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| [21] | Appl. No. | 687,246 |
| [22] | Filed | Dec. 1, 1967 |
| [45] | Patented | Sept. 29, 1970 |
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- [54] ELECTROMAGNETIC PIANO**
2 Claims, 13 Drawing Figs.

- [52] **U.S. Cl.**..... **84/1.15,**
84/1.17, 84/1.24
- [51] **Int. Cl.**..... **G10h 3/00,**
G10h 3/06, G10h 1/02
- [50] **Field of Search**..... 84/1.01,
1.14, 1.15, 184, 185, 186, 265; 335/229, 268

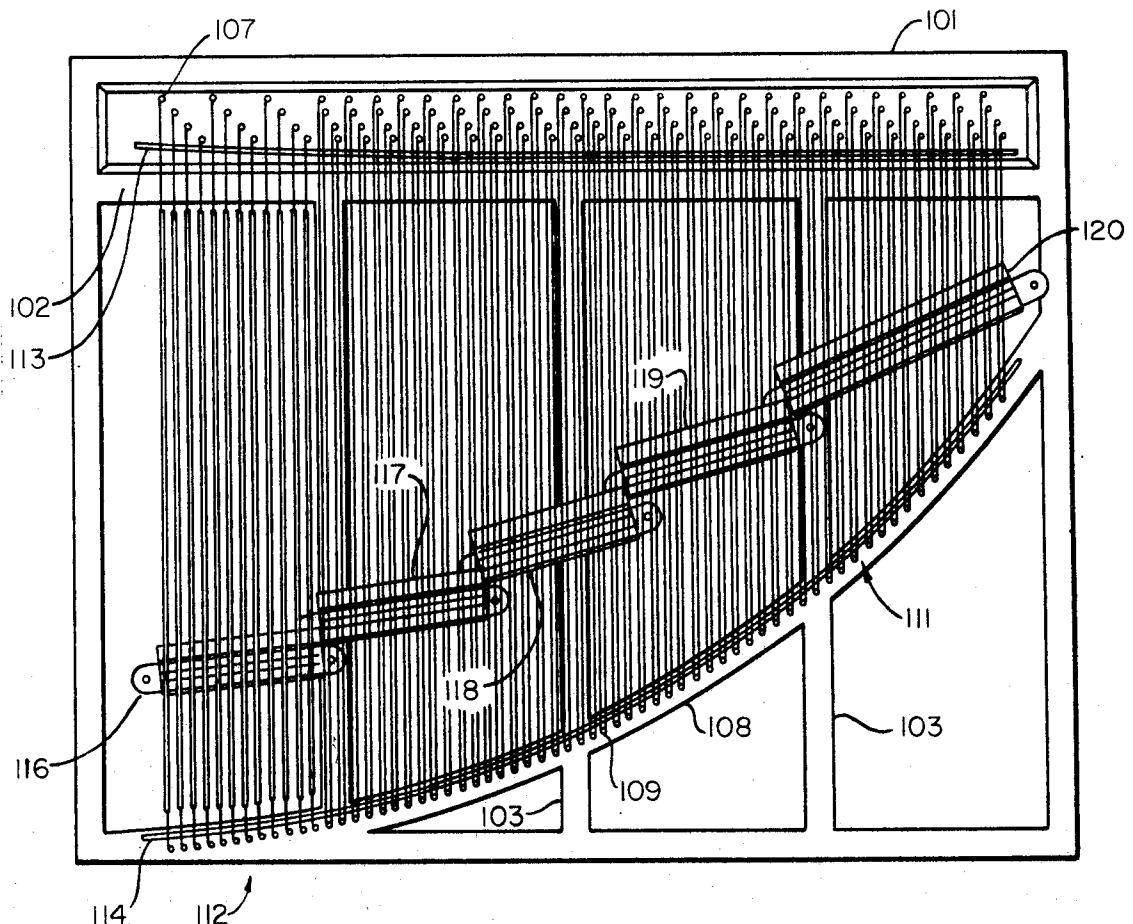
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ABSTRACT: A piano having a conventional hammer and damper for striking the strings. Electromagnetic means coupled to the strings for converting the oscillations of the string into electrical oscillations or signals which are electrically processed and applied to speakers to produce sound.



