May 9, 1961 H. J. SABINE 2,983,177

ELECTRONIC PIANO

Filed May 23, 1958

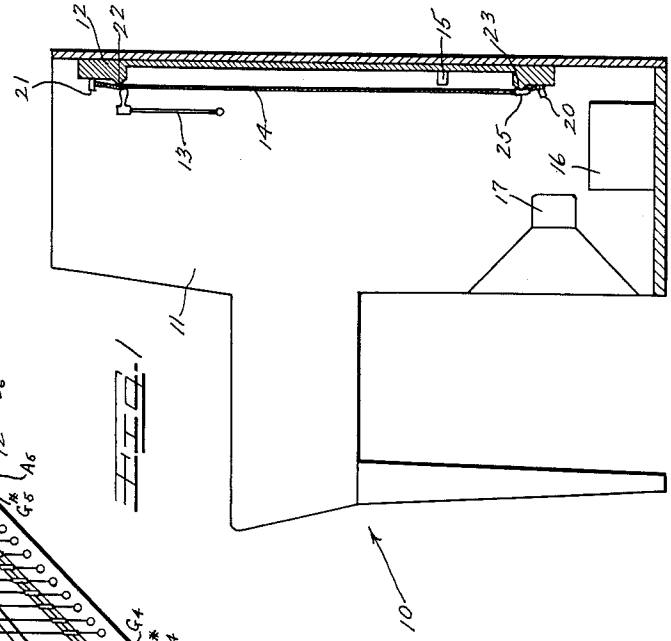


FIG. 1



FIG. 2

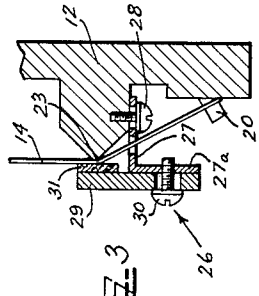


FIG. 3

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# ELECTRONIC PIANO

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This invention relates generally to an improved electronic piano, and more specifically to an improved string frame assembly 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.

Broadly speaking, electronic pianos are old and known in the art. These pianos have had various faults or difficulties, one of which is an excessive size and weight, and another of which is that the piano has not produced a tone which is the same as that of a conventional piano.

Accordingly, it is a principal object of the instant invention to provide a low cost electronic piano having tone quality comparable to a standard piano.

It is a further object of the instant invention to provide an electronic musical instrument of the pianoforte type, the components of which have a minimum size and weight.

A still further object of the present invention is to provide an electronic piano having miniature length strings, having a tone quality comparable to that of 41 inch strings.

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 diagrammatically shown by way of illustrative example.

On the drawing:

Figure 1 is a side sectional view of a piano equipped with a string frame assembly provided in accordance with the principles of the present invention, the string frame being sectioned along line I—I of Figure 2;

Figure 2 is a front view of the string frame assembly shown in Figure 1; and

Figure 3 is an enlarged sectional view of a preferred modification of a portion of the structure shown in Figure 1.

As shown on the drawing:

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 a cabinet **11** supporting a string frame assembly **12** and an action assembly diagrammatically illustrated by the hammer **13** for exciting a string **14** of the string frame assembly **12**. 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 vibrations 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**, the speaker **17**, the cabinet **11**, the hammer **13**, and the pickup **15**.



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 bridge or bearing edge **22** adjacent to the tuning pins **21**, the bearing edge **22** being straight in the instant embodiment. The frame **12** also has a second bridge or bearing edge **23** adjacent to the hitch pins **20**. The bearing edges **22** and **23** are spaced apart so as to jointly define the length of the speaking or vibrating portion of each of the strings **14**.

The frame **12** has been provided with a number of strings **14** which corresponds exactly to the number of notes in the series which the instrument **10** is to provide. Thus, one feature of the instant invention is that only one string is provided per musical note.

The assembly illustrated in Figure 2 has 88 strings representing the quantity required for a full scale piano having a standard keyboard. Each of the tuning pins **21** is so adjusted that the strings **14** are tuned to provide the equal tempered chromatic scale such as as one with a standard pitch for each string. In the specification and claims hereof, each string is referred to by the name of the note as 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. The lowest pitched string is designated as $A_0$, then $A\sharp_0$, $B_0$, $C_1$, $C\sharp_1$, etc., terminating with $C_8$ as being the string for the uppermost note.

