

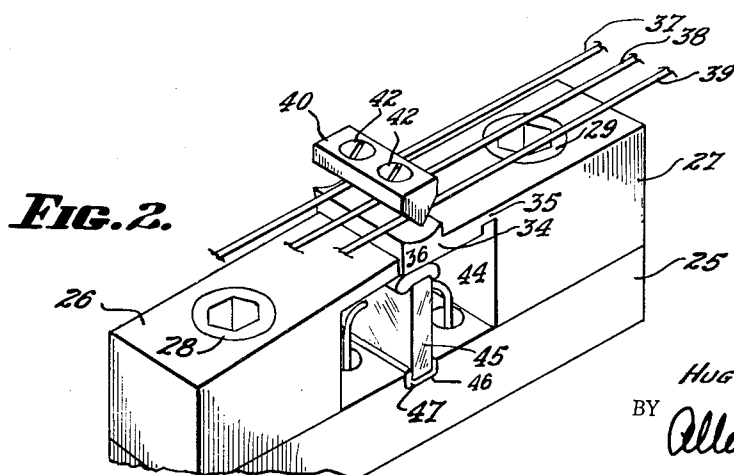
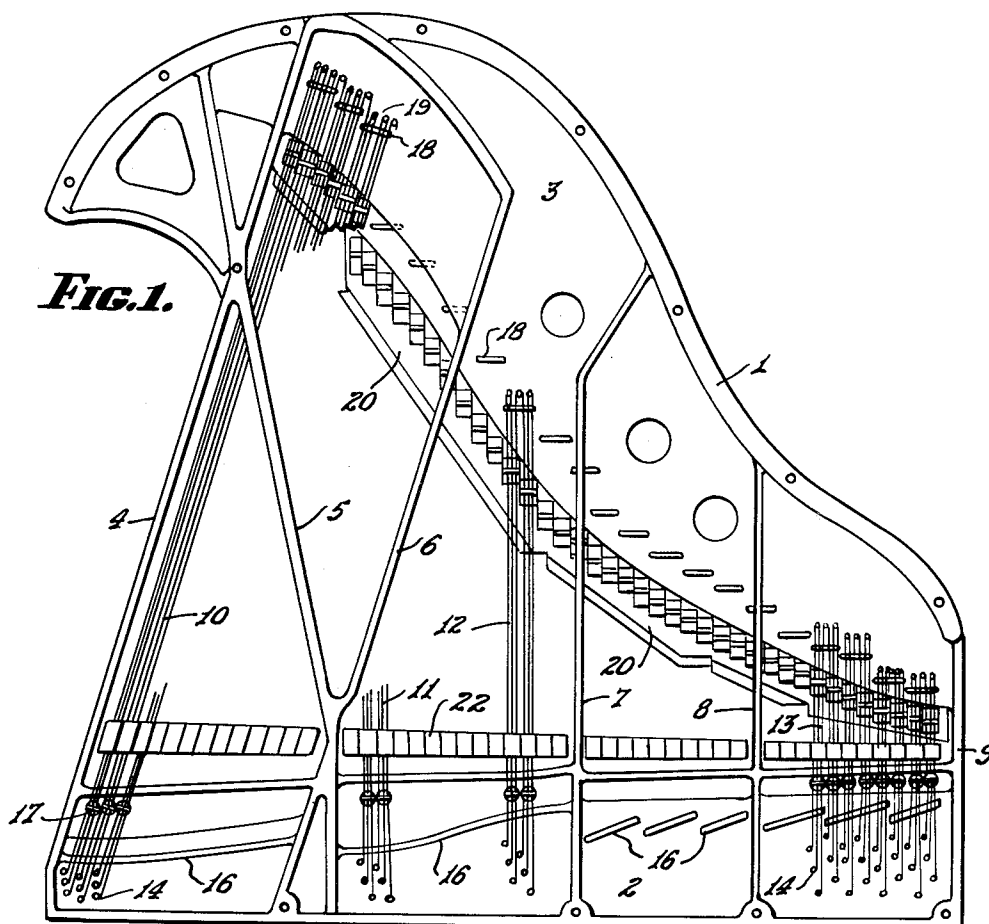
Aug. 21, 1962

