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M. D. BURKHARD ET AL
PIANO STRING AND FRAME ASSEMBLY

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Fig. 2

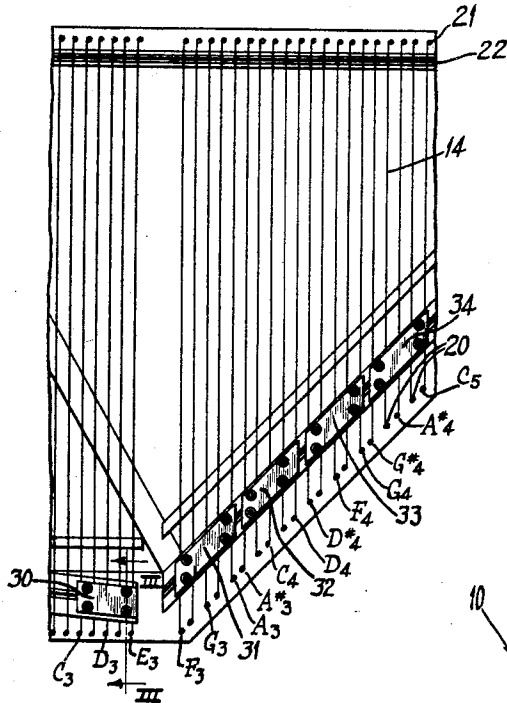


Fig. 1

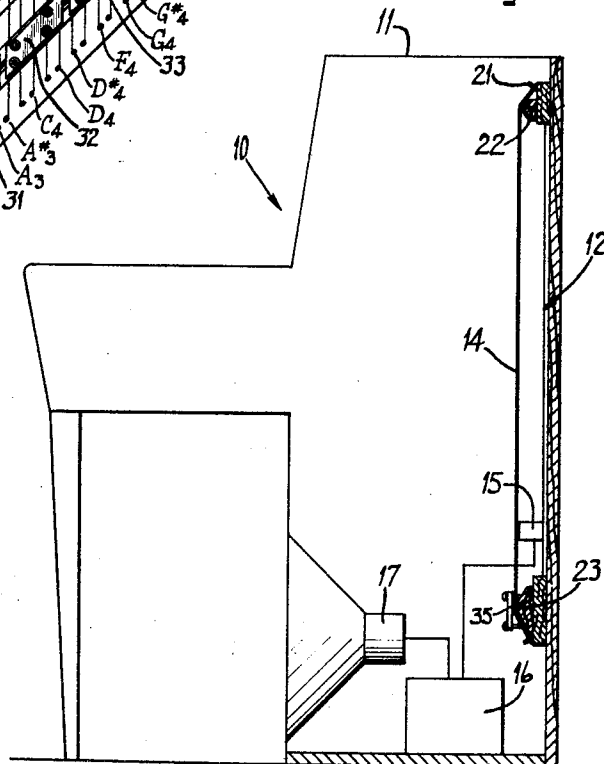
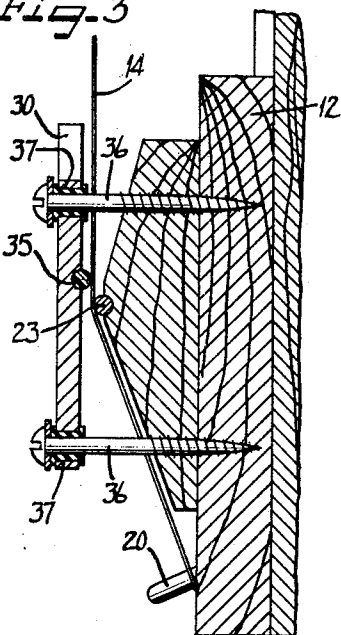


Fig. 3



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PIANO STRING AND FRAME ASSEMBLY

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This invention relates generally to an improved electronic piano, and more specifically to an improved string and frame assembly having a novel damping means for strings incorporated therein.

Although the principles of the present invention may be included in various musical instruments, a particularly useful application is made in an electronic piano of the lightweight type which can be sold at a somewhat lower price than conventional pianos.

One of the principal purposes in providing an electronic piano is to reduce size, weight and cost. This can be done where large and heavy components are eliminated. When the sounding board is eliminated, certain problems arise in tone production.

Conventional pianos employ three strings and a sounding board to obtain the requisite volume. The omission of the resonating sounding board is suggested in the patent to Miessner No. 2,187,612. However, Miessner finds it necessary to retain the use of two strings per note in order to achieve a tone-on-tone effect, one of the strings being provided with damping along its speaking portion. In that patent, the loss of volume due to the removal of the sounding board has been offset by an electrical amplification.

