May 21, 1963 C. L. FENDER 3,090,274

ELECTRIC PIANO

Original Filed June 9, 1959 2 Sheets-Sheet 1

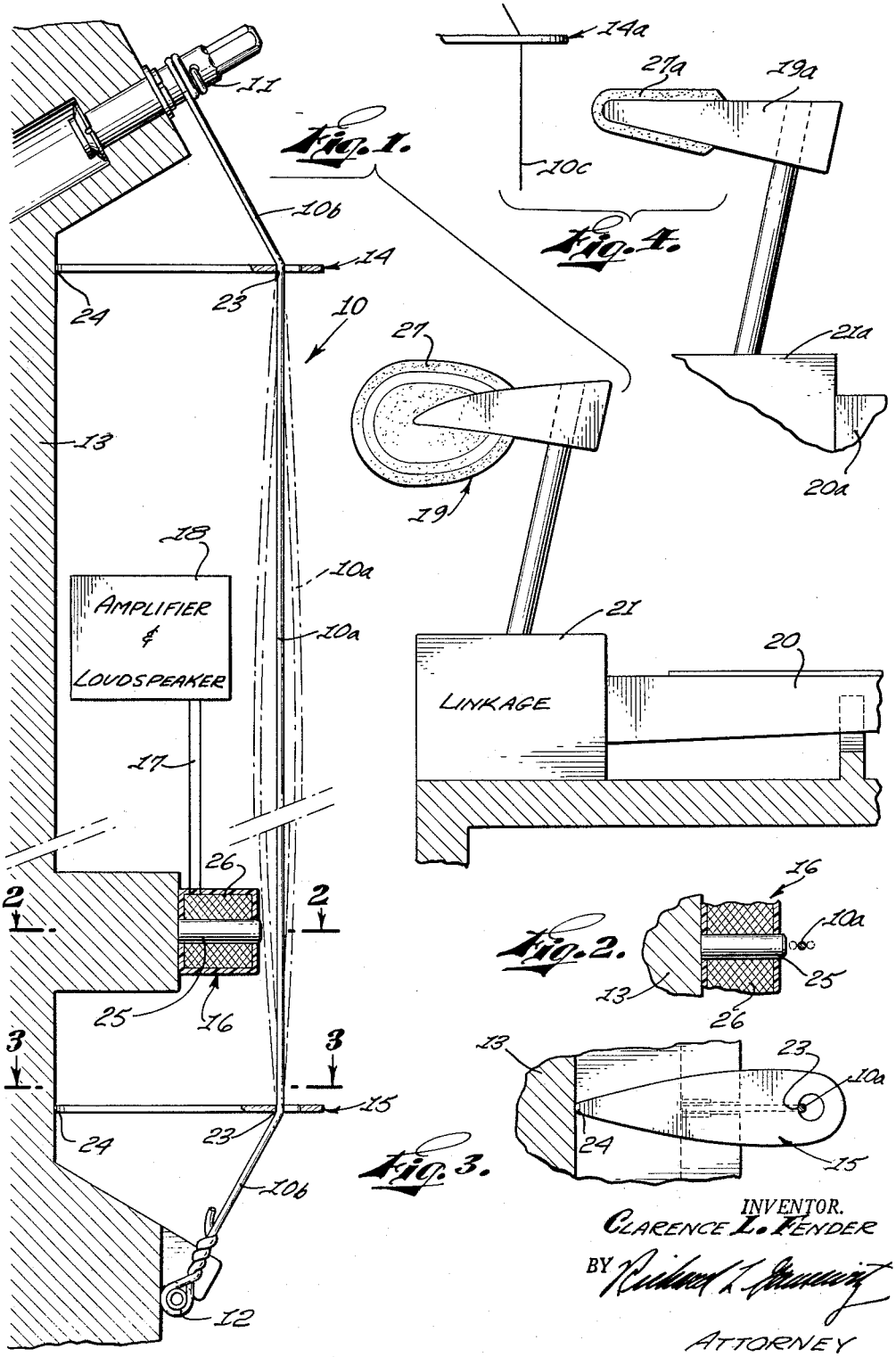

Fig. 1.