H. BENIOFF
ELECTRO-PIANO

3,049,958

Filed Feb. 13, 1959

2 Sheets-Sheet 1



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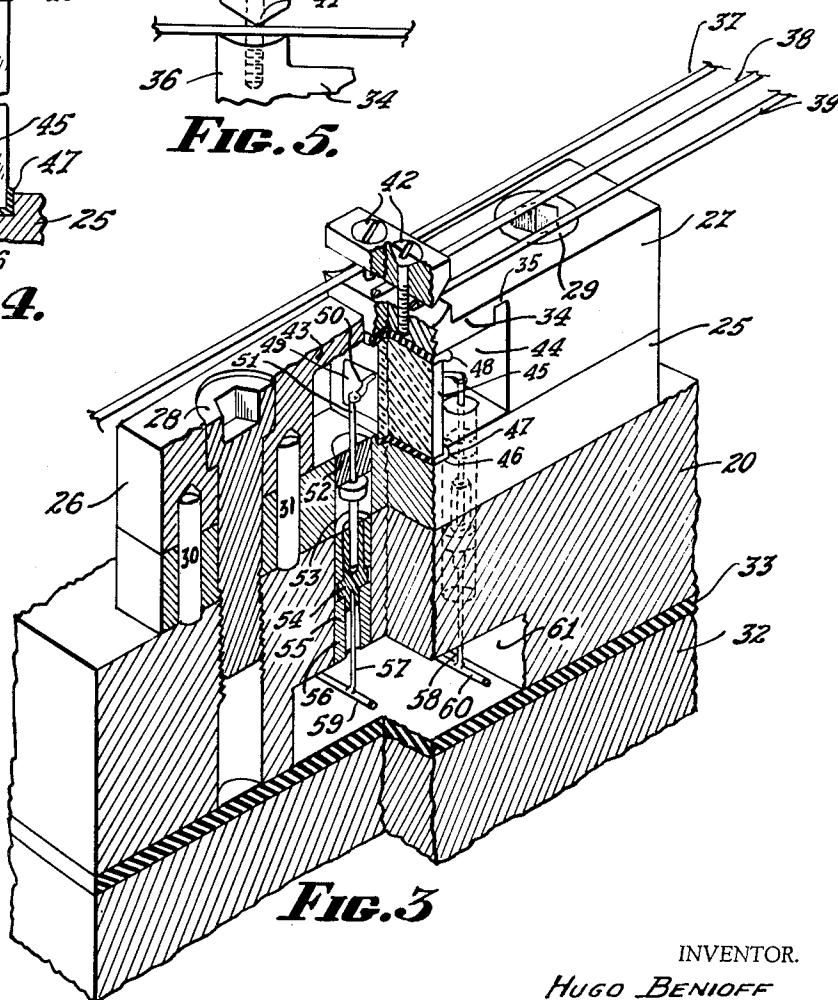
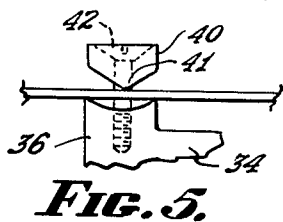
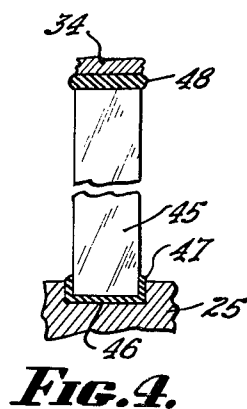
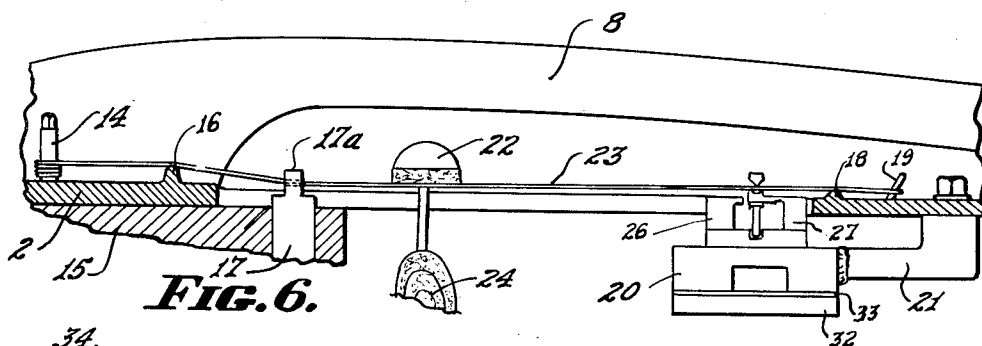
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2 Sheets-Sheet 2



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ELECTRO-PIANO

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Filed Feb. 13, 1959, Ser. No. 793,143
12 Claims. (Cl. 84-1.16)

The invention will be described in connection with an electro-piano, it being understood that the principles of the invention may be applied to other stringed instruments, generally keyboard operated, in which in the past the vibrations of the strings have been transmitted to a sounding board by means of a bridge.

