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[54] **PROCESS FOR HEAT TREATMENT OF METALLIC STRINGS FOR STRINGED INSTRUMENTS**

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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.** **148/131,** 84/199, 148/13, 148/156, 219/58

[51] **Int. Cl.** **C21d 9/52**

[58] **Field of Search** ..... 148/12, 11.5, 154, 148/13, 156, 131; 219/117, 58, 118, 155; 72/286; 84/199, 297 S

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[57] **ABSTRACT**

A string of a stringed instrument is heat treated to a temperature less than its annealing or softening temperature under tensile stress to reduce residual stress in the string and thereby minimize tonal variation over long periods of time after the string has been strung in the instrument. The string is electrically heated, optionally after stringing in the instrument. The tensile stress is 40–160 kg/mm² and the heating temperature is 150°–400°C.

6 Claims, 6 Drawing Figures

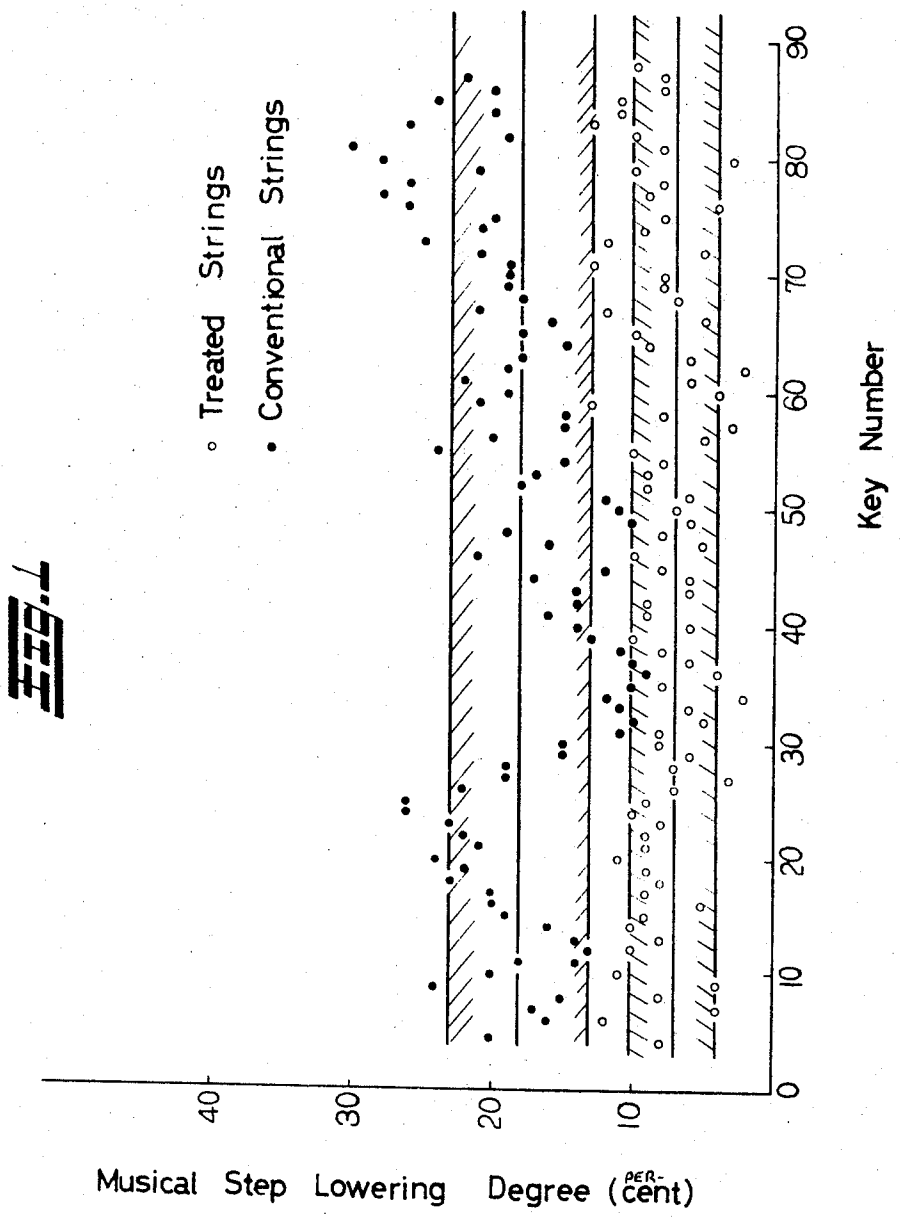
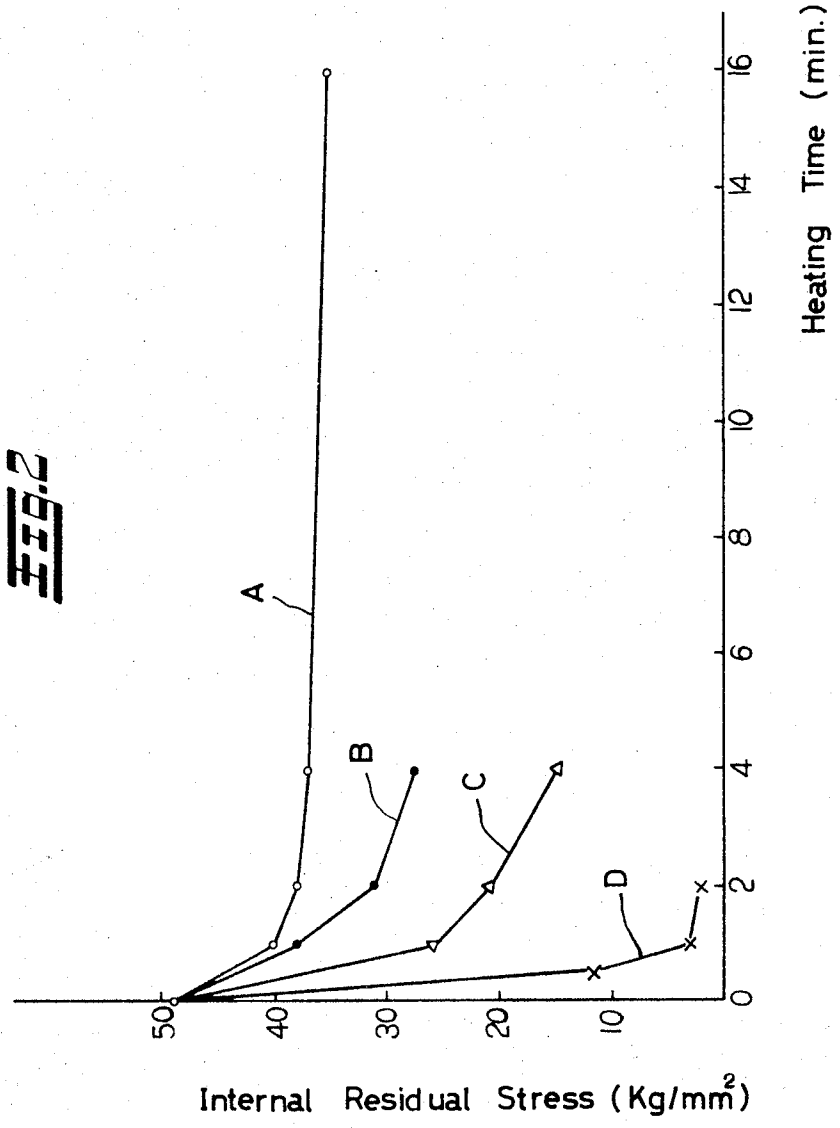