It will be noted that the lower bridge or bearing edge **23**, which is adjacent to the hitch pins **20**, comprises three straight segments. Each of these segments includes over twenty-four strings, and hence includes over two octaves. The center segment of the bearing edge **23** and the segment adjacent to the shortest strings each are so constructed that the speaking portions of successively adjacent strings are of successively shorter lengths, and in that each of these segments is linear, each of the adjacent strings within each of the segments differs in length from its adjacent strings by a like increment. More specifically, the upper 28 strings, used for notes between $A_5$ and $C_8$ inclusive differ from those adjacent to each other by a like amount, while the next lower pitched 28 strings used for notes between $F_3$ and $G\sharp_5$ inclusive also differ from adjacent strings in speaking length by a like amount.

One of the advantages in having the bearing edge or bridge **22** as a straight line is that another feature of the instant invention provides that the hammer **13** shall engage the speaking portion of each of the strings **14** above $A_2$ at a point not over ¼ inch from the bearing edge **22**, and below $E_2$ at a point not over 1½ inches from the bearing edge **22**. For the notes $F_2$ to $A_2$ inclusive, the limit point varies uniformly from 1½ inches to ¼ inch. Excellent results are achieved when the strike points are within the foregoing ranges, the exact point being largely a matter of personal tonal preference. Thus a uniform strike line is achieved for a set of strings by the straight bridge or bearing edge **22**.

The pickup **15** is disposed generally adjacent to the bearing edge or bridge **23**. More specifically, for the lengths of strings disclosed herein, the pickup **15** is preferably disposed about one inch from the bearing edge **23** for the first five strings representing the notes $A_0$ to $C\sharp_1$ inclusive. For the next 27 strings representing the notes $D_1$ to $E_3$ inclusive, the pickup is preferably disposed about 3½ inches which is one-sixth the length of the speaking portion from the bearing edge **23**. For the

next 28 strings representing the notes $F_3$ to $G\sharp_5$ inclusive, the pickup is preferably disposed about 3½ inches from the bearing edge **23** for $F_3$, and about 2 inches from the bearing edge **23** for $G\sharp_5$, and varying uniformly therebetween. This variation is from ⅙ to ⅓ the speaking length. For the top 28 strings representing the notes $A_5$ to $C_8$ inclusive, the pickup is preferably disposed about 2 inches or ⅓ the speaking length from the bearing edge **23** for $A_5$, and at the midpoint of the $C_8$ string which is ¾ inch from the bearing edge **23**. Thus while there is a variation in pickup location to obtain the most piano-like tone, the variation is gradual to thereby avoid discontinuities of type of sound as a scale is being played. Certain wound strings tend to produce a type of static when vibrated adjacent to a magnetic pickup, a phenomenon known as the Barkhausen Effect. In the instant piano, this effect is substantially absent. However, for the lowest five notes, the pickup must be disposed close to the bearing edge **23**, as described above, to avoid this problem.

Conventional pianos employ three strings and a sounding board to obtain the requisite volume. The omission of the resonating sounding board coupled with electrical amplification is suggested by Miessner in his U.S. Patent No. 2,187,612. While Miessner eliminated one string, he found it necessary to use two strings per note, one being damped. His undamped string has a relatively long decay time and his damped string has a much shorter decay time. By superimposing the sounds from the two strings, he achieved a decay in loudness which tended to simulate the loudness decay in a conventional piano achieved by the sounding board.

I have likewise omitted the sounding board and have offset the loss of volume by electrical amplification. However, I employ only a single string per note coupled with a voicing or damping means which even more closely simulates the loudness decay effected by conventional sounding boards.