In prior efforts to produce electro-pianos, it has been the general practice to remove the sounding board and its bridge, to stretch the strings between fixed points on opposite sides of the frame, and to translate the mechanical vibrations of the strings into electrical oscillations by suitable pick-up means. Such pick-up means have included magnetic devices, capacitive means, piezo-electric crystals and the like. In some instances, the speaking length of the strings has been determined by agraffe means at one side of a frame or plate, and, near the other side, by cantilever elements over which the strings pass, the cantilever elements in turn operating pick-up means of various types. The results of these efforts, however, have been disappointing for the reason that the expedients recited have altered the tonal and percussive effects of the tones produced electrically as respects the normal tones of comparable pianos which convert the energy of the vibrating strings into acoustic vibrations by means of the bridge and sounding board. The electrical instruments produced tones disturbingly unlike the expected piano tones.

In an endeavor to overcome this difficulty, prior workers have made many alterations in the normal construction of pianos, including alterations in the size or shape of the frame or plate, alterations in the number and tension of the strings, alterations in the number and positions of the pick-up devices, and others, but without achieving true piano tonality.

Electro-pianos are useful primarily because the volume of the sound produced may be controlled at will and practically without limit. Thus for concert purposes, the volume may be increased so as more adequately to fill a large auditorium, or to comport with the volume of a symphony orchestra; but there are fields of utility also in which a very low volume is desired, or in which the sound is desired to be reproduced electrically by ear-phones or the like without any great general transmission of vibrations to the air. In all of these fields of utility, the elimination of the conventional bridge and sounding board is a practical necessity for such purposes as the prevention of interference between a mechanical transducer and an electrical transducer located at different points, the minimizing of feedback effects, the virtual silencing of the instrument when earphones are being used, etc.

The tonality of a piano is dependent not alone on the number, length, and tension of the strings and the manner in which they are set into vibration, although these have their effect. The percussive characteristics of piano tones are largely due to the damping inherent in the instrument, and which primarily arises from the reaction of the sounding board on the strings through the bridge or bridges. It is an object of this invention to provide an electro-piano or like instrument in which, although the sounding board and bridge are absent, the damping effect on the strings is similar to that of the normal mechanical piano.

It is an object of the invention to provide either for the conversion of a normal piano to an electro-piano or for the initial construction of an electro-piano in such a way

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that in either event the instrument will follow the basic principles of piano design.

It is an object of the invention to provide an electro-piano or like instrument which can be constructed, operated, handled, and tuned in the ways hitherto current and accepted for normal mechanical pianos. Ancillary to this object is the use of conventional means for setting the strings into vibration, such as a normal or accepted piano action including keys such that the musician will encounter no conditions in the operation of the instrument other than those with which he is familiar in the operation of normal mechanical pianos.

It is an object of the invention to provide an electro-piano or like instrument which is economical in cost, based on the cost of the normal mechanical instrument.

It is a specific object of the invention to provide in an electro-piano a means determining the speaking length of the strings at one end, which means gives the essential damping effect normally produced in the mechanical piano by the sounding board and bridge and which, where desired, may embody the pick-up means.

When the strings in a piano are actuated by the hammers, there is produced a component of longitudinal vibration in the strings. Such vibration is not harmonically related to the lateral vibrations and tends to result in an unpleasant roughness of the tones. It is an object of this invention to provide an electro-piano in which the effect of longitudinal vibration of the strings is not exaggerated but, on the contrary, may be substantially and usefully diminished.

It is an object of the invention to provide means where desired for minimizing the transmission of the vibrations of a struck string to adjacent strings mechanically. Such transmission, which can occur in the normal mechanical piano when the dampers are removed from the strings by actuation of the loud pedal, generally detracts from the tonal quality of the instrument.