Fig. 4.

Fig. 2.

Fig. 3.

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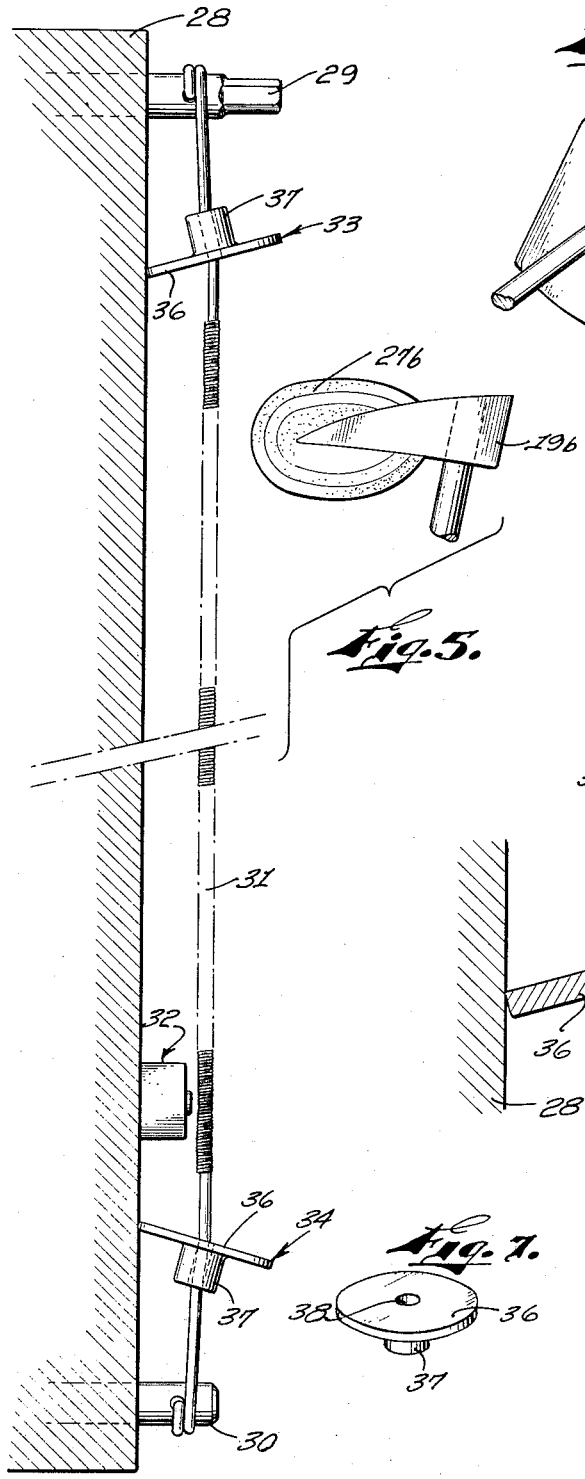

Fig. 8.

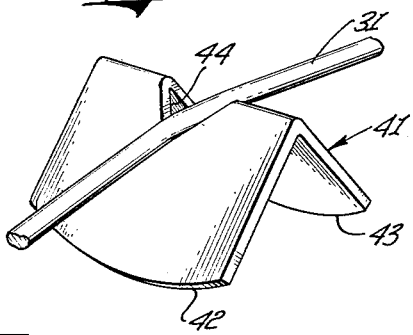

Fig. 5.

Fig. 6.