To this end, I have inserted a damping or voicing member **25** intermediate the string **14** and the bearing edge **23**, remote from the hammer strike line. Since I have desired to match the tone of the instant piano quite closely to that of a conventional piano, I have omitted such damping member from the strings used for about the lowest two octaves, for example below the note $C_3$ as shown in Figure 2, because the effect sought to be simulated is not noticeably achieved by sounding boards of conventional pianos. The damping or voicing member **25** comprises a soft material, such as a resilient plastic or rubber. For convenience, I have illustrated the member **25** as being a short tubular segment which closely fits the string, the length of the speaking portion thereof being defined at a point on the string against which the member **25** engages. By this structure, a tone is produced which simulates that previously obtained by the use of three strings with a sounding (and damping) board.

Where the material from which the voicing member **25** is subject to taking a set or being cut by the piano wire, and when a structure is desired that is more readily adjusted, the member **25** may be replaced by a voicing or damping member **26** shown in Figure 3. The member **26** represents the preferred form of construction, but is separately shown for clarity of illustration.

The member **26** includes a bracket **27**, a plate **29**, and a strip of damping material **31**. The bracket **27** is securely attached to the frame assembly **12** adjacent to the bearing edge **23**, such as by a plurality of screws **28** extending through a hole in the bracket **27**. The size and shape of the screw hole in the bracket **27** afford a degree of adjustability. The bracket **27** has a portion **27*a*** extending angularly therefrom which supports the loading plate **29** in a plane parallel to and spaced from the strings **14**. The plate **29** extends along the length of the bearing edge **23** and overlies a group of the strings **14**. The plate **29** is secured to the portion **27*a*** such as by a plurality of screws **30** each extending through a hole therein, which holes afford a degree of adjustability. The strip of felt **31** is disposed intermediate the plate **29** and the strings **14**, and is held thereagainst by the plate and bracket. By this structure, the backing force on the felt and the distance which the felt overlays or extends along the speaking portion of the string **14** may be selected. The exact position has an effect on the tone produced, the ideal effect being a matter of personal preference.

It is well known that tension, mass per unit length, and speaking length determine the basic or fundamental frequency of a string. It is also well known that mass per unit length can be increased by applying a close winding or overlay of copper over a piano wire. However, the various combinations which can be mathematically obtained to produce a given pitch do not necessarily produce a satisfactory result.

By way of example, a typical good quality upright piano employs strings having a length of 41 inches and a tension of 150 pounds for a given diameter. It is known that this combination produces a pleasant piano type vibration. It is also known that if the string length is increased up to at least 44 inches, or more, and provided with a 150 pound tension, a combination results which produces a top quality type of vibration such as is used in a premium quality piano. It is also well known that if the string length is reduced to 36 inches, tension being retained at 150 pounds to obtain the proper pitch for a given size wire, a somewhat lower quality of vibration is produced, which is usable only in competitively priced pianos. Thus it is known that further reduction in string length without sacrifice of tone is considered impractical if not impossible, heretofore.

In the foregoing known examples, even though all the strings are tuned to the same frequency, the pleasantness is not equal. This difference is due to a difference in harmonic content. The harmonic frequencies present are effected by the modulus of elasticity of the string material and the diameter of the wire or string. The amplitude of the harmonics is determined by the strike point, the hammer impact force, and the hammer material. Heretofore, the strike point has typically varied from 6 inches from the end of the $A_0$ string to ⅛ inch from the end of the $C_8$ string, with only the strings above $E_7$ being less than ¼ inch.

I have discovered that the most significant factor in determining pleasantness is the factor of which frequencies are present rather than their amplitude. Thus if the most desirable harmonics are present and the least desirable ones are absent, pleasantness of tone can be achieved. In the instant invention, for comparison purposes, I have employed a good quality commercial piano having strings of a 41 inch length as a comparison or standard.

By extensive analytical approach, I have found that there is no mathematical relation or formula for "pleasantness" but by extensive experimentation coupled with many failures, I have obtained pleasantness at lower lengths and tensions than have been done heretofore. I have done this for all of the notes in the standard 88-note keyboard.

Since I have been able to reduce tension somewhat the tendency for the resulting piano to go out of tune is somewhat decreased, and the need for substantial mass and rigidity of the string frame is decreased. When the length has been reduced, I have found that the overall size of the piano can be reduced. Size and weight has been further reduced by the omission of the conventional sounding board which has been replaced by the electromagnetic pickup operating in accordance with known principles. The resulting instrument is dramatically smaller and lighter than has been previously thought possible, without sacrifice of tone quality, the quality obtained being about the same as that of a conventional piano having 41 inch strings tensioned at 150 pounds.

