

May 28, 1968

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3,385,153

METHODS OF TUNING MUSICAL INSTRUMENTS

Filed May 18, 1965

2 Sheets-Sheet 1

Fig. 1.

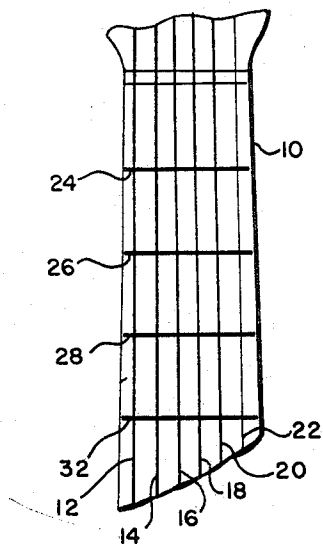


Fig. 2.

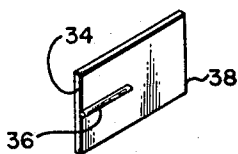


Fig. 3.

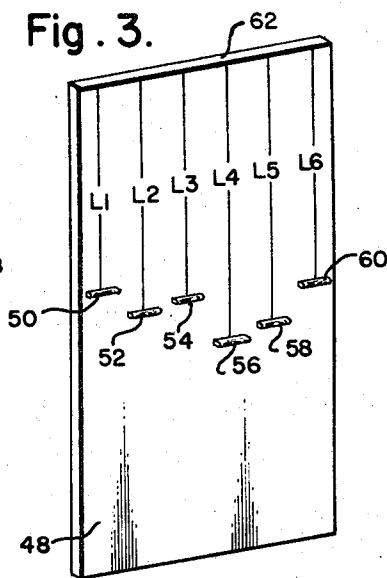
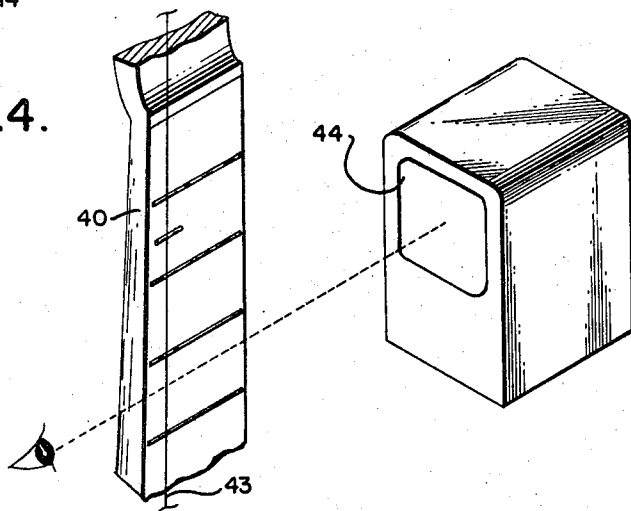


Fig. 4.