The above and other objects of the invention, which will be set forth hereinafter or will be apparent to one skilled in the art upon reading these specifications, are accomplished by that construction and arrangement of parts of which an exemplary embodiment will now be described. Reference is made to the drawings forming a part hereof and in which:

FIG. 1 is a plan view of the frame or plate of a grand piano including a partial showing of the stringing thereof, and indicating the position of the pick-up devices of this invention.

FIG. 2 is a partial perspective view of a pick-up device of this invention.

FIG. 3 is a perspective view of a pick-up device and associated parts, with portions in section to show the interior construction.

FIG. 4 is an end elevation view with parts in section showing the mounting of a crystal.

FIG. 5 is a partial elevational view showing the engagement of a string with a cantilever member of the pick-up device.

FIG. 6 is a sectional view of a piano frame showing the relationship of parts with reference to a string.

Referring, first, to FIG. 1, there is shown the frame or plate 1 of an exemplary piano. The frame is usually formed of cast iron and is characterized by a fore part 2 and a rear part 3 separated by various ribs indicated at 4, 5, 6, 7, 8 and 9. Since the frame can be and preferably is the conventional frame of a mechanical piano, it need not be described in detail. Moreover, the frame will be strung with strings partially indicated as at 10, 11, 12 and 13. The strings at their forward ends engage tuning pins 14 mounted in the usual fashion in a wooden pin block lying beneath the fore part of the frame. A portion of the pin block is indicated in FIG. 6 at 15.

The strings extend rearwardly from the tuning pins 14, frequently passing over one of a series of ribs 16 on the fore part of the frame and are engaged by a suitable agraffe means 17 which may take various forms as known in the art. The particular form illustrated is that of a pin engaged in the pin block and having at its upper end a reduced portion 17a (FIG. 6) having holes through which the strings pass. The agraffe means, whatever their form, determine the forward limit of the speaking length of the strings, as is well understood in this art.

Those portions of the strings which extend from the agraffe means forwardly to the tuning pins are usually interlaced with strips of felt for damping purposes (not shown), as well understood in this art.

In the normal mechanical piano, a sounding board of suitable construction would be mounted beneath the frame or plate 1 and would carry one or more bridge elements over which the strings would pass. The bridge or bridges in this instance would determine the rearward limit of the speaking length of the strings. The rear ends of the strings, after passing over shallow ribs 18 on the frame, terminate at pins 19 set into the frame. As will be readily understood by persons familiar with this art, some of the strings are bare, and some are wound with wire to increase their mass. Also, in certain ranges of the piano, multiple strings are used for a single note. These expedients are employed in conventional fashion in the piano of this invention.

However, the piano of this invention has no sounding board and no bridge or bridges attached to a sounding board or similar mechanical transducer. Instead, the rearward limit of the speaking length of the strings is determined by devices hereinafter described in detail. The frame itself may be configured to support these devices or they may be mounted on a metal support of substantial mass 20 which is affixed to the frame by means of a series of brackets 21, as illustrated in FIG. 6. Conventional action elements and a conventional keyboard are used with the electro-piano of this invention, a series of dampers 22 forming part of the action being indicated in FIG. 1. FIG. 6 also indicates below the string 23 a portion of a hammer 24 of a conventional piano action. The details of the action and the keyboard do not require illustration or description herein since they are conventional.

The devices for limiting rearwardly the speaking length of the strings are illustrated in FIGS. 3 and 4. These devices comprise a metal base block 25 and forward and rearward upper blocks indicated at 26 and 27. These blocks are held together and fastened to a support 20 by means of bolts 28 and 29. These bolts are preferably formed as shown with socket heads recessed into the block members since it is desired to have the strings pass over the block 26 and 27 in close proximity to their upper surfaces. Where desired, pins 30 and 31 may be employed as shown to insure the alignment of the blocks. Where the support 20 is held to the string frame by brackets 21, it may be either individual to a block assembly such as is being described, or it may be of sufficient length to support a plurality of the block assemblies. In either event, if desired, the various supports 20 may be unified by an underlying metal plate 32 bolted to the several supports but separated from them by a layer 33 of insulative or cushioning substance.