I have found that tension can be reduced to a value as

low as three pounds without sacrifice of quality, for certain notes. However, I have found that an entire series of 88 notes may be achieved using tensions between 5 and 23 pounds, the average tension being about 15 pounds. This has been accomplished using strings having a speaking length between 21 and 1½ inches, their average length being 14 inches for the 88-note series. Where a single string is used per note, the total force produced by the strings' tension is less than one ton, being on the order of 1400 pounds. In general, I have found that tension can be varied a good deal without impairment of tone quality, any given string which is satisfactory being usable with maximum and minimum tensions having approximately a four-to-one ratio.

While overlaying a wire with two layers of close-spiral-wound wire increases the mass per unit length, it also increases the natural damping of the string and renders the harmonic content somewhat unpredictable. In particular, non-integral harmonics appear which are undesirable, such as the 2.1 harmonic. However, in accordance with the instant invention, it is now possible to use bass strings having a single layer of covering wire for the note $F\sharp_1$ and all the lower notes, the range previously requiring a double overlayer.

A complete instrument may be constructed in accordance with the principles of my invention if the strings are provided in accordance with the following table:

| Note | String | Core Dia., inches | Cover Dia., inches | Overall Dia., inches | Speaking Length, inches | Tension, pound |
|---|---|---|---|---|---|---|
| $A_0$–$A_1$ | Copper Wound Piano Wire. | .020 | .032 | .084 | 21 | 5–20 |
| $A\sharp_1$–$D\sharp_2$ | do | .018 | .023 | .064 | 21 | 13–23 |
| $E_2$–$A_2$ | do | .018 | .013 | .044 | 21 | 12–21 |
| $A\sharp_2$–$C\sharp_3$ | do | .018 | .009 | .036 | 21 | 16–23 |
| $D_3$ | do | .016 | .009 | .034 | 21 | 23 |
| $D\sharp_3$ | Solid Piano Wire. | | | .025 | 21 | 15 |
| $E_3$ | do | | | .023 | 21 | 15 |
| $F_3$–$B_3$ | do | | | .020 | (1) | 12–17 |
| $C_4$–$F\sharp_4$ | do | | | .017 | (1) | 12–17 |
| $G_4$–$G\sharp_5$ | do | | | .016 | (1) | 12–17 |
| $A_5$–$D\sharp_6$ | do | | | .015 | (2) | 12–17 |
| $E_6$–$A\sharp_6$ | do | | | .013 | (2) | 12–17 |
| $B_6$–$C_8$ | do | | | .012 | (2) | 12–17 |

[1] For $F_3$ to $G\sharp_5$, reduces linearly from 21" to 5¾".
[2] For $A_5$ to $C_8$, reduces linearly from 5½" to 1½".

Thus, to control the non-integral harmonics so that the pleasantness can be controlled, the above combination of strings is preferred and relatively little deviation therefrom can be accompanied for the lengths selected.

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

I claim as my invention:

1. A musical instrument comprising a frame, a plurality of differently tuned strings mounted on said frame, a pair of spaced bridges operatively associated with each string, and a voicing means in contact with each string and extending from one bridge thereof a limited distance along said string.

2. A musical instrument for the production of a series of notes below $E_7$ comprising: a string frame, a plurality of differently tuned strings mounted on said frame, said frame having a pair of spaced bridges operatively associated with each string, and thereby defining the length of the speaking portion of each string, one of said bridges comprising a straight line, a hammer operatively associated with each string and being engageable with the speaking portion thereof at a point not over one-fourth inch from said one straight bridge, a voicing means in contact with each string remotely from said hammer of each string and extending from the other of said bridges a limited distance along said string, and electrical means responsive to string vibration operatively associated with strings tuned between $D_1$ and $E_3$ inclusive at a point on said strings one-sixth the length of said speaking portion from said other of said bridges, and operatively associated with and responsive to vibration of strings tuned between $F_3$ and $G\sharp_5$ inclusive at a point varying uniformly from one-sixth to one-third the length of said speaking portion from said other of said bridges.

