attached to the guitar body and the principal portion of the mechanism which is removable secured thereto. The base plate lower surface fits the top of the guitar body and is secured thereto by screws not shown. It has a pair of threaded posts 28 that are welded into counterbored holes on the underside of the base plate to maintain side view perpendicularity and front view parallelism with the guitar body. A bridge 30 is seated on hubbed and threaded leveling wheels 97 threaded upon the posts. The edges of the wheels are knurled and contain 90° holes for easy rotation, as with a paper clip. The extended thread in the hub of these wheels increases the stability of the system. The undersurface of the bridge chassis contains an oblong hole 101 on one side and a round hole on the opposite side which is aligned onto the leveling wheel hubs. The strings of the instrument when tightened on the string support blocks 40, subsequently to be described, supports the seated system firmly in place on the base plate lever 97.

When securing the base plate 26 to the guitar body and the bridge chassis to the base plate, molded shims as necessary may be interposed to achieve the proper spacing, the ultimate objective being to achieve a proper fit with the guitar body and to support the bridge at an appropriate level relative to the frets on the guitar neck.

The bridge chassis 30 is formed of heavy nonmagnetic sheet metal, brass for instance, its rearward portion forms a flat base as at 22 and has a turned up rearward flange 34 through which six adjustment screws 36 extend. These screws are parallel and are piloted at their front ends in tabs 38 wherein the threads on the steel screws 36 have been removed at the ends to prevent enlargement of the tab holes. The tabs are struck upwardly from the chassis metal. Each of the screws is threaded through a string support block 40 so that when the screws are turned the blocks move forwardly or backwardly. To prevent them from rocking, they have flat bottom surfaces with projections that are guided in narrow slots in a thin flat plate 42 secured to the chassis plate 22 by rivets 44. This plate 42...
covers the openings, not shown, which are formed when the tabs 38 are struck out and generally guide the blocks 40. Supporting the string blocks in this manner offsets production tolerances and provides vibrationless performance. Springs 46 surrounding the screws 36 are wound in a reverse direction to the screw threads to prevent binding or spring rotation and bear against the blocks and prevent the mechanism from rattling. They also hold the screw heads against the flange 34 and aid in preventing change in the setting once the bridge block has been adjusted for proper string length. The flat portion 32 of bridge chassis 30 is extra wide to accommodate a complete latitude of string separation by block adjustment. Thus, eliminating the need to twist the assembly which is a common necessity for tuning string support blocks on guitars.

Forwardly of the tabs 38 the chassis 30 is offset downwardly and the portion 48 ahead of the offset forms a shelf to which an electrical receptacle case 50 is secured by screws 53. This receptacle case has socket sleeves 52 which provide for plug-in electrical connection to pins 54 on each of the pickup cartridges 16. The sleeves 52 are connected to seven pins, not shown, at the case end which form electrical connection with socket sleeves, not shown, but molded into the terminal connector 20 at the end of the signal cord 18. The seven signal leads in the cord 18 include one referred to as the drain which is common to one side of all pickup circuits and six which connect separately to the other electrical side of the individual pickups. To insure that the connector 20 will not inadvertently be pulled loose, the cord 18 is gripped just behind the connector by a clamp 51 tightened by a thumb nut 54. In addition, the connector 20 and electrical receptacle case 50 have an internal interlock in the front end of the receptacle case, upon insertion of connector 20. To disengage from the interlock, the cord 18 must be pulled from the clamp 51 by loosening thumb nut 54 then a light pull at the cord end of the connection will effect the release.

Just in front of the receptacle case 50 the chassis is formed into six pickup cartridge support tines 56 which are bent upwardly slightly and then forwardly so as to be parallel to the rearward portion 52 of the chassis. These tines are identical excepting that the two in the center are at a higher level than those outwardly thereof and the latter are higher than those at the edges FIG. 2. The same is true of the bridge string supports 40 FIG. 3. Thus, the upper surface of the group of strings presents the usual diverging convex configuration relative to the fret board and the individual pickups 16 can be identical as will appear and still be properly located relative to their inductance, the tension, the clip connecting the strings and the bridge. The connector sleeves 52. The front ends of the tines are bent in slightly toward the center line so that each is parallel to its string, the strings passing from notches 58 in the bridge string support blocks 40 to the notches in the nut, not shown which as is customary, are closer together than those at the bridge.

