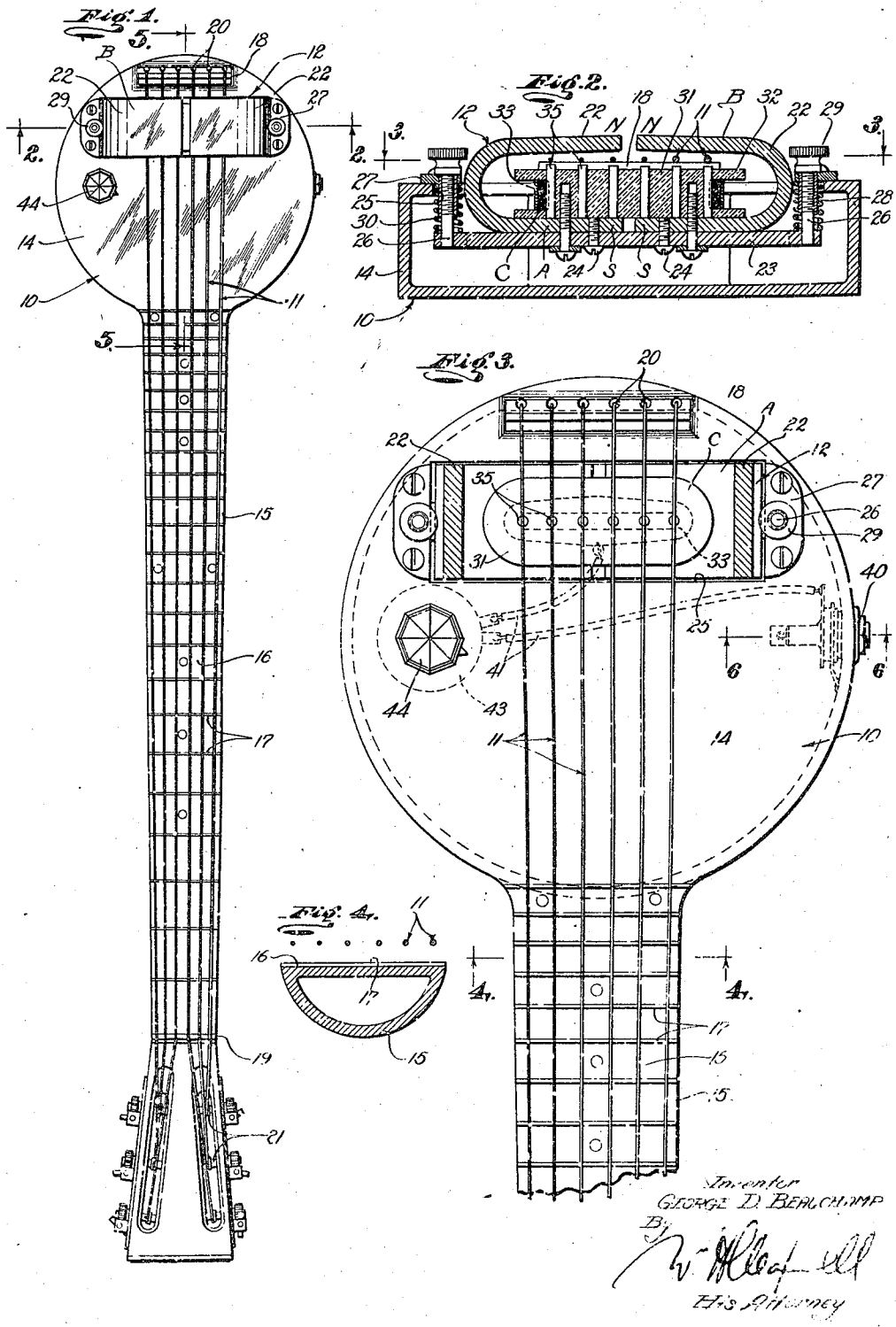
Aug. 10, 1937. G. D. BEAUCHAMP 2,089,171

ELECTRICAL STRINGED MUSICAL INSTRUMENT

Filed June 2, 1934 3 Sheets-Sheet 1



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ELECTRICAL STRINGED MUSICAL INSTRUMENT

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Fig. 5.