3. A musical instrument for the production of a series of notes below $E_7$ comprising: a string frame, a plurality of differently tuned strings mounted on said frame, a pair of spaced bridges carried by said frame and operatively associated with each string, said bridges defining the length of the speaking portion of the strings, means including a hammer operatively associated with each string and engageable with the speaking portion thereof at a point not over one-fourth inch from one of said bridges, and a voicing means in contact with each string and extending from the other of said bridges a limited distance along said string.

4. A musical instrument for the production of a series of notes below $E_7$ comprising: a frame, a plurality of differently tuned strings mounted on said frame, a pair of spaced bridges on said frame operatively associated with each string and defining the length of the speaking portion of each string, one of said bridges comprising a straight line, hammer means operatively associated with each string and engageable with the speaking portion thereof at a point not over one-fourth inch from said one straight bridge, and a voicing means in contact with each string and extending from the other of said bridges a limited distance along said string.

5. A musical instrument comprising: a frame, a plurality of differently tuned strings mounted on said frame, a pair of spaced bridges carried by said frame and operatively associated with each string and defining the length of the speaking portion thereof, electrical means operatively associated with strings thereof tuned between $E_1$ and $E_3$ inclusive at a point on said strings one-sixth the length of said speaking portion from one bridge thereof and responsive to vibration thereof, electrical means operatively associated with strings thereof tuned between $F_3$ and $G\sharp_5$ inclusive at a point varying uniformly from one-sixth to one-third the length of said speaking portion from said one bridge and responsive to the vibration of such strings, and a voicing means in contact with each string and extending from said one bridge thereof a limited distance along said string.

6. A musical instrument comprising: a frame, a plurality of differently tuned strings mounted on said frame, a pair of spaced bridges carried by said frame and operatively associated with each string and defining the length of the speaking portion thereof, electrical means operatively associated with strings thereof tuned between $A_0$ and $C\sharp_1$ inclusive at a point on said strings immediately adjacent to one bridge thereof and responsive to the vibration of such strings and a voicing means in contact with each string and extending from said one bridge thereof a limited distance along said string.

7. A musical instrument comprising: a frame, a plurality of differently tuned strings mounted on said frame, a pair of spaced bridges carried by said frame and operatively associated with each string and defining the length of the speaking portion thereof, electrical means operatively associated with strings thereof tuned between $F_3$ and $G\sharp_5$ inclusive at a point varying uniformly from one-sixth to one-third the length of said speaking portion from one of said bridges, and a voicing means in contact with each string and extending from said one bridge thereof a limited distance along said string.

8. A musical instrument comprising: a frame, a plurality of differently tuned strings mounted on said frame, a pair of spaced bridges operatively associated with each string, and a voicing means in contact with each string

and extending from one bridge thereof a limited distance along said string, said voicing means extending between each and every one of said strings and said one bridge for an adjacent series of strings.

9. A musical instrument comprising: a frame, a plurality of differently tuned strings mounted on said frame, a pair of spaced bridges carried by said frame and operatively associated with each string, said bridges being so arranged that a series of consecutive strings for two octaves of notes above $F_3$ have speaking portions defined by said bridges of successively shorter lengths, each of which portions differs in length from its adjacent strings by the same increment, and a voicing means in contact with each string and extending from one bridge thereof a limited distance along said string.

10. A musical instrument comprising: a frame, a plurality of differently tuned strings mounted on said frame, a pair of spaced bridges carried by said frame and operatively associated with each string and defining the length of the speaking portion thereof, said bridges being so arranged that a series of consecutive strings for notes between $F_3$ and $G\sharp_5$ have speaking portions of successively shorter lengths, each of which portions differs in length from its adjacent strings by the same increment, and a voicing means in contact with each string and extending from one bridge thereof a limited distance along said string.