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Fig. 5 a

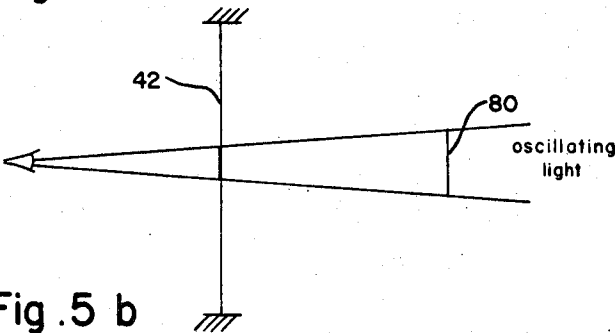


Fig. 5 b

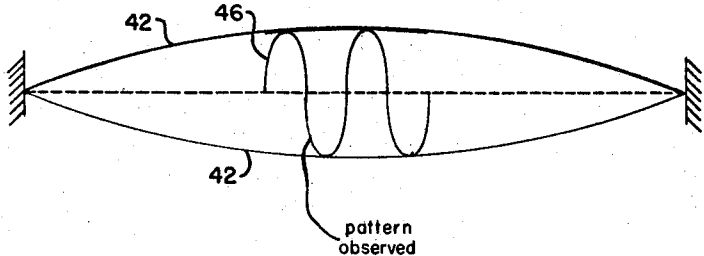


Fig. 6

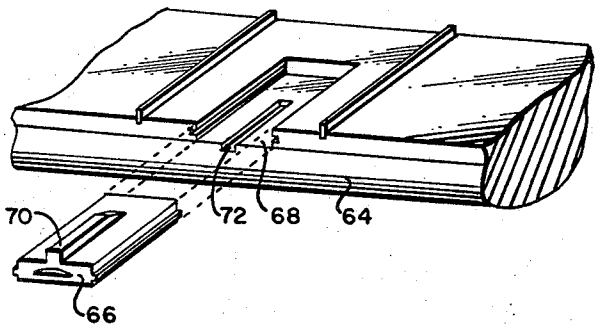
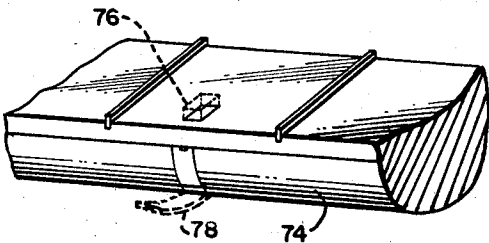


Fig. 7



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3,385,153

METHODS OF TUNING MUSICAL INSTRUMENTS

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5 Claims. (Cl. 84-455)

This invention relates to methods and devices for tuning musical instruments and in particular stringed instruments.

Stringed musical instruments require frequent tuning. Non-metallic strings, such as nylon, require more tuning than metal strings. For example, the guitar must be tuned at least daily if it is to be used on that basis.

By international agreement musical instruments should be normalized such that the first "A" note above "middle C" is 440 cycles per second. This establishes the frequency of all other notes because their relative frequencies are also specified. Musical instruments are designed to be played on "key," which means that the instrument is to be properly tuned and normalized. Strings are presently tuned in the main by sounding a pitch pipe or a tuning fork and simultaneously vibrating the string to be tuned. The strings are in tune when a person tuning judges by ear that both are vibrating at the same rate. This can be done for each string or for a single string and the remaining strings tuned relative to the first tuned string. Forks and pitch pipes are subject to error due to temperature, humidity, air pressure and errors in manufacture. Even if these errors are not present in the tuning device, it is rare to find people, particularly the novice musician, with the ability to accurately judge the equality of two frequencies on an auditory basis. Tuning a stringed instrument by these methods is subjective and not objective. The present invention minimizes the possibility of manufacturing errors, and eliminates all of the remaining errors noted and presents an objective method of tuning a musical stringed instrument. Rather than tuning the instrument by ear, the instrument is tuned by eye.

I provide a method of tuning stringed instruments which comprises providing a stroboscopic light source which operates on a given frequency, altering the effective vibrating length of the string to be tuned to a length which if the string were at the desired playing frequency it would vibrate at a rational fraction of a multiple frequency of the stroboscopic light source, positioning the light source in alignment with the string to be tuned, adjusting the tension in the string to be tuned so that a standing wave form appears as viewed against the light source, and returning the string to its original length whereby the string will then vibrate at the desired playing frequency. In order to shorten the effective vibrating length of the string, I insert a fret at the body which includes the neck of the stringed instrument or other temporary terminating device under the string to be tuned.

I provide a spatially oscillating light source preferably a television raster light source because this light oscillates in the vertical direction at an accurately controlled known frequency of 60 cycles per second when it is receiving a commercial United States broadcast. I position the television raster light in vertical alignment with the longitudinal axis of the string to be tuned. I adjust the tension in the string so that a standing wave appears as viewed against the television. The direction the wave form appears to be running when improperly tuned is dependent upon the tension in the string and directly indicates the direction of mistuning. The number of cycles of the standing wave directly indicates the relative string and raster frequencies.