The blocks 26 and 27 are separated as shown. The rearward block 27 has a forwardly extending cantilever 34. The cantilever is separated from the block by a reduced neck 35, the construction being such that the cantilever will have a natural period of vibration of very low frequency so as not to affect the vibration of the strings but so as to permit the cantilever to vibrate responsively to the vibration of the strings. The forward end of the cantilever 34 is provided with a trough-shaped configuration 36 characterized by spaced ridges to be engaged by the strings 37, 38 and 39; and the strings are

held in contact with these ridges by an upper element 40 having a clamping ridge 41 engaging the strings between the aforementioned ridges of the cantilever. The clamping means is held in place by screws 42 or other suitable means. The strings are not substantially bent or deflected between the ridges of the cantilever and the clamping means, but are held with sufficient firmness to cause the cantilever to follow the vibrations of the strings. It may be noted from FIGS. 2, 3 and 6 that the string portions extending rearwardly of the point of their engagement with the cantilever and the clamping means follow paths which are substantial straight line continuations of the speaking length of the strings. This is of importance in that longitudinal vibrations of the speaking lengths of the strings tend to pass rearwardly through the point of engagement of the strings with the cantilever and clamping means, instead of being reflected back into the speaking length of the strings as is frequently the case where the strings are deflected by the conventional bridge. Those portions of the strings extending rearwardly of the points of their engagement with the cantilever and the clamping means will be interlaced with strips of felt (not shown), and transmitted longitudinal vibrations will be damped thereby, thus accomplishing one of the ancillary objects of this invention.

The block assemblies illustrated in FIGS. 2 and 3 are shown as having cantilevers engaging three strings, and it will be understood that these three strings are those for a single note. It is preferable to provide a separate block assembly for each note within the compass of the scale of the instrument, whether that note has one or more strings.

The forward block 26 has a rearward extension 43, the end of which approaches but does not contact the cantilever 34. Thus, there is formed beneath the cantilever and extension a hollow space indicated at 44 in the drawings. Within this hollow space, it will be seen that there is a vertically extending member 45, the lower end of which is set into a recess 46 in the block 25 and is cemented therein, as at 47 (see FIG. 4) by some suitable cementitious material, so that the structure 45 is maintained in an upright position. The structure 45 underlies the outer end of the cantilever 34 and supports the outer end of the cantilever like a strut through the medium of a resilient mass 48 interposed between the upper end of the structure 45 and the cantilever. This resilient mass damps the movements of the cantilever in response to the vibrations of the string or strings and causes the cantilever to exert upon the strings a damping effect similar to that of the conventional bridge and sounding board assembly. This is the principal reason why the tonal qualities of the electro-piano of this invention are substantially the same as those of the conventional instrument.

The mass of resilient material 48 must have certain qualities. It must have a relatively large viscosity or internal friction relative to its density and elastic coefficient. A particular material found excellent for this purpose is a resinous material sold by the Astatic Corporation under the trademark "Audioid." Other materials which may be used are silicone, neoprene and other synthetic rubbers, rubber cork mixtures and rubber saturated fibrous substances. The specific damping effect will be determined not alone by the characteristics of the mass of material 48 but also by the thickness of this mass and the damping effect of the structure 45.

The structure 45 may be of metal or non-metal with or without damping characteristics of its own; and the purpose of the block assembly with the structure just described may be solely that of providing such damping for the rearward limit of the speaking length of the strings as will produce those dynamic characteristics which are produced in the conventional piano by the sounding board and bridge. In this event the vibrations of the strings may be picked up by any suitable pick-up means, magnetic, capacitive or otherwise, associated with the strings

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in any desired manner. In the preferred form of the invention, however, the structure 45 is in itself a pick-up means and, for this purpose, there is employed a piezo-electric crystal in the form of a plate serving to support the cantilever 34 through the medium of the resilient mass 48. The crystal may be mounted as heretofore described, and as is the case with a metal or other plate, the resilient mass 48 may be cemented to the top of the crystal and also to the under side of the cantilever with any suitable cement.

The crystal may be made of suitable piezo-electric material such as Rochelle salt, ammonium dihydrogen phosphate, lithium sulfate, quartz, etc.