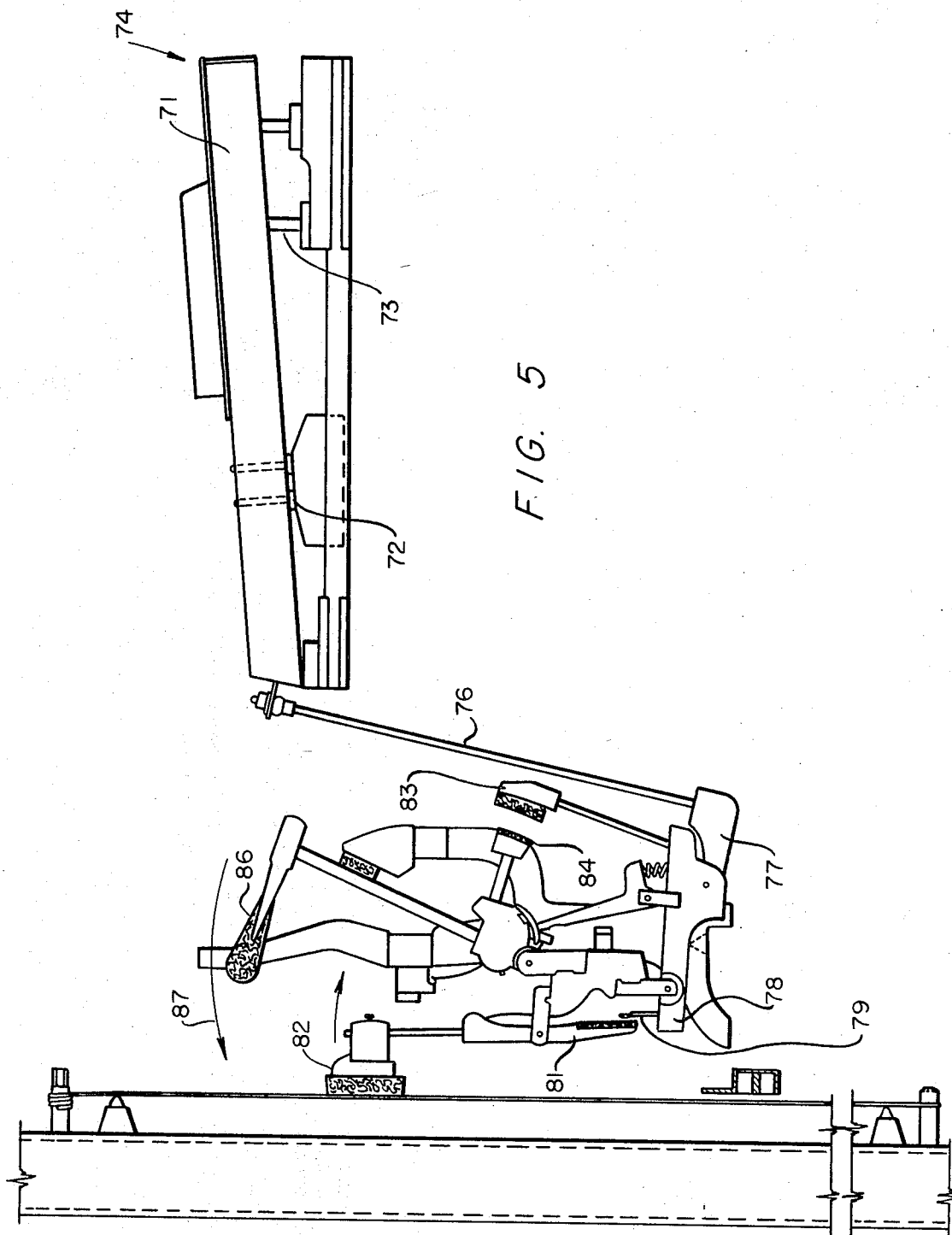


FIG. 5

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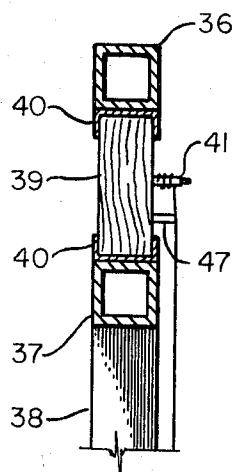