The individual pickup cartridges 16 include an inverted U-shaped yoke member 60 of magnetic material which has paralleled legs 62 and a semicircular connecting portion 64 at the top. To give some idea of scale, in the embodiment shown, the overall length from the center of the curved portion 64 to the ends of the legs is about nine-sixteenths inches. From front to back, parallel to the string it is about seven-sixteenths inches. Internally, the distance between the legs is about three-sixteenths and the metal is about one-thirty second inch thick. A pole piece 68 of magnetic material is centrally disposed between the legs and is formed of material similar to that of the yoke. Its overall length vertically is about eleven thirtyseconds. The lower portion 70 of the central pole piece 68 has the same length horizontally as the yoke, but the upper portion as shown in FIG. 5 is only about one-third as long. This upper portion 72 is centrally located both transversely and longitudinally with respect to the yoke.

A pair of permanent magnets 74 of the resilient type are located on each side between the bottom portion 70 of the central pole piece 68 and the legs 62 of the yoke. Since magnets of this type have a lower induction value than Alnico magnets, increasing the area compensates for this factor. Further, since the coercivity of resilient magnets is higher than Alnico, short flat magnets have a decided advantage. These magnets conform to the surface dimensions of the pole piece portion 70 so that the narrow pole extension 72 projects thereabove. The lower portion 70 of the central pole piece is about double the yoke wall thickness, serving as the flux path for both magnets. It is important that saturation does not occur which would introduce undesired leakage. In addition, the increased thickness also serves as a spacer for the yoke opening needed for string movement, the size of the coil that can be used and the thin magnets that are required. The upper portion 72 is thinner than lower portion 70 to provide even more coil space and to reduce the flux leakage to the yoke walls. The upper pole piece portion 72 is not reduced dimensionally to a point where saturation can be approached. The magnets are inserted during assembly so that they have like poles against the pole piece 68. As shown in FIG. 6, for instance, the North poles of the magnets 74 are against the pole piece 68 and the South poles against the legs 62 of the yoke 60. Thus, the top portion 72 of the central pole 68 has a North polarity whereas, the upper portion of the yoke has a South polarity. The magnetic circuit through the air is therefore between the inside of the yoke and the upper portion of the central pole. This portion of the circuit is well shielded by the yoke and there is, therefore, very little stray flux outside the yoke.

The top pole portion 72 is provided with a coil form 76 wound with a coil 78. The coil leads 80 are connected to the previously mentioned pin terminals 54 which are carried by a thin reinforced plastic panel 82. The coil leads are protected from shorting against portion 70 of the central pole piece by a plastic termination gently 90 thereon. On each side, the faces of the yoke legs 62 are embraced by nonmagnetic sheet spring metal bracket members 84, formed of hard copper alloy for instance, and the assembly is held together by nonmagnetic rivets 86 passed through aligned holes in the several elements. The bracket members 84 are bent around the front of the cartridge to protect the coil 78 and extend below the yoke 60 and are bent so as to embrace the time 56 to form a light press fit. At its ends the two bracket members are also formed to provide spring fingers 88 which press resiliently against the edges of the tine and spring fingers 90 which bear against the tine from beneath. Rearward extensions of the brackets are shaped as at 92 to grasp the terminal panel 82 at side edges. The cartridge assembly, therefore, can be passed upwardly between the yoke and the pins 54 will enter the socket sleeves 52 and make the electrical connections simultaneously with the mechanical mounting.

The rearward portion 32 of the chassis has side wings 94 which are bent upwardly and somewhat inwardly to carry the previously mentioned cover 24 which is recessed on the underside for snap action installation on the bridge chassis wings and is further secured thereto by screws 96. Preferably this cover should be formed of nonmagnetic metal or metal plated plastic material so as to provide electrostatic shielding and grounding for the musician as well as providing physical protection for the pickup elements and generally dressing up and snap-proofing the arrangement. If formed of plated plastic material, it is preferable to plate the inside as well as the outside of the cover so that grounding of the cover to the wings 94 takes place automatically when the cover is attached. The bridge chassis 30 is in turn connected to the drain wire within the receptacle case 50 via a thin copper alloy strap 100 which emerges from an aperture on the underside of the case and is clamped between the case and the chassis when screws 53 are tightened.

After the mounting plate 26 has been attached to the guitar and the chassis secured thereto as previously described, the strings 12 are threaded through the yokes 60 and are secured to whatever anchorages for the strings are provided by the
guitar. For strings that are not easily removable for threading, gaps can be provided on the centerline of the semicircular region of the yokes for entry. Hence, the yoke would be comprised of two pieces. For ease of manufacture, however, the yoke member is best left as one complete piece part. The strings are rested in the notches 58 and are tightened and tuned in the customary fashion, the string supports 40 being adjusted as necessary. The stringing operation will be facilitated if the cover is removed and subsequently replace.