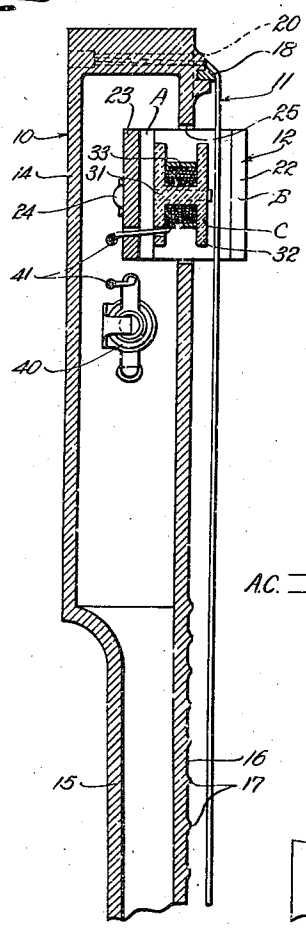

Fig. 6.

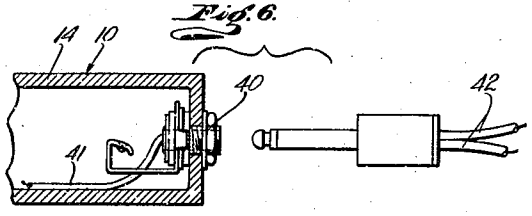

Fig. 7.

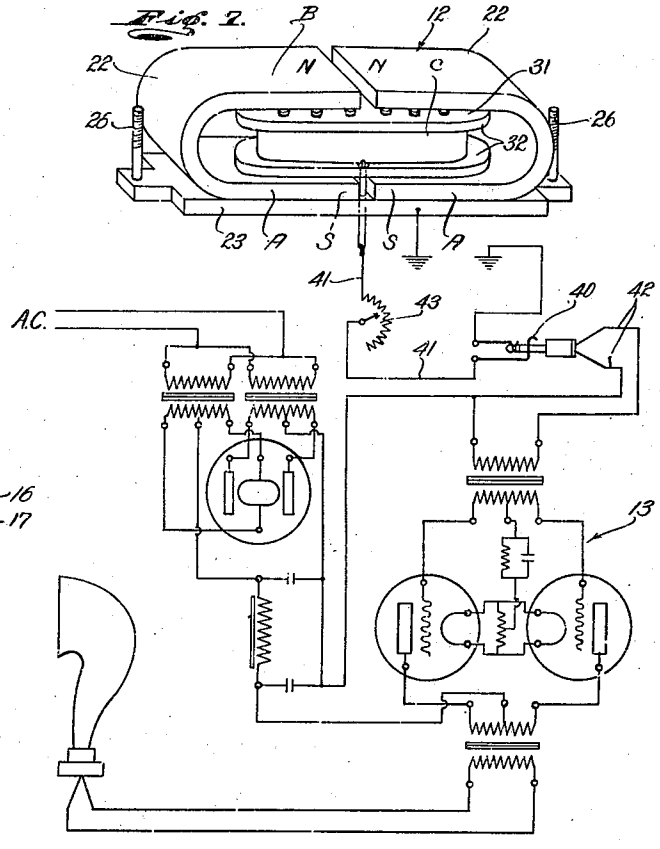

Fig. 8.

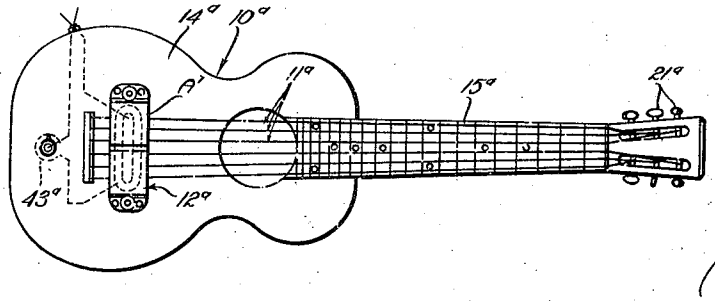

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Fig. 9.