FIG. 1

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FIG. 2



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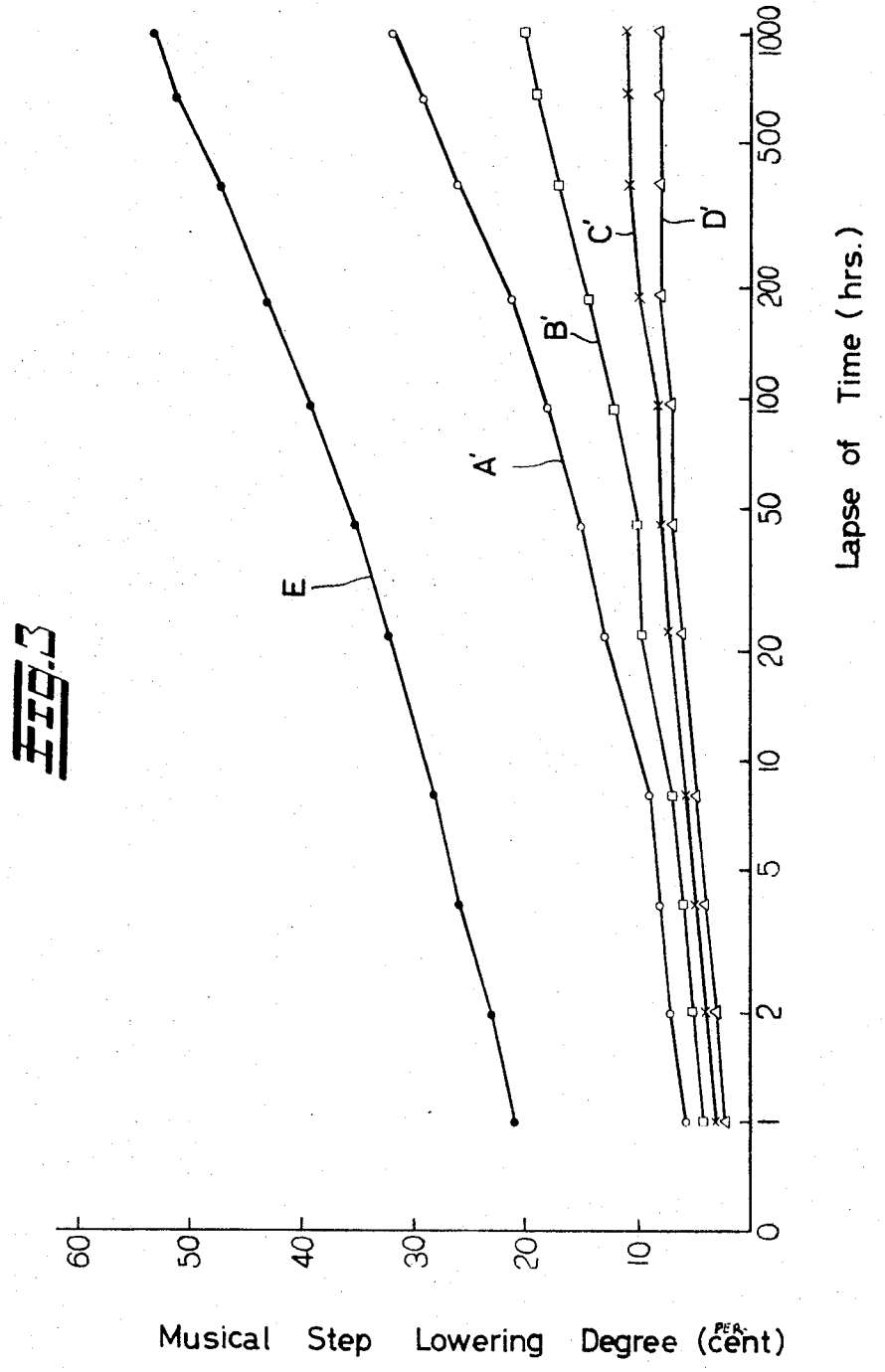
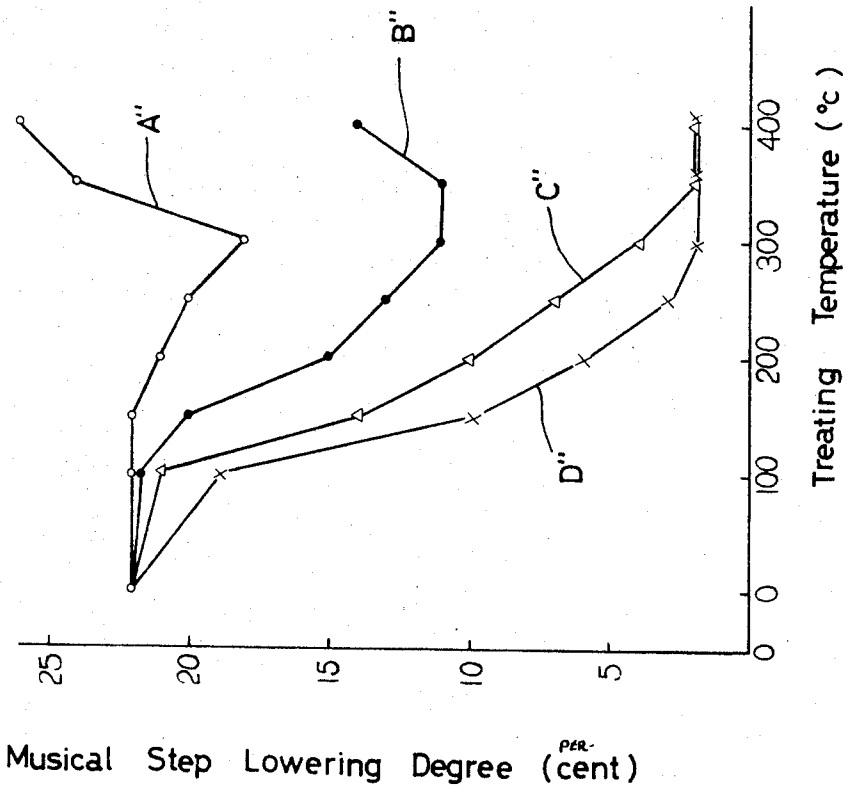