In accordance with our invention, the sounding board can be likewise omitted, and the volume thereby lost replaced by electrical amplification. However, we have found that a truer tone-on-tone effect can be achieved by the use of a single string per note coupled with appropriate string damping.

Those familiar with the art have known for some time that a conventional piano, when sounded, produces a note, the amplitude of which decays at a double rate. The higher rate is present immediately following the striking of the note, followed by the slower decay rate. In the Miessner Patent No. 2,187,612 there is taught a method of producing a double decay rate wherein one string is provided with a flocking or damping material which coats it while the other string is damped. When both strings are simultaneously energized, an output results wherein two decay rates are present. However, we have found that the mere obtaining of two decay rates does not necessarily produce a tone which corresponds to that of a conventional piano.

We have found that the double decay rate in a conventional piano actually comprises a somewhat higher decay rate for the fundamental frequency, together with some of the very highest harmonics, and that the lowest decay rates are experienced by the second to the fifth harmonics inclusive, typically. Thus general damping of a string causes a decay rate which acts on the fundamental as well as on its harmonics.

In accordance with the present invention, we have provided a resiliently supported mass which engages the string and thereby receives energy therefrom. Since it is somewhat easier for a vibrating string to transmit its fundamental frequency to a mass than it is to transmit its harmonics, such a structure assures a somewhat faster decay rate for the fundamental than it does for the harmonics, and thereby effects a simulation of the damping caused by a sounding board, which simulation is so

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close to that of a conventional piano that an untrained ear cannot discern the difference.

Conventional pianos do not have equal tone quality along the entire length of their keyboards, and the trained musician is accustomed to the difference in quality which exists along the length of a full-scale 88-note chromatic keyboard. It is primarily in the range between C_3 and G_5 that a conventional piano has the described decay rates. This range of notes extends from 1 octave below middle C to about 1 and $\frac{1}{2}$ octaves above middle C, and includes all of the most commonly used notes of a piano. Therefore, we have found that it is not necessary to provide this accurate simulation of sounding board produced decay rate over the entire scale, but have found that it may be limited to the most commonly used notes.

Accordingly, it is an object of the instant invention to provide an electronic piano without a sounding board, which has an improved tone quality.

It is a further object of the instant invention to provide an electronic piano which employs only one string per note wherein that one string is suitably damped to have a higher decay rate for the fundamental frequency than for the harmonics thereof.

Another object of the instant invention is to provide means for simulating the tonal characteristics of a conventional piano.

Many other advantages, features and additional objects of the present invention will become manifest to those versed in the art upon making reference to the detailed description and the accompanying sheet of drawings in which a preferred structural embodiment incorporating the principles of the present invention is shown by way of illustrative example.

On the drawing:

FIGURE 1 is a diagrammatic sectional view of a piano equipped with a string frame assembly provided in accordance with the principles of the present invention;

FIGURE 2 is a fragmentary diagrammatic view of the string frame assembly shown in FIGURE 1; and

FIGURE 3 is an enlarged view taken along line III-III of FIGURE 2.

As shown on the drawings:

The principles of the present invention are particularly useful when embodied in an electrical musical instrument or piano such as illustrated in FIGURE 1, generally indicated by the numeral 10. The piano 10 includes the cabinet 11 supporting a string frame assembly 12 which may be actuated by conventional means (not shown). An electrical pickup 15 of the electromagnetic type is also included in the string frame assembly 12, and communicates electromechanically with the strings for converting the vibration thereof into electrical signals. The pickup 15 also communicates electrically with an electronic amplifier 16 which drives a speaker 17, both supported by the case 11. Conventional structure may be utilized for each of the components not described in detail in the instant specification, such as the amplifier 16, speaker 17, the cabinet 11, the pickup 15, and the like.

Referring now to FIGURE 2, the details of the string frame assembly are shown in greater detail. The string frame is provided with a plurality of strings 14 which are each secured at one end to a hitch pin 20 and at the other end to a tuning pin 21. The frame 12 has a bearing edge or bridge assembly 22 adjacent to the tuning pins 21. The frame 12 also has a second bridge 23 adjacent to the hitch pins 20. The bridges 22 and 23 are spaced apart so as to jointly define the speaking portions of the various strings 14. The bridges 22, 23 are thus spaced apart and are fixedly supported by the string frame 12. Thus each of the strings 14 is supported in

contact with the bridges. FIGURE 2 illustrates the central portion of the string frame assembly and includes most of the commonly played strings or notes. The strings which are adapted to be vibrated are polyphonically tuned as desired, and have been identified herein in accordance with a standard adopted by the American Standards Association in 1936, such names appearing in the Handbook of Chemistry and Physics, 39th edition, published by the Chemical Rubber Publishing Company Middle C is identified as C₄.