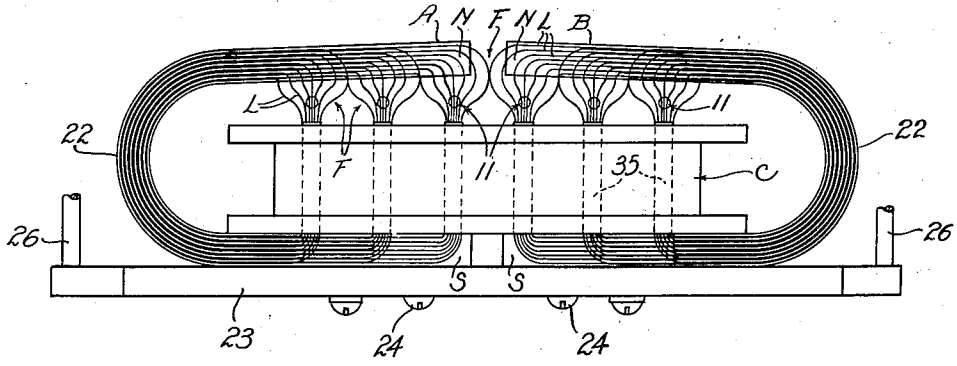
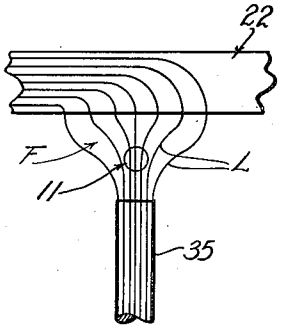


Fig. 10.



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Patented Aug. 10, 1937 2,089,171

UNITED STATES PATENT OFFICE

2,089,171

ELECTRICAL STRINGED MUSICAL INSTRUMENT

George D. Beauchamp, Los Angeles, Calif., assignor to Electro String Instrument Corporation, Los Angeles, Calif., a corporation of California

Application June 2, 1934, Serial No. 728,717

21 Claims. (Cl. 84—1)

This invention relates to musical instruments and it is a general object of the invention to provide a simple, practical and improved electrical stringed musical instrument.

This application for Letters Patent is a continuation in part of my application entitled Electrical stringed musical instrument, Serial No. 615,995, filed June 8, 1932.

An object of this invention is to provide a musical instrument in which the vibrations of the sound producing elements or strings directly vary the reluctance of a magnetic circuit to induce an electric current in a coil within the magnetic field, which current is suitably amplified and transformed into sounds as true reproductions of the sounds produced by the vibrations of the strings. In the present invention the true sound of the vibratory string with all its characteristics is accurately reproduced without the extraneous sounds and vibrations produced by instruments or devices in which a mechanical part is made to vibrate through its mechanical association with the vibratory string.

Another object of the invention is to provide an electrical musical instrument of the character mentioned including a novel, simplified and particularly effective electro-magnetic pick-up unit for converting the vibrations of the strings into an electric current having the characteristics of the string vibrations.

Another object of the invention is to provide an electrical musical instrument of the character mentioned including a single electro-magnetic pick-up unit for transforming the vibrations of the several strings of the instrument into an electric current. In the device of the present invention the vibrations of each of the several strings affect or vary the reluctance of the magnetic circuit of a single permanent magnet unit to induce an electric current in a coil superimposed on the magnet, and the single unit is not subject to the variations necessarily inherent in devices involving a plurality of electro-magnetic units.

Another object of the invention is to provide an electrical musical instrument that does not depend upon a sound board, resonance box, or the like in the production or propagation of the sound of the desired quality, whereby the body of the instrument may be of simple, inexpensive construction.

Another object of the invention is to provide a musical instrument of the character mentioned having tensioned vibratory strings of different diameters and including a single electro-magnetic pick-up unit constructed and designed to deliver an electric current to an amplifier which current is properly and truly characteristic of the vibrations of the several strings.

Another object of the invention is to provide an electrical stringed musical instrument that is adapted to be played manually in any typical or desired manner and electrically reproduce the sound or music at a remote point.

Another object of the invention is to provide an electrical musical instrument of the character mentioned that may be easily and conveniently adjusted by the musician or player to vary the volume of the music or sound produced.

Another object of the invention is to provide an improved electro-magnetic pickup unit capable of embodiment in stringed musical instruments of various characters with little or no modification.

A further object of the invention is to provide an electrical stringed musical instrument of the character mentioned that is small and compact and easy and convenient to play.