Fig. 3

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FIG. 4



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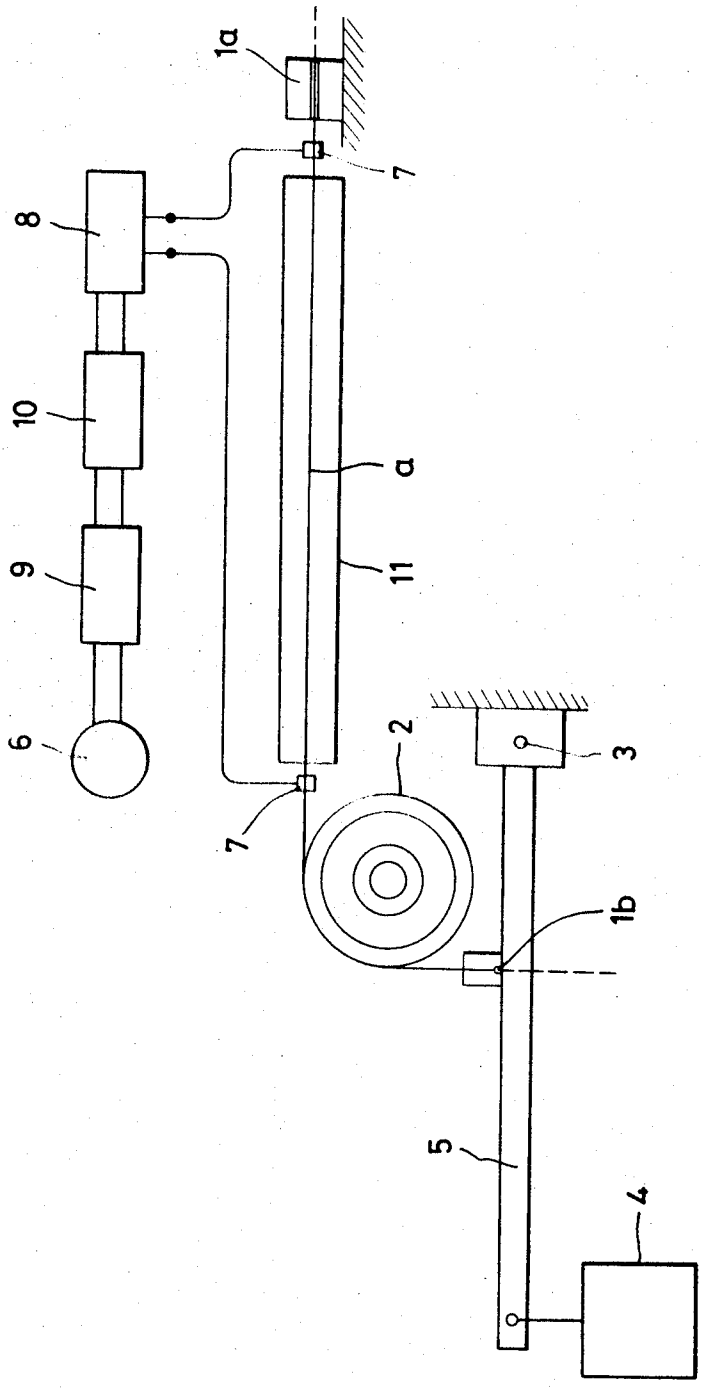
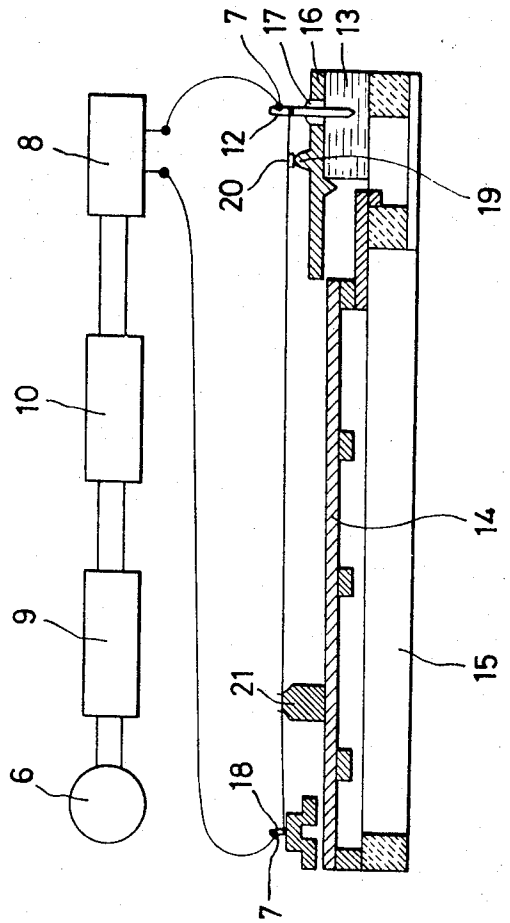


Fig. 5

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FIG. 8



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PROCESS FOR HEAT TREATMENT OF METALLIC STRINGS FOR STRINGED INSTRUMENTS

BRIEF SUMMARY OF THE INVENTION

This invention relates to a process for the heat treatment of a metallic string for a stringed instrument such as a piano or the like.

It has been usual hitherto to produce a piano string of a desired diameter from steel, such as a carbon steel, by effecting a heating treatment and a wire drawing operation, successively.

The piano string thus obtained has a satisfactory tensile strength. If, however, the string is installed in a piano under a tensile stress of 100–180 kg/mm² and is left as is for a long period of time, the tensile stress is relieved to cause lowering of the musical tone or step thereof. The upper portion in FIG. 1 shows this condition. Namely, the change of the musical step of each string two months after stringing is shown therein. It will be clear therefrom that the musical tone or step of each string is lowered 10–30 percent from the initial musical step at the time of stringing as shown by black dots. The average thereof is about 18 percent, and even though considering a range of ± 5 percent therefrom (this range is considered to be one in which a generally trained person cannot detect the difference by hearing), there are still some strings which are outside this range. It is almost impossible to hold the variation within a range of ± 3 percent (this range is considered to be one in which a specially trained person cannot detect the difference by hearing).