11. A music instrument comprising: a frame, a plurality of differently tuned strings mounted on said frame, a pair of spaced bridges carried by said frame and operatively associated with each string and defining the length of the speaking portion thereof, said bridges being so arranged that a series of consecutive strings for notes between $A_5$ and $C_8$ have speaking portions of successively shorter lengths, each of which portions differs in length from its adjacent strings by the same increment, and a voicing means in contact with each string and extending from one bridge thereof a limited distance along said string.

12. A musical instrument comprising: a frame, a plurality of differently tuned strings mounted on said frame and having an average tension of about 15 pounds each, a pair of spaced bridges operatively associated with each string, and a voicing means in contact with each string and extending from one bridge thereof a limited distance along said string.

13. A musical instrument comprising: a frame, a plurality of differently tuned strings mounted on said frame, said strings each having a tension less than 23 pounds, a pair of spaced bridges operatively associated with each string, and a voicing means in contact with each string and extending from one bridge thereof a limited distance along said string.

14. A musical instrument comprising: a frame, a plurality of differently tuned strings mounted on said frame, said strings having a tension between 5 and 23 pounds each, a pair of spaced bridges operatively associated with each string, and a voicing means in contact with each string and extending from one bridge thereof a limited distance along said string.

15. A musical instrument comprising: a frame, a plurality of differently tuned strings mounted on said frame, said strings having an average speaking length of about 14 inches, a pair of spaced bridges operatively associated with each string, and a voicing means in contact with each string and extending from one bridge thereof a limited distance along said string.

16. A music instrument comprising: a frame, a plurality of differently tuned strings mounted on said frame, a pair of spaced bridges carried by said frame and operatively associated with each string and defining the speaking length thereof, said strings each having a speaking length not over 21 inches, and a voicing means in contact with each string and extending from one bridge thereof a limited distance along said string.

17. A musical instrument comprising: a frame, a plurality of differently tuned strings mounted on said frame, a pair of spaced bridges carried by said frame and operatively associated with each string, said strings each having a speaking length between 21 inches and 1½ inches, and a voicing means in contact with each string and extending from one bridge thereof a limited distance along said string.

18. A musical instrument comprising: a frame, a series of differently tuned strings mounted on said frame and operative to produce a series of 88 notes between $A_0$ and $C_8$ inclusive, said strings having a combined tension of less than one ton, a pair of spaced bridges operatively associated with each string, and a voicing means in contact with each string tuned above $C_3$ inclusive, and extending from one bridge thereof a limited distance along said string.

19. A musical instrument comprising: a frame, a series of differently tuned strings mounted on said frame and adapted to produce a series of 88 notes between $A_0$ and $C_8$, said strings having a combined tension of about 1400 pounds, a pair of spaced bridges operatively associated with each string, and a voicing means in contact with each string tuned to $C_3$ inclusive and higher, and extending from one bridge thereof a limited distance along said string.

20. A musical instrument comprising: a frame, a plurality of differently tuned strings mounted on said frame, said strings being adapted to be tuned to a range of notes inclusive of $F\sharp_1$ and $C_3$, a single helical overlaid winding for each of said strings tuned to $F\sharp_1$ and lower, a pair of spaced bridges operatively associated with each string, and a voicing means in contact with each string tuned to $C_3$ and higher, and extending from one bridge thereof a limited distance along said string.

21. A musical instrument comprising: a frame, a plurality of differently tuned strings mounted on said frame, a pair of spaced bridges carried by said frame and operatively associated with each string and defining the speaking length thereof, electrical means operatively associated with strings thereof tuned between $D_1$ and $E_3$ inclusive at a point on said strings one-sixth the length of said speaking portion from one of said bridges, and responsive to the vibration of said strings, and a voicing means in contact with each string and extending from said one bridge thereof a limited distance along said string.

22. A musical instrument comprising: a frame, a plurality of differently tuned strings mounted on said frame, said strings being tunable to include the notes $E_2$ and $C_3$, a pair of spaced bridges carried by said frame and operatively associated with each string and defining the length of the speaking portion thereof, a series of hammers operatively associated with said strings, the hammers thereof for the strings tunable below $E_2$ being engageable with the speaking portion thereof at a point not over one and one-half inches from one of said bridges, and a voicing means in contact with each string tunable to $C_3$ and higher and extending from one bridge thereof a limited distance along said string.

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