Other objects and features of the invention will be better and more fully understood from the following detailed description of typical forms and applications of the invention, throughout which description reference may be had to the accompanying drawings, in which:

Fig. 1 is a top or plan view of one typical embodiment of the present invention. Fig. 2 is an enlarged, transverse, detailed sectional view of the pickup unit and body taken as indicated by line 2—2 on Fig. 1. Fig. 3 is an enlarged plan elevation of the main portion of the body with the magnets in cross-section, being a view taken as indicated by line 3—3 on Fig. 2. Fig. 4 is a transverse detailed sectional view taken as indicated by line 4—4 on Fig. 3. Fig. 5 is an enlarged fragmentary detailed sectional view taken as indicated by line 5—5 on Fig. 1. Fig. 6 is a fragmentary detailed sectional view of the body showing the socket and illustrating the plug in position to enter the socket. Fig. 7 is a wiring diagram of the circuit involved in the present invention. Fig. 8 is an elevation view of the present invention embodied in a stringed musical instrument having a wooden body. Fig. 9 is a diagrammatic view illustrating the non-uniform magnetic fields of the pick up unit and Fig. 10 is an enlarged fragmentary diagrammatic view illustrating a portion of one pole portion of the magnet and a portion of one core member with a string passing through the field provided thereby.

The instrument provided by the present invention includes, generally, a body 10, a plurality of sound propagating elements or tensioned strings 11 on the body 10, an electric magnetic pickup unit 12 on the body 10 for transforming vibrations of the strings 11 into an induced electric current, and an amplifying unit or system 13 for amplifying the pulsations in said current and converting them into sounds which are the true sounds of the strings 11.

The body 10 may be varied considerably in size, shape and construction, and may be constructed of various materials without departing from the spirit of the invention. In the particular form of the invention in Figs. 1 to 7, inclusive, of the drawings, the body 10 is a simple integral casting of metal, such as aluminum or the like, and comprises a major or main portion 14 and a neck 15. The main portion 14 of the body is substantially disc shaped, having flat upper and lower sides and a curved or cylindrical periphery. The neck 15 projects radially with respect to the center of the portion 14 and is of gradually diminishing cross-section. The neck 15 has a flat upper side forming a fingerboard 16 provided with spaced frets 17. The underside of the neck 15 may be convex or rounded as illustrated in Fig. 4. The body 10 may be hollow as shown in the drawings to be light in weight, it being understood that in some instances it may be desirable to make the body 10 solid.

The strings 11 are the sound vibration producing elements of the instrument and are adapted to be manually plucked or otherwise manipulated to produce the desired vibrations. The strings 11 extend diametrically across the top of the body portion 14 and over the fingerboard 16 to the outer end of the neck. In the particular instrument illustrated there are six spaced strings 11 in a substantially parallel series. The plurality of strings 11 preferably lie in the same plane, that is, their central longitudinal axes are in or adjacent a common plane. The strings 11 pass over a bridge 18 on the main portion 14 of the body and over a similar bridge 19 on the outer portion of the neck 15. The inner ends of the strings are suitable secured in openings 20 adjacent the bridge 18 and the strings have their outer ends engaged by securing and tensioning keys 21. The portions of the strings 11 extending between the bridges 18 and 19 are under various degrees of tensile strain and are free to vibrate in the production of recognized musical tones. It is to be noted that the opposite ends of the strings 11 are rigidly and unyieldingly connected to the rigid metallic body 10 so that their major portions may have long periods of vibration with no dampening action due to the absorption of the vibrations by wooden body parts or the like at the ends of the strings. In accordance with the usual practice in instruments of the class illustrated the strings 11 are graduated in diameter. The strings 11 are formed wholly or in part of conducting material or magnetic material having a different degree of magnetic permeability than the surrounding air to properly influence or affect the reluctance of the magnetic field in the unit 12.

The pick-up unit 12 is a magnetic or electromagnetic device for converting the actual tone producing vibrations of the strings 11 into an induced electric current. The frequencies and the other characteristics of the vibrations of the strings 11 which may be termed the physical properties of the sound produced by the strings are represented in the electrical circuit in a proportional or definite manner with relation to the actual physical vibrations of the strings so that the amplifying unit 13 is actuated by or influenced by the physical properties of the sound to faithfully and accurately reproduce the sound. The pick-up unit 12 comprises a magnet which, in practice, may be a pair of like opposed permanent magnets 22. The magnets are U-shaped or of horse-shoe design and are attached to a supporting plate 23. The opposed lower or inner arms A of the magnets 22 have their lower sides resting on the plate 23 and the arms A are attached to the plate by suitable screws 24. In accordance with the invention the ends of the magnets 22 are in opposed relation with their poles north to north and south to south, as indicated in the drawings. This provides a continuous polarity at the opposite sides of the magnet or magnet unit. In the preferred construction the confronting or opposed ends of the magnets 22 are in spaced relation.