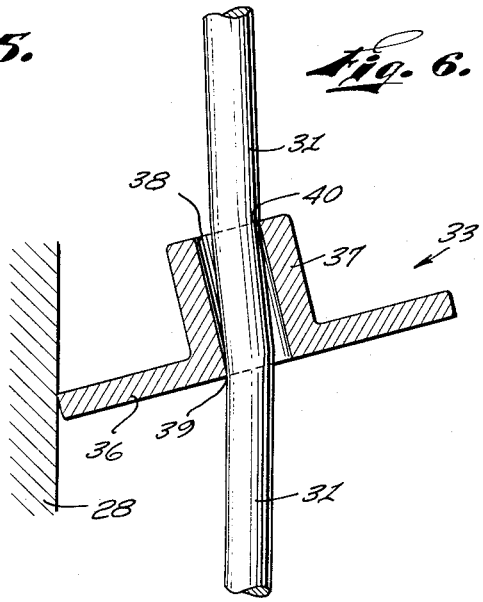

Fig. 7.

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3,090,274
ELECTRIC PIANO

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Continuation of application Ser. No. 819,082, June 9, 1959. This application Apr. 28, 1961, Ser. No. 107,009
17 Claims. (Cl. 84—209)

This invention relates to an electric piano, and more particularly to a string-supporting means therefor. This application is a continuation of my co-pending application Serial No. 819,082, filed June 9, 1959, for Electric Piano, now abandoned.

It has long been desired to produce a practical and economical piano incorporating tensioned strings and in which the vibrations of the strings are converted into electrical signals which are electronically amplified and fed into a loudspeaker. No such instrument is yet extensively marketed, however, one important reason being that rotation of the planes of vibration of the strings produces undesired beating noises which render the instrument musically unsatisfactory. Such beating noises result from the fact that a loud sound is generated when each string is vibrating toward and away from the pickup means, but only a soft sound results when the string is vibrating in such a plane that the distance between it and the pickup means does not vary substantially. Attempts have been made to prevent the plane of vibration of each string from rotating after the hammer blow is imparted thereto, but the apparatus suggested for accomplishing this result has not been practical or economical. Other limitations and defects of prior-art electric pianos included the difficulty or impossibility of changing the effective length of each string.

In view of the above and other factors characteristic of prior-art electric pianos and other musical instruments, it is an object of the present invention to provide an electric piano incorporating novel, simple and practical means for preventing rotation of the plane of vibration of each string, so that no beating noises are produced.

A further object of the invention is to provide bridge or acoustical isolation means for preventing the plane of vibration of a string from rotating subsequent to the hammer blow, and which are readily movable to effect changing of the effective length of the string.

A further object of the invention is to provide a novel bridge and string relationship whereby the bridge is adapted to pivot or roll freely and to be moved at will, yet which is such that the bridge will not be so unstable as to permit movement of the string to undesired locations.

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 drawings to which they relate.

In the drawings:

FIGURE 1 is a schematic vertical sectional view illustrating one set of elements constructed and related in accordance with the present invention;

FIGURE 2 is a fragmentary transverse section taken on line 2—2 of FIGURE 1, and illustrating the plane of vibration of the string;

FIGURE 3 is a transverse section on line 3—3 of FIGURE 1;

FIGURE 4 is a fragmentary view illustrating a hammer and string adapted to produce a note of relatively high pitch;

FIGURE 5 is a schematic view corresponding generally to FIGURE 1 but illustrating a second embodiment of the invention, in which the bridge elements are in shifting-pivot or rolling engagement with a frame or support;

FIGURE 6 is an enlarged longitudinal sectional view

illustrating the manner of engagement between the string and one of the rollers of FIGURE 5;

FIGURE 7 is a perspective view of one of the roller bridges; and

FIGURE 8 is an enlarged perspective view illustrating a third embodiment of the invention, in which each bridge is formed as a V-shaped plate having arcuate edges and notched to receive the string.

The electric piano comprises a large number of substantially independent assemblies each including a piano key, a hammer, a string, a mechanical-electrical transducer, and two bridge or acoustical isolation devices. The electrical signals generated in the transducers are amplified and fed into a common loudspeaker. Since all of the assemblies are identical in principle, although varying in string diameters and lengths as well as in hammer constructions, only a few such assemblies will be described herein.