FIG. 6

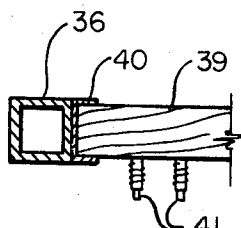


FIG. 7

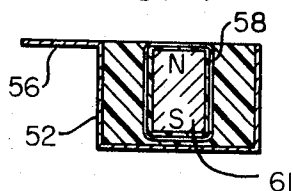


FIG. 9

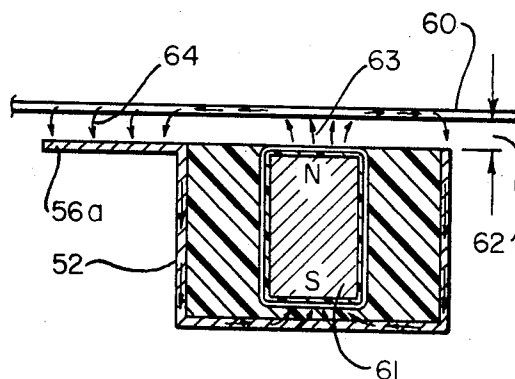


FIG. 10

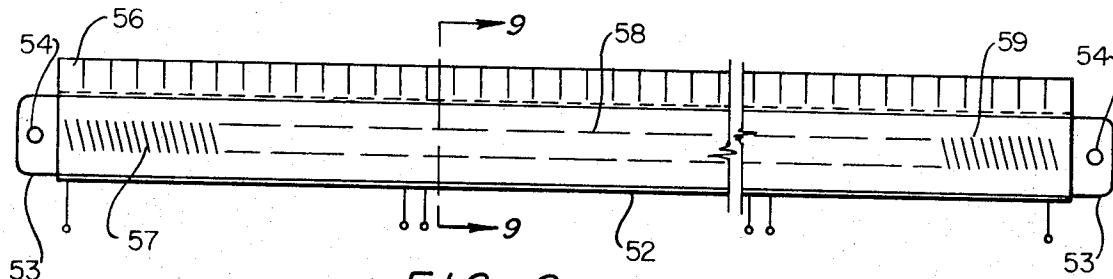


FIG. 8

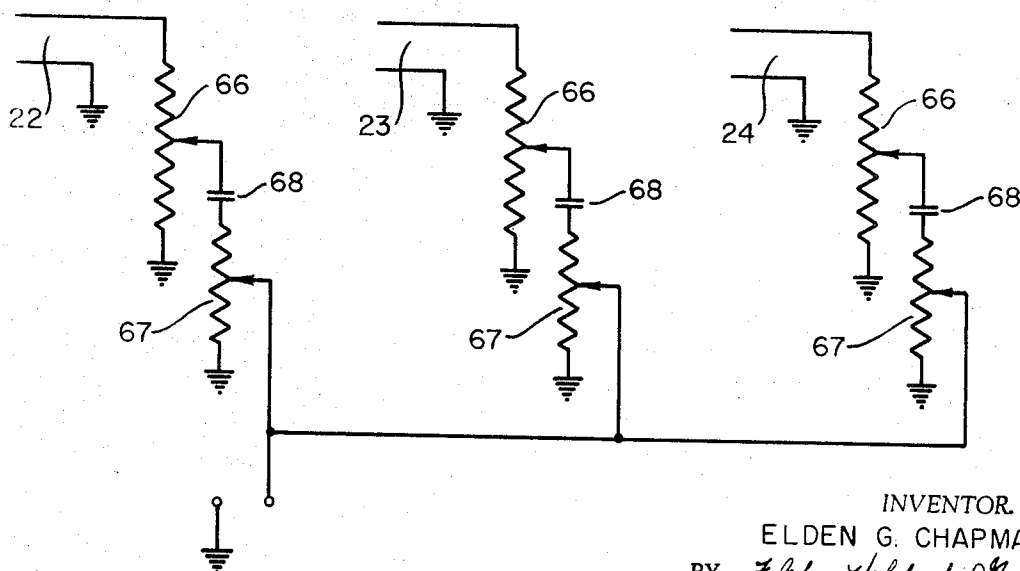


FIG. 11

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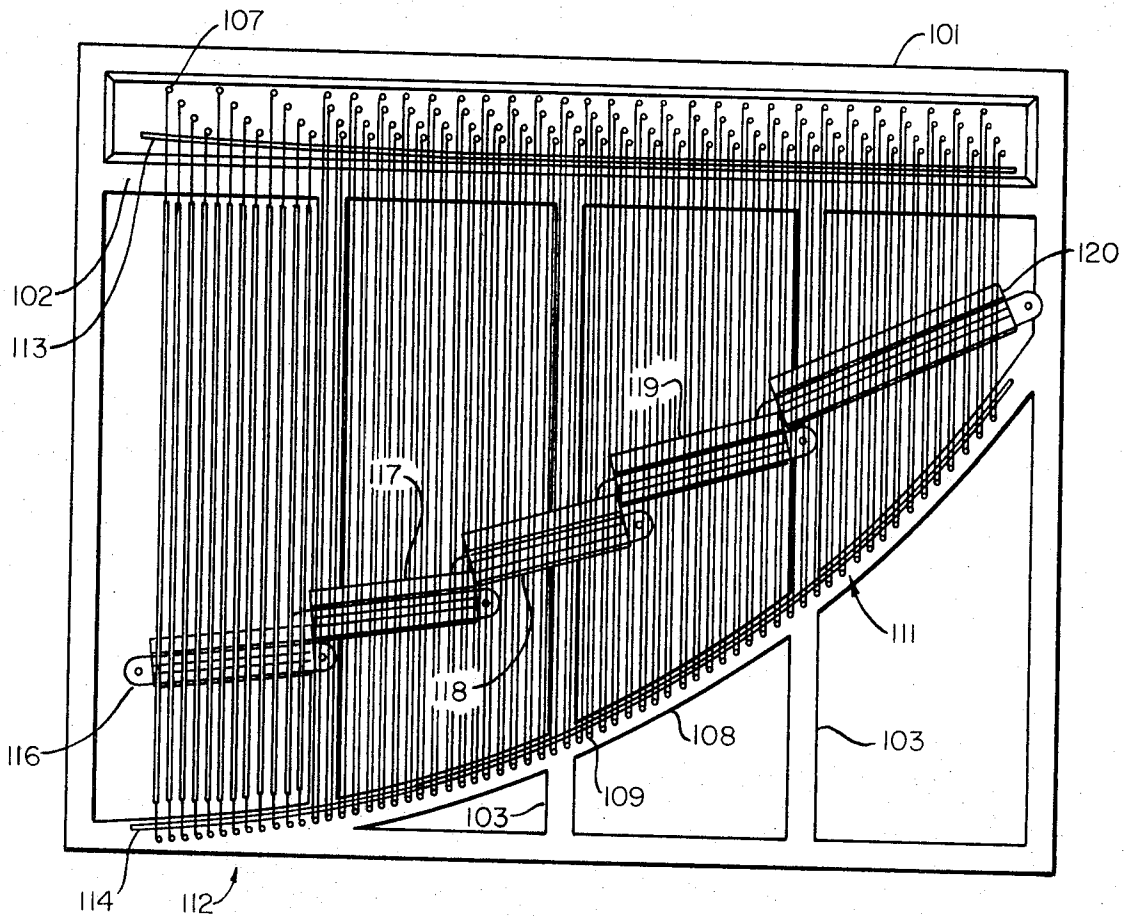


FIG. 12

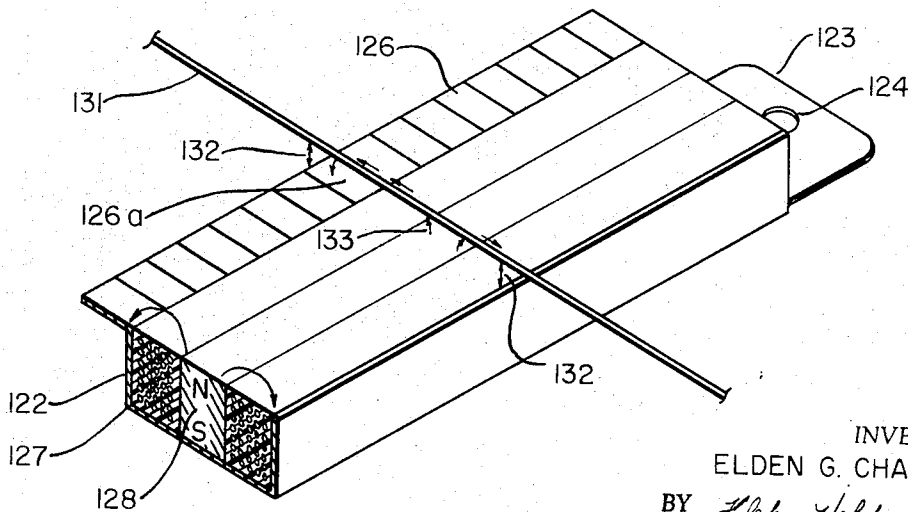


FIG. 13

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ELECTROMAGNETIC PIANO

This invention relates, in general, to a new and improved piano utilizing a combination of novel mechanical, magnetic and electronic concepts and in particular to an electronic piano in which the vibratory motions of the strings serve to generate electrical signals or oscillations having corresponding frequencies suitable for processing and transformation into sound.

When electrical oscillations of audible frequency are transformed into mechanical oscillations by a loudspeaker, audible sound is produced. If these electrical oscillations are under the control of the musician frequency by frequency (note by note), it may be said that a new type of musical instrument has been created. Prior art instruments of this character are of two general types: those which generate their own oscillations, and those which amplify the natural vibrations of well known musical instruments.