An opening 25 is provided in the top or upper side of the body portion 14 to receive the pickup unit 12. The plate 23 carrying the magnets 22 is inserted in the opening 25 and studs or bolts 26 project upwardly from the opposite ends of the plate to extend through openings in plates 27 on the body. The plates 27 may carry sleeves 28 for receiving the bolts 26. It is preferred to mount or support the unit 12 so that it may be adjusted and accurately set with relation to the strings 11. Nuts 29 are threaded on the outer ends of the bolts 26 and bear against the outer sides of the plates 27. The nuts 29 may be tightened down to adjust or shift the unit 12 outwardly. Springs 30 surround the bolts 26 and are arranged under compression between the plate 23 and the plates 27 to normally urge the unit inwardly and hold it against movement.

With the unit 12 mounted or supported as just described the pair of opposed magnets 22 are disposed transversely of the series of strings 11 and their upper or outer arms B are spaced above the top surface of the body. The strings 11 pass under the magnet arms B with considerable clearance. The strings 11 pass through the magnetic field of the magnets 22. The outer arms B of the magnets may be slightly inclined toward their opposing ends to compensate for the widened magnetic field at their poles or ends. The above described inclination of the magnetic arms B is such that the spaces between the arms and strings vary substantially in proportion to the intensity of the magnetism of said arms.

The pickup unit 12 includes a coil C arranged on or superimposed on the permanent magnet. The coil C is supported on the inner arms A of the pair of magnets 22 and is to receive an induced electric current when the reluctance of the field of the magnet or magnet unit is varied. The coil C includes a coil form or spool 31 having spaced upper and lower flanges 32. A winding 33 of suitable enameled wire is provided on the spool 31 between the flanges 32. The spool 31 is formed of a suitable insulating material. The number of turns in the winding 33 and the gauge of the wire of the coil depends upon the particular amplifying unit 13 with which the instrument is to be used. In accordance with the invention the coil C is positioned between the north and south poles of the magnet and is related to the strings 11 to be influenced or affected by their vibration in the magnetic field.

The outer side of the spool 31 is spaced below the series of strings 11.

The invention includes a plurality of core members 35 for concentrating the magnetic force of the magnet in non-uniform fields linked with the coil. The members 35 may be in the form of plates. However, it has been found practical to make the members 35 in the form of posts or pins as illustrated throughout the drawings. The lower ends of the pins rest on or engage the lower arms A of the magnets while the upper ends of the pins project from the spool 31. The upper ends of the core pins 35 are spaced directly below the strings 11 as clearly illustrated in Figs. 2 and 3 of the drawings. In order to properly compensate for differences in the extent or degree of variation of the magnetic reluctance in the spaces between the outer ends of the members 35 and the adjacent arms of the magnet due to the differences in the diameter of the strings 11, the spaces between the upper ends of the pins 35 and the strings 11 are graduated substantially in proportion to the graduation in the diameter of the strings.

To eliminate the necessity of a ground lead from the coil C one or both of the end pins 35 project from the surface of the spool 31 and are engaged by the inner windings 33 which have the enamel removed therefrom to electrically contact or connect with the pins. The pins 35 thus electrically connected with the inner winding or windings of the coil C are grounded to the body 10 through the magnet arms A, the plate 23, bolts 26 and plates 27. By thus grounding the coil winding to the body through the magnets the sounds or noises that are characteristics of the coil and magnets are eliminated or avoided. It is believed that it will be apparent how the nuts 29 may be employed to set or position the unit where the pins 35 are related to the strings 11 to provide for the desired operation of the pickup unit 12. The pins 35 in extending into the coil C operate to concentrate the magnetic force in spaced zones or fields in the spaces between their outer ends and the adjacent arms of the magnet and carry the magnetic force into the center of the field of the coil. The strings passing between the ends of the pins 35 and the magnet arms B vary the reluctance of the magnetic field when vibrated and thus induce an electric current in the coil C.