It will be noted that no sounding board has been provided for this piano and that only one string per note has been included. Each of the tuning pins 21 may be adjusted so that the strings 14 are tuned to provide the equal tempered chromatic scale used in pianos.

As seen in each of the figures, a string weight has been provided for the strings 14. Ideally, one such weight should be provided for each of the strings 14. However, we have found that the desired results can be approximated by using one weight for a number of adjacent strings, in the instant example, five strings. Thus a weight 30 has been provided for the strings C₃-E₃, a weight 31 has been provided for the strings F₃-A₃, a weight 32 has been provided for the strings A₃-D₄, a weight 33 has been provided for the strings D₄-G₄, and a weight 34 has been provided for the strings G₄-C₅. The string weight 30 is typical of each of the weights 30-34 and may be seen in greatest detail in FIGURE 3.

The weight 30 includes a hard rigid portion which is provided with a rigid bridge 35. The material from which the bridge 35 is made may be selected for its electrical properties in the event that current is carried in the strings 14. Otherwise, any hard material will suffice. The bridge 35 of the string weight 30 engages the speaking portion of the string 14 at a point quite close to the bridge 23. The exact distances which we have found to be satisfactory are set forth in a table presented later herein.

Each of the weights 30-34 has a mass which is graduated in size so that the larger or heavier weights engage the strings which have the lower fundamental frequencies when tuned. The table below also lists the exact weights which we have found to be satisfactory.

Each of the weights 30-34 is supported in position with respect to the strings 14. Thus the weight is supported by the string frame 12. In this embodiment, and to this end, four screws 36 extend between various strings and into the string frame 12. Intermediate each of the screws 36 and the weight 30 there is provided a damper 37 which may be molded or fitted to the weight 30. The damping members 37 here comprise rubber, but may comprise any resilient plastic or mixtures of material which have a substantial amount of internal damping coupled with resilience. The dampers 37 thus may comprise either a portion of the support 36 or a portion of the weights themselves. The dampers 37 provide resilient support for the weight and connect the weight to the support 36 on the frame.

When the string 14 has been set into vibration, each of the weights 30-34 senses such vibration by the fact that it engages the speaking portion of the various strings 14, and thus each of the weights absorbs vibrational energy from the string. This vibrational energy is transmitted to the damper 37 which converts the vibrational energy in the weight 30 to heat which is dissipated. This conversion is accomplished by the internal friction within the damping members 37. Thus it can be seen that the engagement of the weight 30 is a damping engagement with the string 14.

Since it is somewhat easier for the string 14 to set the weight 30 into motion at its fundamental frequency, particularly at the points indicated herein for sensing the vibration, the structure thereby simulates the string damping of a conventional sounding board in that it selectively damps the fundamental frequencies to a greater extent

than it damps other higher frequencies or harmonics, and thereby damps the fundamental frequencies at a higher rate than it damps a plurality of the harmonics thereof. Thus the fundamental is damped relatively fast while the harmonics are damped more gradually.

We have found that the heavier weights must be placed closer to the bridge 23 while the weights having lighter masses may be positioned further away, and their position is less critical or effective, as judged by listening tests.

The exact weight or mass of a given weight 30-34 is not extremely critical, but yet the amount of weight must be selected with some regard for frequency. If one of the weights 30-34 is too heavy, it will behave seismically, and not be placed into any efficient amount of motion. This being so, it can be seen that little energy is absorbed from the string 14. On the other hand, if the mass of the weight 30 is too low, all of the frequencies present will be absorbed, and a general damping will occur. As the size of string increases, it will be apparent from the following table that larger masses of weight are needed to selectively pick out and absorb the fundamental frequencies from the various strings.

Since there is a relationship between the weights and the strings, including the spacing of the weights with respect to the stationary bridge, the following table is presented to give the reader a general idea of operative combinations, any one of which may be considered to be typical. Nothing herein is to be construed to limit the invention to the following values which, while they are the best values known to us, may not be the ideal ultimate combinations. Referring to the "weights" portion of the table, it is to be understood that ideally, a given mass should be the proper one for the middle one of the strings contacted. Further, there is no right or wrong spacing, the results obtained for different spacings differing among themselves and thereby producing differences in tonal quality the best sounding of which is a matter of personal taste. However, for the strings used, the spacings would for almost all people be preferred to be less than 1/4 inch from the stationary bridge.