Referring first to the embodiment of FIGURES 1–4, inclusive, each assembly comprises a tensioned string 10, means 11 and 12 to connect the ends of string 10 to a frame or support 13, and first and second bridge means 14 and 15 disposed between the connectors 11 and 12 to acoustically isolate a string section 10*a* adapted to vibrate at a predetermined pitch. Mechanical-electrical transducer means 16 are provided to convert the mechanical vibrations of the vibrating string section into electrical signals, such signals being transmitted through leads 17 to suitable amplifier and loudspeaker means indicated schematically at 18. The string section 10*a* is set into vibration by means of a hammer 19 which is actuated upon pressing of a piano key 20, there being a suitable linkage or action interposed between the key and the hammer as schematically represented at 21.

Stated more definitely, the string 10 may be a conventional piano wire having the vibaating section 10*a* between the bridges 14 and 15, and stay sections 10*b* between the respective bridges and the adjacent connectors 11 and 12. The connectors may be of any suitable type adapted to fixedly secure the ends of the string 10 to the support or frame 13. In the illustrated form, the connector 11 is a post rotatably mounted in the frame 13 with a great amount of friction and adapted to be turned in order to vary the string tension. Connector 12, on the other hand, is illustrated as comprising a suitable eyelet locked in cooperating ear portions of the frame. It is to be understood that the support 13 may be any suitable structure such as a mass of metal or wood. The same frame may be provided for all or most of the strings, or individual frames or bars may be provided for each string.

The first and second bridge means 14 and 15 comprise identical metal stampings having string-engaging portions 23, illustrated as the walls of openings, and having pivot portions 24 at which the frame 13 is pivotally engaged. The stampings are caused, as by tumbling, to be sufficiently smooth so that the friction at the points of engagement between pivot portions 24 and frame 13 will be minimized. The bridge elements are thus permitted to pivot very freely, being substantially completely unrestrained by direct action from the frame 13.

As illustrated in FIGURE 1, the string 10 is threaded through the openings in the bridges 14 and 15, and such bridges are oriented perpendicular to the vibrating string section 10*a* and caused to engage the frame 13 at the pivot portions 24. The string is tensioned sufficiently, by turning the post 11, that the pivot portions 24 bear tightly against the frame and are frictionally prevented from moving.

It is emphasized that the pivot portions 24 engage the frame a substantial distance on one side of a straight

line between the points where the string ends engage the connectors 11 and 12. String section 10*a* is disposed a substantial distance on the opposite side of such straight line. It is this relationship which prevents the assembly from being unstable, so that the bridges tip over. To illustrate, let it be assumed that the pivot portion 24 of each bridge engages the frame 13 at a point on a direct line between the points of engagement of stay portions 10*b* with connectors 11 and 12. Such an arrangement would be very unstable, since the bridges could tip over in planes perpendicular to string section 10*a* without tending to effect stretching of stay sections 10*b*. However, with the present relationship whereby the pivot ends of the bridges engage frame 13 a substantial distance from such direct line, the bridges may not pivot in planes perpendicular to string section 10*a* without tending to stretch sections 10*b*. It follows that sections 10*b* tend to cause the bridges to remain upright as is desired.

It is a very important feature of the invention that, although the stay sections 10*b* tend to cause the bridges to remain upright, they nevertheless permit a small amount of pivotal movement of the bridges about pivot portions 24 and in planes perpendicular to vibrating section 10*a*. This pivotal movement is sufficient that the bridges 14 and 15 will not support substantial vibrations of section 10*a* in a plane perpendicular to the bridges. However, the bridges and the cooperating connectors 11 and 12 are such that the string-engaging bridge portions 23 do not tend to move when the string section 10*a* is vibrating in the same plane as a plane containing both bridges, and will thus support vibrations in such plane. Such plane of vibration is illustrated in solid and dashed lines in FIGURES 1 and 2, and is the one which results when the hammer 19 strikes the string as will be described. Since the bridges 14 and 15 will only support substantial string vibrations in the plane containing both bridges, and not in a plane perpendicular to the bridges, it follows that the plane of vibration of string section 10*a* will not rotate. Instead, the string continues to vibrate toward and away from the transducer means 16 to effect uniform generation of strong electrical signals therein, so that there is no beating noise emitted from the loudspeaker means.