The coil C is electrically connected to a suitable amplifier and speaker unit 13 whereby the variations in the reluctance of the magnetic circuit imposed on the coil are converted into sound. The sound thus produced is a true reproduction of the sounds or tones produced by the strings 11. The particular amplifying unit 13 illustrated in the drawings is a one stage audiofrequency amplifying circuit and is merely typical of the various amplifying systems that may be employed. Means is provided for conveniently connecting the coil C with the amplifying unit 13. In the form of the invention being described a socket or jack 40 is provided in the body 10 and is electrically connected with the coil C by a conductor 41. The socket 40 is adapted to removably receive a plug on the end of a flexible two-conductor cord 42 extending from the amplifying unit 13. Means is interposed between the coil C and the amplifying unit 13 for varying the amplification of the sound. The volume control is preferably provided on the instrument proper to be conveniently accessible to the player. In the drawings I have shown a typical variable resistance element 43 connected between the socket 40 and the coil C and including a control or regulating knob 44 projecting from the upper surface of the body.

Fig. 8 of the drawings illustrates the invention embodied in an instrument in the form of a guitar having a wooden body 10^a. The body 10^a has the usual resonance box 14^a and the neck 15^a. The strings 11^a extend across the upper surface of the body and are maintained under the required tension by keys 21^a. The electromagnetic pickup unit 12^a is supported on the body 10^a so that the strings 11^a pass under its outer magnet arms A^1. The strings 11^a pass between the magnet arms A^1 and the coil of the unit. The unit 12^a operates in the same manner as the unit 12 and suitable conductors extend from the coil of the unit to connect with an amplifying unit or system. A volume control element 43^a is arranged in the circuit of the coil. In the instrument illustrated in Fig. 8 of the drawings where the body 10^a is of wood a ground conductor is connected with the coil of the unit 12^a.

It is believed that the operation of the instrument provided by the present invention will be readily understood from the foregoing detailed description. In playing the instrument the strings 11 are plucked or otherwise vibrated as desired and may be engaged along the fingerboard 16 by the fingers of the player or by a steel or playing bar held in the player's hand.

As best illustrated in Figs. 9 and 10 of the drawings the magnetic flux passes between the upper or outer arms of the magnets 22 and the members 35 in concentrated non-uniform fields F. That is, the lines of magnetic force as illustrated diagrammatically by the spaced lines L in Figs. 9 and 10 are relatively concentrated in the spaces or fields F between the outer arms of the magnets and the exposed ends of the pole members 35 and converge to or flare outwardly from the relatively limited surfaces presented by ends of the members 35. The lines L appearing in Figs. 9 and 10 are not intended to illustrate the total lines of magnetic force in the fields F and merely illustrate the general grouping and the general direction of the lines of force in the fields when the strings 11 are in their normal positions. The vibratory strings 11 of magnetic material pass through these concentrated non-uniform fields F and when they are stationary or unmoved there is a fixed or stable condition of magnetic flux and reluctance in the fields F. Movement or vibration of a string 11 in any direction alters this fixed condition of the field F through which it passes varying the reluctance in the space or field F. The variation in the reluctance of the field F induces a current in the coil C. The current induced in the coil C has characteristics proportional to the characteristics of the movement of the strings 11. As the fields F are non-uniform or composed of flaring or converging lines L of magnetic force, movement or vibration of the strings 11 in the direction of the longitudinal axes of the members 35 and movement of the strings 11 in a direction transverse of said axes both vary the reluctances of the fields F and thus induce a current in the coil. However, the tone or the character of the tone produced by the amplifier 13 resulting from the current induced in the coil C by variation in the reluctance of a given field F caused by movement or vibration of the string 11 therein in a direction substantially transverse of the longitudinal axis of the