A conventional piano produces its characteristic tones by means of an action consisting primarily of mechanical levers which serve to cause a felt hammer to move and strike one or more taut steel wires or strings to set the same into vibration. The velocity and force of the hammer is under control of the player or performer. A skilled performer can exert an extremely high order of control over the amplitude and other tonal characteristics of the sound. The wide range of amplitude results mainly from the construction of mechanical linkage between the key which is struck by the performer and the felt hammer.

Certain prior art devices have tried, without success, to do away with the steel strings used in the conventional piano and to substitute purely electronic means for generating the electrical tonal frequencies or oscillations. Because of the varying parameters of the piano, such as the decay characteristics, damping, sostenuto and softness, such prior art electronic pianos required complex electronic circuits for each note of the scale to provide all of the above mentioned characteristics. Because of the complexity of the piano and the tones produced thereby, such prior art devices have not been entirely successful in their imitation of string vibrations.

A second technique for amplifying the natural vibrations of well known stringed musical instruments has resulted in the modification of the stringed instruments into quasi-electrical instruments by addition of electrical pickups to some part of the normal sound producing mechanism. In the case of such instruments as the banjo, mandolin, guitar and violin, the pickup is ordinarily attached to the body of the instrument. The output of the pickup is electronically amplified and converted into sound by a loudspeaker. Such techniques are practical for small and relatively inexpensive instruments.

In a conventional piano, when the strings vibrate, they transmit pressure differences to a bridge attached to a sound board. The large area of the sound board is set into motion and this, in turn, agitates the air in its immediate vicinity to produce sound. The board is extremely elastic and is capable of reproducing the most complicated waveforms with minimum loss of energy. In addition, the sound board may be made of a material of low density and of uniform texture. As is apparent from the above requirements, the production of a suitable sound board is extremely complicated and expensive and is a key feature which sets off the finer pianos from the less expensive ones. It is obvious, therefore, that those techniques which retain the normal tone producing mechanism are unsuitable for the electrification of a piano because the sound board would still be required and the tonal characteristics would again be dependent upon its construction and quality.

It is an object of the present invention to provide a new and improved electromagnetic piano.

It is another object of the present invention to provide a new and improved electromagnetic piano in which the vibrations of the strings are converted into electric oscillations having corresponding frequencies.

It is another object of the present invention to provide an improved harp and frame for an electromagnetic strung piano.

The present invention overcomes the above drawbacks by providing a strung electromagnetic piano which retains the normal mechanical linkages between the keys and felt hammers. An electromagnetic pickup converts the mechanical oscillations of the strings into electrical output signals having a frequency which corresponds to the mode of vibration of the strings which are struck. In particular, the present invention contemplates the use of an electromagnetic pickup in which the steel string itself varies the reluctance of a magnetic path coupled to a coil to induce a change in current through the coil which is proportional to the change in flux. The frequency of the changes is directly dependent upon the mode of vibration of the string, and the strength of the signal is dependent upon the amplitude of vibration.

The foregoing and other objects of the invention will become more clearly apparent from the following detailed description taken in conjunction with the accompanying drawings.

Referring to the drawings:

FIG. 1 is a perspective view of a piano in accordance with the present invention;

FIG. 2 is a block diagram of the electronic circuits associated with the piano of the present invention;

FIG. 3 is a plan view showing a strung frame and harp constructed in accordance with another feature of the present invention;

FIG. 4 illustrates a pedal mechanism suitable for use in the present invention;

FIG. 5 illustrates in cross-section the piano action and the electromagnetic pickups of the present invention;

FIG. 6 is a sectional view taken along the line 6-6 of FIG. 3 showing the pinblock support;

FIG. 7 is a sectional view taken along the line 7-7 of FIG. 3 showing the pinblock support;

FIG. 8 is a plan view of the electromagnetic pickup shown in FIG. 3;

FIG. 9 is a sectional view taken along the line 9-9 of FIG. 8;

FIG. 10 is an enlarged sectional view showing the magnetic flux path through the pickup and associated strings;

FIG. 11 is a suitable voicing circuit associated with the electromagnetic pickup;

FIG. 12 is a plan view showing another strung frame and harp; and

FIG. 13 is a perspective view of another electromagnetic pickup.

A console piano 10 is illustrated in FIG. 1. The piano includes a keyboard 11. The full keyboard may include 88 keys, whereas a smaller and more portable piano may include 64 keys. As will be presently described, the keys 11 are associated with a conventional lever and hammer action for striking the strings.