In view of the above, it will be understood that the bridges 14 and 15 comprise extremely simple and economical yet highly effective means for preventing rotation of the plane of vibration of string section 10*a*. Furthermore, the bridges may be readily shifted, as by means of pliers, to change the length of a vibrating string section 10*a* in order to adjust the pitch thereof, the locations of the nodes, etc.

The mechanical-electrical transducer means 16 is illustrated to comprise an electromagnetic pickup having an elongated permanent magnet pole piece 25 disposed perpendicular to the string section 10*a* and in the same plane as bridges 14 and 15. A coil 26 is wound around the magnet 25 and connected through the leads 17 to the amplifier and loudspeaker means 18. Since the string 10 is formed of a magnetizable material such as steel, vibration thereof effects generation of a corresponding voltage in the coil 26.

The hammer 19 is adapted to move perpendicular to string section 10*a* and in the same plane as the string as well as the bridges 14 and 15. For the relatively low-pitched strings, the hammer is covered with a relatively thick layer of felt 27 in order to effect initial damping of undesired harmonics in a manner known to the art. The hammer is, as previously indicated, connected to a conventional piano key 20 through a suitable linkage or action 21 which may be of a conventional type.

Referring to FIGURE 4, a smaller-diameter string 10*c*, adapted to produce a note of higher pitch, is illustrated as associated with a bridge 14*a*, the other bridge being unshown. The hammer 19*a*, having a relatively thin layer of felt 27*a*, is associated with the string 10*c* to impart a hammer blow thereto when the piano key 20*a* is depressed. Except as stated, the construction is identical to that shown in FIGURE 5. As previously indicated, the relationship between the elements for the various notes of the instruments may be identical, each string having two bridges which are associated with the frame or frames as described in detail above.

Embodiment of Figures 5–7

Referring next to the embodiment of FIGURES 5–7, a frame or support is indicated schematically at 28, and has first and second posts 29 and 30 rotatably mounted therein but with a great deal of friction. A piano string 31 is connected between the posts 29 and 30, and one of the posts 29 is rotated until the string is under substantial tension. Mechanical-electrical transducer means, in the form of an electromagnetic pickup 32, is mounted between the string and frame 28 and is associated with amplifier and loudspeaker means as in the embodiment of FIGURE 1. Hammer means, indicated at 19*b* and 27*b*, is adapted to effect vibration of the string toward and away from the frame in response to the striking of a piano key, also as indicated in the first embodiment.

First and second bridges 33 and 34 are mounted between the frame 28 and string 31 and in engagement with both, and comprise light-weight or low-mass metal discs 36 having axially-extending hubs 37. A bore 38 is formed axially in each disc and hub and has a diameter substantially greater than that of the adjacent portion of string 31. The radial dimension between the wall of bore 38 and the periphery of disc 36 is sufficient to effect spacing of the central (vibrating) string section farther away from frame 28 than would be the case if no bridge members were employed. The central string section is thus substantially acoustically isolated from the end sections, i.e., from the string sections between the respective bridges and the posts 29 and 30.

As best shown in FIGURE 6, each bridge has a tendency to tilt or cant, which causes two-point engagement between sharp edges 39 and 40 and spaced portions of the string. Such two-point engagement insures against transmission of vibrations from the central or operative string section to the end sections, and prevents undesired damping and slapping effects.

In the operation of the embodiment of FIGURES 5–7, it is pointed out that the peripheral portion of disc 36 may roll on frame 28 about an axis generally parallel to the central (vibrating) string section. Such rolling engagement (which also comprises a shifting-pivot or rocking relationship), in combination with the low mass of each bridge, cause resistance to lateral movement of the ends of the central string section to be very slight. Since such resistance is very slight, the central string section will not vibrate laterally (in a plane perpendicular to the the illustrated posts 29 and 30) for the reason that there is nothing to oppose the vibration. However, the bridges present substantial resistance to movement of the engaged string portions toward and away from the frame 28, so that vibration of such central string portion toward and away from the frame is effected when the hammer 19*b*—27*b* strikes the string. The result, as described above, is that the plane of vibration of the central string section does not rotate but instead is maintained in such relationship to pickup 32 that the maximum nonbeating response is achieved.