The supports 36 have been illustrated as being screws whereby the force with which the bridge 35 engages the individual strings may be adjustably selected. The loading per string is on the order of 10 to 40 grams per string, the higher loadings being for the lower pitched strings while the lighter loadings are for the higher pitched strings.

Strings

Note	Piano Wire	Core Dia., inches	Cover Dia., inches	Overall Dia., inches	Length, inches
C ₃ -C# ₃ -----	Copper Wound.	.018	.009	.036	21
D ₃ -E ₃ -----	do-----	.016	.009	.034	21
F ₃ -A# ₃ -----	Solid-----			.020	Note (*)
B ₃ -D ₄ -----	do-----			.018	
D# ₄ -G# ₄ -----	do-----			.016	

*For F₃ to G#₄, length reduces linearly from 21 inches to 5 3/4 inches.

Weights

Note	Mass, gm.	Spacing	
		Useful Range, inches	Preferred, inches
C ₃ -E ₃ -----	265	1/16-1/4	1/8
F ₃ -A ₃ -----	59	1/16-1/4	1/8
A# ₃ -D ₄ -----	31	1/16-1/4	1/8-1/4
D# ₄ -G ₄ -----	31	1/16-1/4	1/8
G# ₄ -C ₅ -----	19	1/16-1/4	1/8

While the distance between the fixed bridges 22 and 23 has been referred to herein as being the speaking length of the string, and is so used and intended in inter-

preting the claims which follow, it is admitted that the speaking portion of the string may actually terminate at the resiliently movable bridge 35 or intermediate the bridge 35 and the bridge 23 sonically.

Although various minor modifications might be suggested by those versed in the art, it should be understood that we wish to embody within the scope of the patent warranted hereon all such embodiments as reasonably and properly come within the scope of our contribution to the art.

We claim as our invention:

1. In an electronic piano having a string frame, a pair of spaced bridges rigidly and fixedly supported by the frame, and a series of strings supported on the frame in contact with the bridges, said bridges jointly defining the speaking portion of each of the strings, the improvement of a rigid weight resiliently supported on said frame by the frame in contact with the speaking portion of one of the strings adjacent to one of the bridges.

2. In an electronic piano having a string frame, a pair of spaced bridges rigidly and fixedly supported by the frame, and a series of strings supported on the frame in contact with the bridges, said bridges jointly defining the speaking portion of each of the strings, the improvement of a rigid weight resiliently supported by the frame in contact with the speaking portion of each of a plurality of the strings adjacent to one of the bridges.

3. In an electronic piano having a string frame, a pair of spaced bridges rigidly and fixedly supported by the frame, and a series of strings supported on the frame in contact with the bridges which jointly define the speaking portion of each of the strings, the improvement of a weight, a hard bridge on said weight engaging the speaking portion of one of the strings adjacent to one of the frame bridges, and means supporting said weight on the frame, said means including a damping member for absorbing vibrational energy.

4. In an electronic piano having a string frame, a pair of spaced bridges rigidly and fixedly supported by the frame, and a series of strings supported on the frame in contact with the bridges which jointly define the speaking portion of each of the strings, the improvement of a weight having a hard portion engaging the speaking portion of one of the strings adjacent to one of the frame bridges, a support secured to the frame, and means connecting said

weight to said support, said means being operative by internal friction to convert vibrational energy from the weight into heat.

5. In an electronic piano having a string frame, a pair of spaced bridges rigidly supported by the frame, and a series of strings polyphonically tuned to frequencies between C₃ and G₅ and supported by the bridges which jointly define the speaking portions of the strings, the improvement of: a plurality of string weights of non-resilient material; and a plurality of weight-supporting damping members carried by the frame; said weights each being disposed by some of said damping members in contact with the speaking portions of a number of the strings, said weights being of graduated mass which are progressively greater as the tuned frequency decreases.

6. In an electronic piano having a string frame, a pair of spaced bridges rigidly and fixedly supported by the frame, and a series of strings supported on the frame in contact with the bridges which jointly define the speaking portion of each of the strings, the improvement of a plurality of string weights, each of said weights having a first portion comprising non-resilient material in contact with at least one of the strings at a point near one of the bridges, and a second portion supported by the frame, said second portion being adapted to absorb by internal friction the vibration of said first portion.

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