adjacent member 35 is different from that resulting from vibration of the string in a direction substantially axially of said axis. Assuming that a string 11 is vibrated to move substantially transversely through its field F relative to the general direction of the lines of force L, the magnetic path through the string 11 is longer or greater when the string is in the end positions of its vibratory motion than when the string is in the intermediate position of such motion. The reluctance of the space or field F therefore is greater with the string 11 in the end positions of its vibratory motion than with the string in the intermediate position of its movement. Thus vibration of the string 11 horizontally or substantially transverse of the longitudinal axis of the member 35 induces a current in the coil C which is converted by the amplifier 13 into a tone in which the second harmonic of the note of the string predominates. Assuming that the above-mentioned string 11 is vibrated in a general vertical direction or in a direction substantially parallel with or axially of the longitudinal axis of the member 35, the effect of the string in reducing the reluctance of the field F is greater when at the end of its vibratory travel nearest the member 35 than when at the end of its travel nearest the arm of the magnet 22. This is due to this particular movement of the string 11 in the non-uniform or substantially fan shaped field F made up of the lines L of force converging to or flaring from the end of the member 35. Vibration of the string 11 in a substantially vertical direction or in a direction substantially axial of the member 11 induces a current in the coil C which actuates the amplifier to produce a tone which is strongly that of the fundamental note of the string. While it may not be practical to vibrate the strings 11 in truly vertical or truly horizontal directions the player or musician may at will readily vary and control the character of the tones produced electrically by the instrument by plucking or otherwise vibrating the strings 11 to vibrate in a generally vertical direction or a generally horizontal direction. The sound produced by the system or unit 13 therefore has all the tonal qualities of the sound which results from the physical vibration of the strings 11. The element 43 may be employed to control or vary the volume of the sound produced by the unit 13 and is conveniently accessible to the hand of the player or musician employed to pluck or vibrate the strings. The sound is reproduced without the mechanical vibration of any part at the pickup unit 12 other than the strings 11. The resultant music or sound accordingly does not have any extraneous vibrations or unwanted qualities.

Having described only typical preferred forms and applications of my invention I do not wish to be limited or restricted to the specific forms and applications herein set forth, but wish to reserve to myself any modifications or variations that may appear to those skilled in the art or fall within the scope of the following claims.

Having described my invention, I claim:

1. A pick up unit for use with the vibratory strings of a musical instrument, including a permanent magnet, a coil supported by the magnet between its poles, means mounting the magnet to have the strings pass between one of its poles and the coil, and core members within the coil each having an end facing a string.

2. In combination, a series of tensioned strings of magnetic material of different diameters, a single magnet having its pole portions at opposite sides of the series of strings, a coil between the pole portions of the magnet, and magnetic core members extending from one of the pole portions toward the other and terminating to form string spaces which vary in size with the strings.

3. In combination, a plurality of spaced vibratory strings of magnetic material, and a pick up unit including, a pair of permanent magnets arranged to surround the strings with their corresponding poles opposed, a coil within the field of the magnets, and means supporting the magnets and coil for adjustment relative to the strings.

4. A musical instrument comprising, a body to be held by the player, a plurality of spaced vibratory strings of magnetic material at the exterior of the body having portions accessible to be engaged by the player, a permanent magnet having a polar part extending over the strings to cover the same adjacent said portions and form a guard therefor and a rest for the operator, and a coil within the field of the magnet sensitive to disturbances therein.

5. A musical instrument comprising, a body to be held by the player, a plurality of spaced vibratory strings of magnet material at the exterior of the body having portions accessible to be engaged by the player, a permanent magnet having its polar parts spaced above and below the strings whereby the strings pass through a dense portion of the field of the magnet, the upper polar parts extending over the strings adjacent said portions to cover the same and form a guard for the strings and a hand rest for the player, and a coil in said field sensitive to disturbances therein.

6. A musical instrument comprising, a plurality of spaced vibratory strings of magnetic material, a magnet unit positioned so that the strings pass through its field, a coil associated with the magnet unit to have a current induced therein having the characteristics of the vibrations of the string, and means supporting the magnet unit at spaced points for individual adjustment at said points relative to the strings to effect tuning of the pick up means.

7. A pick up unit for use in combination with a plurality of spaced strings of a musical instrument, said pick up unit comprising, an elongate magnet unit disposed transversely of the strings to have a polar part above the strings, a coil carried by the magnet to receive an induced current from its field, and means for shifting the magnet from either end to move it relative to the strings to tune the pick up unit.

8. A pick up unit for use in combination with the vibratory string of an instrument including, a magnet having spaced polar parts, an induction coil positioned between the said polar parts, and means for supporting the magnet and coil so that the string passes through the space between the coil and one of said parts whereby vibration of the string varies the reluctance of the said space to induce a current in the coil.

9. A pick up means for use in combination with a musical instrument having a vibratory string of magnetic material, said pick up means including, a magnet having spaced polar parts, a coil positioned between the said parts, the magnet and coil being positioned so that the string passes through the space between the coil and one of said parts whereby vibration of the string varies the reluctance of a relatively dense portion of the magnetic field to induce a current in the coil,

and means carrying the magnet and coil for adjustment relative to the string.