The keyboard 11 is suitably supported from the cabinet 12 which serves to enclose the frame and harp to be presently described. The electrical components which serve to generate and process the electrical signals are mounted within the cabinet. The electrical components include electromagnetic transducers and amplifiers. One or more speakers 13 are indicated in dotted line behind grill 14 and serve to convert the electrical signals into sound.

Since the tones of the piano are produced through an electromagnetic system, the bass, treble and volume can be electrically controlled. For this purpose, controls 20 are provided. These controls are designated B, T and V for bass, treble and volume, respectively. Additional tonal effects such as vibrato and tremolos and the addition of various harmonics to the fundamental notes to imitate the quality of the tone issuing from other stringed instruments such as a harpsichord, rick-a-tink piano and guitar can be easily introduced, and such are indicated in the electrical circuit of FIG. 2.

Referring more specifically to FIG. 2, there is illustrated an electromagnetic pickup 21, to be described in detail. The electromagnetic pickup includes bass, midrange and treble out-

puts 22, 23 and 24 connected to a voicing circuit 26. The voicing circuit varies the relative amplitude of the output and combines and applies the voiced output to a preamplifier 27. The output from the preamplifier is amplified by amplifier 28 and applied to a speaker 29. The preamplifier 27 and amplifier 28 may be of conventional construction such as used in high fidelity equipment and may include such controls as volume, bass and treble. A shaper 31 may also be connected in the preamplifier. The shaper serves to shape the signals at the preamplifier to achieve the various special tonal effects described above. The shaper may be of conventional design. As shown, it includes a harp control H, a harpsichord control HC, rick-a-tink control RT, and tremolo control T. The power amplifier 28 may include a volume control 32 which is controlled by a pedal for pedal control of the volume knob V, on the console.

Referring now more particularly to FIG. 3, there is shown a harp and frame in accordance with the present invention. As previously described, the harp arrangement for a conventional piano includes a harp made of aluminum or cast iron on which the strings are mounted to cooperate with a bridge which activates or drives the sounding board.

In the present invention there is provided a tubular rectangular steel frame 36. A cross member 37 is spaced from the top of the frame to define a pinblock space. Spaced vertical reinforcing members 38 are provided between the bottom of the frame 36 and the cross member 37. Channel members 40 are secured to the frame and cross member to receive and hold the wooden pinblock 39. This is more clearly illustrated in FIGS. 6 and 7. Tuning pins 41 are inserted in the pinblock in a conventional manner.

A member 42 extends diagonally across the frame and is secured thereto and to the reinforcing members 38. The member 42 serves to receive hitch pins 43.

The strings are strung between the tuning pins and the hitch pins. A number of the strings are so-called bi-strings while 12 of lower frequencies are singles. These two types of strings are designated generally by the arrows 44 and 46, respectively, on FIG. 3. A top rail or bridge 47 is interposed between the pinblock and the strings and a bottom rail or bridge 48 is interposed between the diagonal member and the strings. In contrast to a conventional piano in which the bottom rail is mounted to the sounding board, the bottom rail in this particular instance is mounted directly on the member 42.

It is particularly noted that in the present design all the strings are parallel to one another and arranged vertically simplifying the stringing. The piano is tuned in a conventional manner by adjusting the tuning pins. It is to be noted that the frame and harp is a single unit made of one material and that because of its unitary construction, it is less sensitive to environmental changes than a conventional piano.

An electromagnetic pickup unit 51 is coupled to the strings. The unit is disposed generally parallel to the member 42 between the top and bottom bridges. The unit is shown in more detail in FIGS. 8-10. It comprises a tray or housing 52 made of high permeability magnetic material. The tray 52 is in the form of an open box. The lower portion of the box has outwardly extending tabs 53 provided with openings 54 for mounting the electromagnetic pickup unit in coupled relationship with the strings. One side wall of the box is provided with a plurality of lips or tabs 56 which extend outwardly substantially parallel to the upper surface of the box. The unit includes coils 57, 58 and 59 wound about a permanent magnet bar 61 in the manner shown. Thus, the permanent magnet bar is disposed longitudinally within the box 52 and the coils 57, 58 and 59 are wound thereabout and disposed between the magnet and the adjacent sides of the box. Epoxy or other suitable material may be introduced to form a sealed unit. It will thus be seen that the magnetic lines will extend upwardly from the magnet as shown from the north pole, across the gap between the magnet and the side walls of the tray and then travel along the low reluctance path back to the south pole of the magnet. When the pickup is placed adjacent to a vibrating