Embodiment of Figure 8

The construction of the embodiment of FIGURE 8 is identical to that described with relation to FIGURES 5–7, except that each of the bridges 33 and 34 is replaced by a bridge 41.

Each bridge 41 is illustrated as comprising a relatively low-mass light-weight angular sheet-metal element having corresponding arcuate ends 42 and 43 which

ride on the frame or support **28** for for rolling or shifting-pivot movement in planes generally perpendicular to the central string section. A relatively deep notch **44** is cut in the apex portion of bridge element **41**, so that each leg of the bridge has a generally V-shaped edge which engages the string **31**. String **31** is thus engaged at two points which are spaced apart by a distance determined by the depth of the notch **44**. The bridge **41** is sufficient in size to eeffct spacing of the central or operative string section away from frame **28** a greater distance than if no bridges were employed, that is to say if the string were merely stretched between the post **29** and **30** in the absence of any bridge means.

The operation of the embodiment of FIGURE 8 is similar to that of the embodiment of FIGURES 5–7, in that the rolling engagement between arcuate edges **42** and **43** and the frame **28** is such that no substantial resistance to lateral shifting of the engaged string portions is presented. This being the case, the string **31** will not vibrate substantially in a lateral plane, but will only vibrate toward and away from the frame **28** as is desired and upon striking of the string by the hammer.

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. In an electric piano, a string, first and second means to connect the end portions of said string to a support and under tension, hammer means movable generally perpendicular to said string to impart a hammer blow thereto, first and second bridge means disposed respectively between said connector means and the point of engagement of said hammer means with said string to acoustically isolate a section of said string, said bridge means each engaging said string and said support to prevent movement of the engaged increments of said string in a first predetermined direction perpendicular to said string section, the portion of each bridge means engaging said string being freely movable through small distances in a second direction perpendicular to said first predetermined direction and to said string section whereby substantial vibrations of said string section are supported only in said first predetermined direction, said hammer means moving in a direction parallel to said first predetermined direction, mechanical-electrical transducer means to sense the vibrations of said string section in said first predetermined direction and convert the same into electrical signals, and amplifier and loudspeaker means to convert said electrical signals into sound.

2. In an electrical musical instrument, a string, a support, means to connect two points of said string to said support and place said string in tensioned relationship, at least one bridge element mounted between and in engagement with said string and said support, pivot means on said bridge to pivotally associate said bridge with said support for pivotal movement of said bridge in a plane generally perpendicular to said string, and pickup means disposed adjacent said string to sense the vibrations thereof and transform the same into electric current, in which the point of engagement between said bridge and said string is disposed a substantial distance on one side of a straight line between the two points where said string engages said support and in which the point of pivotal engagement between said bridge and said support is disposed a substantial distance on the other side of said straight line.

3. In an electrical musical instrument, a support, a string, means to mount said string in tensioned relationship over said support, mechanical-electrical transducer means disposed adjacent said string to sense the vibrations thereof and convert the same into electric current, and a bridge element mounted between said support and said string and in engagement with both, said bridge

having an arcuate portion in rolling engagement with said support and oriented to permit limited rolling movement of said bridge on said support about an axis generally parallel to said string.

4. In an electrical musical instrument, a support, a string, means to mount said string in tensioned relationship over said support, first and second bridges mounted between said string and said support and in engagement with both, said bridges being shaped to increase the distance between said string and said support and to acoustically isolate a portion of said string, and mechanical-electrical transducer means associated with said portion of said string to sense the vibrations thereof and convert the same into electrical current, characterized in that said bridges are low-mass elements having arcuate edge portions in rolling engagement with said support and oriented to permit limited rolling of said bridges on said support about axes generally parallel to said portion of said string.