In the method of mounting the crystal as hereinabove described, it will be insulated from the metallic elements of the device by the layer 46 of cementitious substance at the bottom and by the resilient body 48 at the top. Electrical contact may be made with the crystal by means of conductors such as vacuum evaporated metal to which pieces of foil can be affixed for leads to opposite sides of the crystal, one of which is indicated in FIG. 3 at 49 which, in turn, will be connected by an extension of the foil, or other flexible conductor 50, to a conductor rod 51. This conductor rod may be mounted by means of an insulative plug 52 in a hole 53 in the block 25, so as to be insulated from the block. The lower end of the rod-like conductor may engage in a conductive socket member 54 mounted by means of an insulative plug 55 in a hole 56 in the support member 20.

A similar arrangement is provided at the other side of the crystal, as will be readily understood and as indicated mainly in dotted lines in FIG. 3. There is thus provided a separable bayonet-type connection for each side of the crystal, permitting the removal of the assembly including blocks 25, 26 and 27 from the support 20 for replacement, repair, or adjustment. The two socket members in the support 20 are connected by leads 57 and 58 to busses 59 and 60 which are suspended in a space 61 formed in the under side of the support 20. The busses 59 and 60 may be common to all of the pick-up devices in the instrument, or they may be common to groups of pick-up devices, since it is within the scope of the invention to apply individual electric filtering means to groups of notes within the scale of the instrument if desired for tonal balance or any other purpose, as will be readily understood by the skilled worker in this art.

While the various block and support structures may be made of any suitable material (generally metallic for the sake of rigidity, although other materials may be used if desired), it is preferred to make the lower cover plate 32, the support 20, and the base plate 25 of steel, while the blocks 26 and 27 may, with advantage, be made of aluminum, alloys of aluminum with magnesium, or alloys of aluminum with other metals.

The busses 59 and 60 will, of course, be connected to a suitable preamplifier which, in turn, feeds an amplifier and one or more loud speaker units. It will be understood that where the pick-up devices are segregated into separate groups, each of these groups may have its own preamplifier, the outputs of the preamplifiers being separately amplified or fed into a common amplifier as desired.

In the organization of parts as illustrated, where there is essentially a separate damping means and pick-up device for each note in the scale, at least in the middle and lower registers of the instrument, there will be comparatively little tendency for the vibrations produced in a string or group of strings for a single note to induce vibrations in a string or group of strings for immediately adjacent notes, such as may occur in the mechanical piano where the dampers are kept in the inactive position by the actuation of a loud pedal. However, it has been found that this tendency may be minimized by the expedient of mounting alternate crystals in reversed positions as to polarity. In other words, if the crystal for one note is mounted in such a way that, when it is com-

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pressed, a positive potential will appear at that face of the crystal which is directed toward the front of the instrument, the immediately adjacent crystals may be reversely mounted, i.e. in such a way that, when compressed, positive potentials will appear at their rear faces, and so on. The connections from the several crystals may be alternately reversed as respects the busses 59 and 60 within the space 61 so that the potentials generated by the crystals will be additive in the operation of the instrument. But the reversal of the crystals, as herein described, will tend to minimize the electrical effect of shock vibrations induced in an unstruck and undamped string by the striking of an adjacent string.

While the invention has been described in connection with a grand piano having a horizontal frame, it will be clear to the worker in the art that the principles are equally applicable to other types of pianos such as those with vertical frames and vertical actions, and to other stringed keyboard instruments of known types. While special structures may be made without departing from the spirit of the invention, and while the damping characteristics of the pick-up means herein taught can be used with instruments having special frames, special stringing, and special actions, it will be apparent that a great advantage of the present invention lies in the fact that it may utilize the standard components of conventional pianos as presently manufactured, excepting for the sound board and the bridge or bridges. Thus, the finished instrument can be made so as not to present variations from normal stringing, so as to be tunable in the same way and with the same tensions as normal instruments, and so as to employ normal actions so that the performer is not required to master any new techniques or to familiarize himself with the operation of a keyboard which is characterized by a different "touch." Amplifiers and transducers have not been illustrated herein because they may be conventional and need not be mounted in or on the instrument itself. The instrument may, if desired, be provided with a volume control accessible to the performer which will enable him either to select a general or over-all volume level, or continuously to vary the volume for purposes of expression. However, since the electro-piano of this invention has tonal quality, percussive effects such as tone decay, and dynamic effects such as a specific volume dependent upon the force applied to the keys, all of which are comparable and proportional to those of the conventional mechanical piano, volume adjustment means, which can be set at the amplifier, are usually all that is required.