string, a portion of the magnetic path will be through the lower reluctance string. For purposes of illustration, FIG. 10 shows a single string in cooperation with the upper surface of the electromagnetic pickup unit. The string 60 is disposed a distance 62 above the upper edge of the box. The magnetic lines will then travel upward from the magnet as shown by the arrow 63 along the string and back down to the tray or box 52 as shown by arrow 64. It is readily apparent that as the string vibrates, the distance between the string and the edges of the tray is varied thereby varying the reluctance path. Since the electromotive force is constant, the amount of flux will vary. This change in flux induces an electric current in the portions of the coil associated therewith. Referring particularly to the lip 56a associated with the string, it is seen that the return path for the flux extends along the entire lip. Thus, by bending the lip upwardly towards or away from the string, the reluctance can be incrementally varied. This feature is used to "voice" the piano.

The electromagnetic pickup is mounted in the cabinet closely adjacent to the strings whereby the vibratory motion of the string will result in a change in the flux linkage on the coils. In practice, it has been found that the spacing of about one-eighth inch from the strings produces a suitable output signal. Each of the strings will induce its own currents and there will be a mixing action on the coil to provide a complex output signal for each of the bass, midrange and treble windings.

The complex signals on lines 22, 23 and 24 are applied to voicing circuit 26. A suitable circuit is shown in FIG. 11 and includes three resistive-capacitive circuits having a common output. Each of the circuits includes two serially connected potentiometers 66 and 67 coupled by a capacitor 68. The potentiometers provide for varying the gain or amplitude which the capacitor provides in connection with the associated resistance of a frequency sensitive delay circuit.

Referring to FIG. 5, there is shown a conventional piano action and, as such, will only be briefly described. The action shown includes a key 71 mounted on pins 72 and guided for rocking movement by the forward pins 73. Depression of the front end of the key as shown at the arrow 74 serves to lift the rear of the key and lift the rod 76 which rotates the lever 77. This rotates lever 78 which causes spoon 79 to strike the lever 81 which lifts the associated damper 82 away from the string. Further rotation of the lever 77 causes the member 83 to strike the striker 84 which then drives the felt hammer 86 in the direction of arrow 87 to strike the associated string.

The tone is modified by means of two pedals, the left-hand pedal moving the hammer nearer to the strings and, therefore, decreasing the force of the blow. The right-hand pedal lifts all of the dampers simultaneously from the strings so as to sustain harmony as long as required and not merely to increase power. In addition, a central pedal is often added, called a sostenuto which, instead of lifting all the dampers, affects only those which happen to be already lifted keeping them so lifted until the pedal is released. Thus, one is able to sustain a chord leaving the other hand free for other notes. Since, however, the volume of the tone of the present invention can be electronically controlled, the left-hand pedal 91, where the usual soft pedal is placed, is used as a volume pedal.

The pedal action is more clearly shown in FIG. 4 and includes the conventional pedal 92 pivoted at 93 and extending through a spring-loaded plunger 94. The other end of the spring-loaded plunger may, for example, rotate a gear 96 which, in turn, drives gear 97 attached to a potentiometer connected in an amplifier circuit to control the volume. This is indicated generally in FIG. 2 by the line marked "pedal". The level of volume can also be adjusted at the console to provide maximum full amplification for the audio level of the room which can then be varied by the foot pedal as desired during playing of a number.

Referring now more particularly to FIG. 12, there is shown another embodiment of a harp and frame in accordance with the present invention.

The frame 101 is made of tubular metal such as tubular steel. Cross member 102 is spaced from the top of the frame to provide a space for the pinblock. Reinforcing members 103 are provided between the bottom of the main frame and the cross member 102. Tuning pins 107 are inserted in the pinblock in a conventional manner. A curved member 108 extends across the frame and serves to receive hitch pins 109. The strings are strung between the tuning pins and the hitch pins. A number of the strings are so-called bi-strings while 12 of lower frequencies are singles. These two types of strings are designated generally by the arrows 111 and 112, respectively, on FIG. 12. A top rail or bridge 113 is interposed between the pinblock and the strings and a bottom rail or bridge 114 is interposed between the curved member and the strings. Again, it is particularly noted that in the present design all the strings are parallel to one another and arranged vertically simplifying the stringing.

It is to be noted that the frame and harp is a single unit made of one material and that because of its unitary construction, it is less sensitive to environmental changes than a conventional piano. A plurality of electromagnetic pickup units 116-120 are coupled to the strings. The units are disposed generally one-third of the distance between the bottom and top bridges.