5. An electric piano, which comprises a frame, means to mount a plurality of strings over said frame in tensioned relationship, said mounting means permitting adjustment in the tension of each string, first and second bridges associated with each of said strings and each having at least a portion disposed between a string and said frame and in engagement with both, said last-named portions of said first and second bridges having sufficient size to shift an intermediate section of said string away from said frame and substantially acoustically isolate said section from the end portions of said string, said first and second bridges each being in pivotal contact with said frame to permit pivoting of said bridges in planes substantially perpendicular to said section, electromagnetic pickup means disposed adjacent said section of each of said strings to sense the vibration thereof toward and away from said frame, and hammer means to strike said section of each of said strings to set said section into vibration toward and away from said frame.

6. The invention as claimed in claim 5, in which each of said bridges is in shifting-pivot engagement with said frame.

7. The invention as claimed in claim 6, in which each of said bridges comprises a low-mass disc having an axial hub portion, said disc and said hub portion having an axial opening therethrough, said string being extended through said opening.

8. The invention as claimed in claim 6, in which each of said bridges comprises a low-mass angular plate having spaced arcuate edges in rocking engagement with said frame, the apex portion of said plate being notched relatively deeply, said notch serving to receive said string to effect contact between said plate and said string at two points.

9. An electrical musical instrument including a support, at least one tuned string, said string being anchored at its ends on said support, a bridge means adjacent each end of said string, said bridge means having single point contact with said support, a string exciting means and pick-up means adjacent said string in a plane normal to that of said support.

10. The invention as claimed in claim 9, in which said string exciting means is a hammer operably associated with a piano action.

11. The invention as claimed in claim 9, in which said pickup means is an electromagnetic pickup mounted adjacent said string, said pickup being spaced sufficiently far from said string to be out of contact therewith in all positions of said string.

12. The invention as claimed in claim 9, in which said string exciting means is a hammer operably associated with a piano action, and in which said pick-up means is an electromagnetic pickup mounted adjacent said string, said pickup being spaced sufficiently far from said string to be out of contact therewith in all positions of said string.

13. The invention as claimed in claim 12, in which amplifier and loudspeaker means are connected to said pickup and cooperate therewith to reproduce the vibrations of said string in the form of sound.

14. The invention as claimed in claim 12, in which each of said bridge means comprises an elongated metal stamping one end of which is provided with a hole through which said string is extended, and the other end of which is a relatively sharp point in engagement with said support.

15. The invention as claimed in claim 12, in which each of said bridge means comprises a low-mass element having an arcuate edge one point of which is in contact with said support, said arcuate edge being disposed to rock on said support about an axis parallel to said string.

16. The invention as claimed in claim 15, in which said low-mass element is a disc having an axially-projecting apertured hub portion through which said string is extended.

17. An electric piano including a support, a plurality of tuned piano strings, means to anchor each of said strings at its ends on said support, each of said strings being connected only with said support and being independent of each other one of said strings, first and second light-weight low-mass acoustical isolation elements engaged with each string at spaced points therealong to acoustically isolate a predetermined section thereof, said predetermined string section being between said acoustical isolation elements, each of said acoustical isolation elements having one portion thereof in contact with said string and another portion thereof in contact with said support, said last-mentioned portion of each acoustical isolation element being spaced a substantial distance from said one portion thereof, said last-mentioned portion of each acoustical isolation element being so related to said support that said one portion thereof may move freely with said string in a first predetermined direction whereby vibrations of said predetermined string section in a first plane parallel to said first predetermined direction are substantially prevented, said acoustical isolation elements being adapted to support vibrations of said predetermined string section in a second plane perpendicular to said first plane, hammer means movable in said second plane to strike said predetermined string section and set the same into vibration in said second plane, and mechanical-electrical transducer means operably associated with said predetermined string section to sense the vibrations of said predetermined string section in said second plane and convert the same into an electrical signal.

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