When properly set up, the strings will pass centrally through the yokes at about or slightly below the center of curvature of the top portion 64. The distance from the string to the end 72 of the central pole is equal or less than it is to the yoke either at its sides or at the top. The relationship is approximately as shown in FIG. 6, for instance. The magnetic flux is, therefore, strong from the pole end 72, to the steel string 12 and thence to the yoke 60. If now it is assumed that the string is moved horizontally in either direction, its distance to the yoke will be reduced, but the distance from the central pole 72 will not be changed as much. The total flux path length through the air will, therefore, be reduced and the flux density through the magnetic circuit including the coil 78 will be changed. If now it is assumed that the string moves downwardly from its rest position, the distances to the yoke sides will remain the same but the distance to the end pole 72 will be reduced and the magnetic reluctance of the circuit is, therefore, changed. If the string moves upwardly, the distance to the yoke is reduced, but the distance to the central pole 72 is increased. Note, however, that since the starting position of the string is closer to the pole end 72, increase of the shorter distance will have more of an effect to change the total reluctance than an equal decrease in length of the longer path. This is because the reluctance of a magnetic circuit which is contributed by a air-gap that is not small approaches a function of the square of the distance.

As the string moves in vibrating, it not only shifts from side to side and up and down as mentioned above, but the portion in the pickup which is close to the bridge support also is inclined relative to the notch 58. This inclination causes the string to be closer at the front edge of pole end 72 than at its back edge. During movement of the string from side to side or upwards and downwards, it is even closer to the front edge of the yoke and the central pole than it is at the rearward edges of these elements. The effect of this is to increase the change in the reluctance of the circuit as the string moves away from its rest position.

From the above it will be seen that vibration of the string in any major plane of its elliptical movement will produce a signal output which will not change appreciably as the plane of vibration precesses, but is more truly representative of vibration amplitude only. It is also apparent that since the magnetic flux path for each string and pickup is substantially wholly within each pickup yoke and since no part of the magnetic circuit for any pickup is common to another, extremely good isolation between adjacent pickups is achieved together with extreme insensitivity to external hum fields.

Although the invention has been illustrated and described as applied to a conventional six string guitar, it can, of course, by the use of more or fewer pickup cartridges and apparent revision of the other structure be adapted to other stringed instruments, such as four string bass guitars or mandolins, or even in instruments with many strings, pianos for example. With an external filter system for selection of the desired electrical components, the pickup system can, of course, have even wider application.

Having described the invention, what is claimed as new and useful is:

1 claim:

1. An electrical pickup system for a stringed musical instrument having strings of magnetic material comprising means providing a pole of magnetic material at one side of a string in proximity thereto, means providing a yoke of magnetic material having a portion in proximity to said string enclosing a length of said string in the region of said pole and on substantially all sides of said string other than the said one side, means providing a magnetic circuit between said pole and said yoke, said magnetic circuit including permanent magnet means for providing a magnetic polarity at said pole opposite the magnetic polarity of the yoke portion in proximity to said string, and a pickup coil secured in inductive relation to said magnetic circuit.

2. The pickup system of claim 1 in which said yoke in the dimension parallel to said string extends beyond said pole in both directions.

3. The pickup system of claim 1 in which said string when at rest is equal or closer to said pole than to said yoke.

4. The pickup system of claim 3 in which said string when at rest is substantially equidistant from said yoke through out half the string circumference.

5. The pickup system of claim 1 in which said yoke encloses said pole, said permanent magnet means and said coil.

6. The pickup system of claim 2 in which said string when at rest is equal or closer to said pole than to said yoke.

7. The pickup system of claim 6 in which said string when at rest is substantially equidistant from said yoke throughout half the string circumference on the side opposite said pole.

8. An electrical pickup system for a guitar with strings comprising a chassis for securement to guitar, a plurality of bridge string supports secured to said chassis, said chassis having a plurality of pickup cartridge mounting elements individually in vertical planes passing through strings supported by said string supports, said mounting elements all being individually the same distance from their respective strings, and a plurality of identical pickup cartridges, one for each string of the guitar, comprising means providing a pole of magnetic material at one side of a string in proximity thereto and means providing a yoke of magnetic material having a portion in proximity to last-mentioned string enclosing a length of said string in the region of said pole and on substantially all sides of said string other than the said one side, said pickup cartridges removably secured to said mounting elements.

9. The pickup system of claim 8 in which said chassis and said pickup cartridges have mutually engaging electrical terminal adapted to engage when said cartridges are secured to said mounting elements and to separate when said cartridges are removed from said mounting elements.

10. The pickup system of claim 8 in which said bridge string supports are individually longitudinally adjustable on said chassis.

11. The pickup system of claim 8 in which said chassis is vertically adjustable to provide proper string positioning relative to the guitar frets.