One of the causes of the change in musical value is considered to originate in the internal residual stress caused at the time of wire drawing. Heretofore, a heat treatment at a temperature lower than an annealing and softening temperature under no tension has been carried out for removing this internal residual stress, but only about 20–30 percent of the internal residual stress is removed. Accordingly, the lowering of the musical tone of the string after stringing thereof has shown a large value similar to an untreated string.

An object of this invention is to provide a process for heat treatment of a string whereby the internal residual stress is removed and the lowering of the musical value is not brought about even over a long period of time after stringing.

The invention is characterized in that a metallic string obtained by a wire drawing operation is heated to a temperature lower than the annealing and softening temperature while being subjected to a tensile stress.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a graph showing the degree of lowering of the musical step of each string in a piano for conventional strings and for strings according to the invention;

FIG. 2 is a graph showing the relation of internal residual stress in a piano string as a function of heating time;

FIG. 3 is a graph showing the relation between the musical step lowering degree and elapsed time;

FIG. 4 is a graph showing the relation between the musical step lowering degree and heat treatment temperature;

FIG. 5 is a side elevational view of one embodiment of apparatus according to this invention; and

FIG. 6 is a side elevational view, partly in cross-section, of another embodiment according to this invention.

DETAILED DESCRIPTION

Four piano strings A,B,C, D are prepared, and are heated at a temperature of 300°C below the annealing and softening temperature thereof under conditions in which string A is not subjected to tensile stress and strings B,C,D are given tensile stresses of 42, 84, and 126 kgs/mm², respectively. The internal residual stress of each string is measured at different heating times and the results are shown in FIG. 2. Therein it can be seen that the internal residual stress in string A is reduced only 20–30 percent, whereas the degree of reduction of the internal residual stresses in strings B,C,D increases as the applied tension stress is increased. In the case of string D, the reduction of internal stress is more than 95 percent.

The strings A′,B′,C′,D′ each heated for one minute by the foregoing process are strung under a tension stress of 155 kg/mm² and at the same time a conventional string E which has not been subjected to heat treatment is similarly strung. The degree of lowering of the musical tone during lapse of time is measured and the results are plotted in FIG. 3. In comparison with the string E (not subjected to heat treatment), the string A′ subjected to a heat treatment under no tension, and the strings B′, C′, D′ gradually increased in tensile stress, are generally reduced in the degree of lowering of the musical tone.

Considering the tuning operation, which is the last stage of a conventional piano manufacturing process, this requires several tens of hours from the initial tuning step to the completion tuning step. The lowering of musical tone during this tuning operation does not cause great problems because the tone is adjusted in the completion tuning step.

Considering this fact, substantial significance lies in the period subsequent to the lapse of the several tens of hours. FIG. 3 shows that the lowering of the tone of string E between 20–1,000 hours is 20 percent, while that of string A′ is more than 10 percent. The strings B′, C′, D′ subjected to the heat treatment of this invention, have extremely small lowering of tonal values and these are ½ – 1/10 in comparison with strings A′ and E. The string D′ is especially excellent. Accordingly, retuning after the last tuning step is not required for the strings which have been treated according to the invention.

FIG. 4 shows the relation between the treatment temperature and the degree of lowering of the musical tone 20–1,000 hours after stringing a string A″ subjected to no tension stress and strings B″, C″, D″ subjected to tension stresses of 42, 84 and 126 kg/mm², respectively. As for the lowering of the musical values during this time, up to about 13 percent is permissible. Accordingly, the heat treatment temperature may be from about 150°C to about 400°C within the range of tensile stress of 40–100 kg/mm².