Modifications may be made in the invention without departing from the spirit of it. The invention having been described in certain exemplary embodiments, what is claimed as new and desired to be secured by Letters Patent is:

1. In a keyboard operated, stringed, electrical musical instrument, the combination of a frame, a string stretched on said frame between a tuning pin at one end and an attachment means at the other, and a device comprising a substantially non-vibratile support fixedly mounted with respect to said frame, a block attached to said support and configured to provide a cantilever with means at its outer end for contacting said string, the speaking length of said string extending between an agraffe at one point on said frame and the point at which said cantilever contacts said string, and means interposed between said cantilever and said non-vibratile support to damp the vibrations of said cantilever as produced by said string so that said cantilever is caused to exert on said string a damping action similar to that of a sounding board and bridge.

2. The structure claimed in claim 1 where the said damping means comprises a member in the form of a strut extending between said non-vibratile member and the outer end of said cantilever and separated from said cantilever by a body of resilient damping substance.

3. The structure claimed in claim 2 wherein said cantilever has a natural period of vibration so far removed from the period of vibration of said string as to have substantially no effect upon the vibrations of said cantilever in response to said string.

4. The structure claimed in claim 3 wherein the speaking length of said string on one side of said cantilever and the portion of said string on the other side of said cantilever are in substantially rectilinear alignment, said string being held to an outer end portion of said cantilever by a clamping means, whereby longitudinal vibrations of said string are enabled to pass through the point of attachment of said string to said cantilever into the continuation of said string on the said other side thereof, so that the effect of said longitudinal vibrations is minimized in the speaking length of said string.

5. The structure claimed in claim 3 wherein said strut is a member made of piezo-electric material, and wherein means are provided to conduct away electrical potentials generated by the compression of said piezo-electric material upon vibration of said cantilever, whereby to convert the mechanical vibrations of said string into electrical oscillations.

6. In an electro-piano, a conventional frame, strings stretched on said frame in a conventional manner, a conventional action for energizing said strings, and a series of electrical devices each comprising a block having an extension in the direction of the extent of said strings and forming a cantilever, said devices being cantilevers of said devices having means at their ends for contacting said strings, there being one of the said devices for each of the strings and groups of strings tuned to an individual note within the range of the electro-piano, the said devices being so located that the contacting ends of their respective cantilevers lie substantially in the positions which would be occupied by the bridge in a conventional piano, and damping means applied to each of said cantilevers to exert on said strings a damping action substantially equivalent to the damping action of a sounding board and bridge in a conventional piano whereby the percussive effects of said strings, when actuated, will simulate those of the conventional piano, and means for translating the vibrations of the said strings into electrical oscillations.

7. The structure claimed in claim 6 wherein said damping means include a strut extending between each cantilever and its adjacent non-vibratile support and separated from its cantilever by a pad of resilient damping substance.

8. The structure claimed in claim 7 wherein said strut is a member of piezo-electric material acting as a pick-

up to convert the vibrations of said strings into electrical oscillations.

9. The structure claimed in claim 8 wherein said strings are clamped to the ends of their respective cantilevers, and wherein the portions of said strings on either side of said clamping means are in substantial rectilinear alignment so that longitudinal vibrations produced in the speaking length of said strings are transferred to portions of said strings lying beyond said clamping means.

10. The structure claimed in claim 9 in which alternate struts of piezo-electric material occupy reversed positions as to polarity.

11. A pick-up means for an electro-piano or the like comprising a support member, a base plate thereon alignable with a string of a musical instrument, a pair of blocks on said base plate, one of said blocks configured to provide a cantilever extending in the direction of the length of said string, and the other configured to provide an overhang extending in the opposite direction, said cantilever and overhang being respectively spaced from said base plate, said cantilever having a free end configured with an upward extension to contact said string, a piezo-electric material in the form of a strut engaging said base plate and extending toward said cantilever, there being interposed between the end of said cantilever and said strut a pad of damping material and means within said space for making electrical contact with opposite sides of said piezo-electric strut.

12. The structure claimed in claim 11 wherein said base plate is fastened to a support, said support having a channel on its under side, there being electrical connections from said piezo-electric strut through said base plate and said support to busses located within said channel.

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