One pickup unit is shown in more detail in FIG. 13. It comprises a tray or housing 122 made of high permeability magnetic material. The tray 122 is in the form of an open box. The lower portion of the tray has outwardly extending tabs 123 provided with openings 124 for mounting the electromagnetic unit in the cabinet adjacent the strings. One side wall of the box is provided with a plurality of lips or tabs 126 which extend outwardly substantially parallel to the upper surface of the box. The unit includes a coil 127 which is wound about a permanent magnet bar 128 in the manner shown. Thus, the permanent magnet bar is disposed longitudinally within the box 122 and the coil 127 is wound thereabout and disposed between the magnet and the adjacent sides of the box. Epoxy or other suitable material may be introduced to form a sealed unit. It will thus be seen that the magnetic lines will extend upwardly from the magnet as shown from the north pole, across the gap between the magnet and the side walls of the tray and then travel along the low reluctance path back to the south pole of the magnet. When the pickup is placed adjacent to a vibrating string, a portion of the magnetic path will be through the lower reluctance string. For purposes of illustration, a single string is shown in cooperation with the upper surface of the unit. The string 131 is disposed a distance 132 above the upper edge of the box. The magnetic lines will then travel upward as shown by the arrow 133 along the string and back down at the outer surface. It is readily apparent that as the string vibrates, the distance between the string and the edges of the tray is varied thereby varying the reluctance path. Since the electromotive force is constant, the amount of flux will vary. This change in flux induces an electric current in the coil 127. Referring particularly to the lip 126a associated with the string, it is seen that the return path for the flux extends along the entire lip. Thus, by bending the lip towards or away from the string, the reluctance can be incrementally varied. This feature is used to "voice" the piano when it is tuned.

The electromagnetic pickups 116-120 are mounted in the housing closely adjacent to the strings whereby the vibratory motion of the string will result in a change in the flux linkage on the coils. In practice, it has been found that the spacing of about one-eighth inch from the strings produces a suitable

output signal. Each of the strings will induce its own currents and there will be a mixing action on the coil to provide a complex output signal which is added to the signals from the other pickup units and applied to the preamplifier. In certain instances a plurality of magnetic pickups may be desired since the spacing between the magnetic pickups and the strings will vary depending upon whether they are the bass, midrange or treble strings. It is apparent that the treble strings will not have as great an amplitude of vibration and that, therefore, the pickup unit will be much closer to the strings than is the unit for the bass strings which have a substantial excursion in their vibrations. In the present example, the first four units 116, 117, 118, 119 are associated with one octave each, 12 strings, while the unit 120 is associated with 16 strings. The outputs of the pickup units are applied to either directly or through a voicing circuit 26 to the preamplifier 27.

Thus, there is provided a piano in which the vibratory motion of the strings serves to generate electrical signals or oscillations which can be electronically processed and applied to a speaker. Voicing, tone, special effects, volume, etc., are controlled primarily electrically. A piano in accordance with the invention will be substantially less costly because of the use of electronic circuits.

I claim:

1. An electromagnetic piano comprising means supporting a plurality of strung strings, means including keys and hammers for striking said strings to set the same into vibration, a plurality of electromagnetic means magnetically coupled to selected ones of said strings serving to generate electrical signals responsive to the vibration of the strings and having frequencies corresponding to the frequency of vibration of said strings, each of said electromagnetic means comprising a low reluctance U-shaped tray having a bottom and upstanding walls, a lip formed at the upper end of at least one of said walls and extending substantially parallel to said strings, and elongated permanent magnet having north and south poles along its edge disposed in said tray with one magnetic pole magnetically coupled to the bottom of the tray and the other pole spaced from and coupled to the upper end of said walls and lip via a gap, a coil coupled to said permanent magnet whereby as the strings are vibrated they modulate the reluctance across the gap and induce electrical signals in the associated coil, voicing means comprising a resistive-capacitive network coupled to receive the output of each of said electromagnetic means, means for receiving, processing and amplifying the signals from each of said voicing means, and a speaker connected to receive said processed and amplified signals serving to generate sound.
2. A pickup device for stringed instruments comprising an elongated magnet having north and south poles along its edge, a coil coupled to said permanent magnet, and low reluctance means comprising a U-shaped tray having a bottom and upstanding walls with said magnet disposed in said tray and having one of said poles magnetically coupled to the bottom of the tray and the other pole spaced from and coupled to the upstanding walls via a gap, a lip formed at the upper end of at least one of said walls and adapted to extend substantially parallel to said strings whereby said lip can be bent to adjust the coupling to selected strings to voice the stringed instrument, the reluctance across said gap being modulated responsive to vibrations of the strings whereby to induce an electrical signal in said coil.