The lower portion in FIG. 1 refers to piano strings each heat treated for 1 minute at 300°C under a tensile stress of 100 kg/mm² and strung in a piano and the degree of lowering of the musical tonal values after two months is illustrated. The average degree of lowering is 7 percent, and the range of this change may be held within about ± 3 percent (this range is the range in

which a person having a high auditory sense cannot tell the difference by hearing).

Thus, a piano string treated in accordance with this invention, has a very small degree of lowering of musical tone even over a long lapse of time after stringing in comparison with a conventional string. Consequently, the number of tuning steps required may be substantially decreased. Furthermore, the dispersion of the lowering degree is narrow and thus the tone can be maintained for a long time.

An oxide coating is formed on the surface of the string to prevent rusting thereof.

The process of the invention is effective not only for high carbon steel strings but also for stainless steel strings, phosphor bronze strings and others. Additionally, the strings of this invention are not limited to use in a piano but are applicable to any other stringed instruments.

FIG. 5 shows the apparatus for effecting the process of the invention treatment. Therein, a steel string *a* is fixed at one end to an electrically insulated clip **1***a* and passes over a guide roller **2** and is fixed at its other end to a clip **1***b* mounted on a lever **5** supported at one end by an axle **3** and carrying a weight **4** at its other end. Consequently, a tensile stress is produced in string *a* by the weight **4**. Terminals **7** are connected to an electrical source **6** and are connected to string *a* at spaced locations thereon so that a predetermined electrical current flows through the string for a predetermined length of time under the control of a time-limit relay **8**. Numeral **9** denotes a voltage regulator and numeral **10** denotes a voltmeter. Numeral **11** designates a cover for the string *a* to permit the string to be heated uniformly while being isolated from air flow. In a modification, the string *a* can be a long continuous string as shown by dotted lines and it is moved step by step for each unit length of the final string to be obtained

FIG. 6 shows an embodiment wherein the string *a* is heated by electrical current flow in a condition in which the string has been actually strung in a piano. Namely, a tuning pin **12** is driven in a wooden tuning pin plate **13** and thereby is electrically insulated from a sound plate **14** and a back **15**, and is also insulated from a frame **16** by a bushing **17**, the string *a* being strung between the foregoing tuning pin **12** and a hitch pin **18** while being subjected to a tensile stress of 100 kg/cm^2. An insulating material **20** is interposed between the string and a pillow **19** so that the string *a* becomes completely electrically isolated. Numeral **21** denotes a bridge which is an electrical insulator. Terminals **7** connected to an electric source **6** are connected to both ends of the string *a* and a predetermined electrical current is passed therethrough for a predetermined length of time under the control of time-limit replay **8**. Thus, the string *a* which has an electrical resistance of 0.1 to 0.4 Ω/m is heated. The heating temperature thereof is set within the foregoing range of 150°–400°C.

In the illustrated embodiment of FIG. **6**, it is not only possible to heat a single string *a*, but it is also possible to heat several strings simultaneously.

What is claimed is:

1. A process for heat treatment of a piano wire produced of a wire from the class consisting of high carbon steels, stainless steels and phosphor bronze, said process comprising heating said piano wire to a temperature of 150°–400°C which is lower than its annealing and softening temperature while simultaneously subjecting the piano wire to a tensile stress of 40–160 Kg/mm^2 for a relatively short period of time so as to reduce the degree of tonal reduction of the piano wire to a value of no more than about 13 percent after about 2,000 hours after the piano wire has been strung in the instrument.

2. A process as claimed in claim **1** wherein the string is subjected to tensile stress by fixing the string at one end and applying a weight to its opposite end and the string is heated by passing an electrical current through an intermediate portion of its length.

3. A process as claimed in claim **1** comprising mounting the string in the piano before it is heated under tensile stress.

4. A process as claimed in claim **3** wherein the string is mounted in the piano by being connected to a tuning pin and a hitch pin, the piano wire being heated by passage of electrical current therethrough.

5. A process as claimed in claim **4** comprising electrically isolating the string in said instrument.

6. A process as claimed in claim **1** wherein the string is heat treated for 1 minute.

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