10. In combination, a series of vibratory strings of magnetic material of different diameters, a magnet, a coil in the field of the magnet, the magnet being positioned so that the strings pass through its field, magnetic core members extending from one pole portion of the magnet and passing through the coil toward the other pole portion of the magnet and terminating at points spaced from the said other pole portion to leave spaces through which the strings pass, and means for shifting the magnet to vary the relation between the strings and said spaces.

11. A musical instrument comprising a body to be held by the player, a plurality of vibratory strings of magnetic material extending across an exterior face of the body in spaced relation thereto, a permanent magnet on the body having a polar part related to the strings to cover the strings and form a guard therefor and a hand rest for the player, and a coil in the field of the magnet sensitive to disturbances therein.

12. In a musical instrument, a series of spaced vibratory strings of magnetic material, an elongate magnet unit disposed transversely of the strings where the strings pass through its field, a coil carried by the magnet unit to receive an induced current from the magnetic field, and means for shifting the magnet from either end to adjust it relative to the strings.

13. In a musical instrument, a series of spaced vibratory strings of magnetic material, an elongate magnet unit disposed transversely of the strings where the strings pass through its field, a coil in the magnetic field of the unit to receive an induced current therefrom, and means for rocking the magnet unit in a plane substantially transverse of the strings to adjust it relative to the strings.

14. In a musical instrument, a series of spaced vibratory strings of magnetic material, an elongate magnet unit disposed transversely of the strings where the strings pass through its field, a coil in the magnetic field of the unit to receive an induced current therefrom, and means for tilting the magnet unit in a plane substantially transverse of the strings, said means including supports for the magnet unit at points at opposite sides of the series of strings.

15. In combination, a vibratory string of magnetic material, a magnet having pole portions at opposite sides of the string, a coil between the pole portions of the magnet, a magnetic core member extending from one of the pole portions toward the other pole portion and terminating at a point spaced therefrom to form a space through which the string passes, and means for shifting the magnet to vary the positions of the core member and the said other pole portion with relation to the string.

16. A musical instrument comprising a body, a plurality of exposed vibratory strings extending across a face of the body in spaced relation thereto, a pair of opposed magnets on the body having polar portions disposed transversely of the strings and related to the strings to form a guard therefor, said guard extending over the strings to cover the same, and a coil in the field of the pair of magnets sensitive to disturbances therein.

17. In a pick up unit, vibratory strings of magnetic material, a magnet having spaced pole portions and positioned so that the strings pass between said pole portions, a plurality of magnetic pole members on one of said pole portions, each member having a limited surface of magnetic attraction adjacent one string whereby the strings act in zones wherein the lines of magnetic force flare inwardly to said limited surfaces, and a coil surrounding the pole members.

18. In a pick up unit, vibratory strings of magnetic material, a single permanent magnet having a series of projecting pole parts of like polarity, each pole part presenting a limited surface adjacent a string whereby the lines of magnetic force flare outwardly from said surfaces about the strings, and an induction coil surrounding said series of parts.

19. In a pick up unit, a plurality of vibratory strings of magnetic material, a magnet having spaced pole portions positioned so that the strings pass between the pole portions in closer proximity to one than the other, magnetic posts extending from said other pole portion and each having a surface of limited extent adjacent a string and opposing the first mentioned pole portion whereby the strings vibrate in a zone where the lines of magnetic force converge to said surfaces, and a coil in the field of the magnet.

20. In a pick up unit, a plurality of vibratory strings of magnetic material having their axes in a common plane, a magnet having a pole portion adjacent the strings and inclined with respect to said plane so that the spaces between said portion and the strings vary substantially in proportion to the intensity of the magnetism of said pole portion, and a coil in the field of the magnet.

21. In a pick up unit, a plurality of vibratory strings of magnetic material having their axes in a common plane, a magnet having a pole portion adjacent the strings and inclined with respect to said plane so that the spaces between said portion and the strings vary substantially in proportion to the intensity of the magnetism of said pole portion, the magnet having a second pole portion, magnetic posts on said second pole portion having limited surfaces adjacent the strings and opposing the first mentioned pole portion whereby the vibratory strings act in fields where the lines of magnetic force converge to said limited surfaces, and a coil in the field of the magnet.

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