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I provide an additional method of tuning an electrical stringed instrument having an amplifier which comprises providing 60 cycles or any other known electronic signal frequency enriched in harmonics to the amplifier, inserting a fret at the body of the stringed instrument under the string to be tuned, the fret shortens the effective vibrating length of the string to a length which if the string were at the desired playing frequency it would vibrate at a rational fraction of a multiple frequency of 60 cycles, adjusting the tension of the string to be tuned so that a zero beat note is heard when the 60 cycle amplifier signal is mixed with the string signal produced by a vibration of the string, and removing the fret from the neck of the stringed instrument.

I provide a method of stopping the motion of an oscillating body and determining its frequency and displacements which comprises providing a spatially oscillating light source and directing the oscillating source against the vibrating body.

Other details, objects and advantages of the invention will become apparent as the following description of a present embodiment and method of practicing the same thereof proceeds.

In the accompanying drawings I have shown a present preferred embodiment of the invention and have illustrated a present preferred method of practicing the same in which.

FIGURE 1 is a top view of a portion of the body of a guitar showing the neck;

FIGURE 2 is an insertable fret for one string;

FIGURE 3 is an insertable fret for six strings;

FIGURE 4 is an isometric view of a portion of a guitar body with one string in vertical alignment with a television raster;

FIGURE 5a shows a string in vertical alignment with a spatially oscillating light source;

FIGURE 5b is an apparent wave form of a vibrating string shown in FIGURE 5a;

FIGURE 6 is an isometric sketch of a portion of a guitar neck without the strings and having an insertable fret; and

FIGURE 7 is an isometric sketch of a portion of a guitar neck without strings having a recessible fret.

The strings of musical stringed instruments vibrate at a constant time rate. The rate of vibration of stringed instruments is inversely proportional to the string length. The first order fundamental frequency of vibration is determined from the following formula:

$$F = \frac{1}{2L} \sqrt{\frac{T}{m}}$$

L =length between terminated ends of the string

m =mass per unit length

T =tension along the string

If the stringed instrument is placed in front of a strobe light or in alignment with the strobe light operating on a given frequency and the string is plucked and vibrates at certain rational fractions of a multiple frequency of the strobe light frequency, then a standing wave form will appear. This is known as the stroboscopic effect. For example, if the strobe frequency is 60 c.p.s. and the string vibrates at 90 c.p.s., in this situation the multiple is 3 and the rational fraction would be $\frac{1}{2}$. [$(\frac{1}{2}) (3) 60 \text{ c.p.s.} = 90 \text{ c.p.s.}$] In this case two stationary images of the string will be observed.

If a strobe light source of a given fixed frequency is used, no standing wave would normally appear but using the formula above, the lengths of the strings of various instruments can be altered in order to vibrate at a rational fraction of a multiple frequency of the light source so that an apparent standing wave appears. The light frequency

can be varied to any critical desired string frequency but this would require an expensive light source having a multiple range of frequency capabilities. This invention uses a single strobe light frequency for tuning all musical stringed instruments. The effective vibrating lengths of the strings are varied to produce apparent standing wave forms using a standard light source operating on a single frequency.

Example

The desired operating frequency of the "A" string on a guitar is 110 cycles per second. Assume a strobe light source operating on a frequency of 60 cycles per second. The most convenient multiple of 60 cycles for the 110 cycles would be 2 thereby providing 120 cycles. By shortening the length of a perfectly tuned "A" string a predicated amount using the above formula, the string will vibrate at 120 cycles per second and an apparent standing wave will appear when viewed against the 60 cycle light source. Now assume the "A" string is out of tune, the string is shortened the same amount as above (i.e., when in perfect tune) so that it will vibrate at 120 cycles per second when the string is tuned perfectly. The "A" string is then tuned in front of the strobe light source of 60 c.p.s. by adjusting the tension in the untuned shortened "A" string of the guitar until an apparent standing wave is viewed. Then when the string is returned to its ordinary vibrating length, it will be vibrating at 110 cycles per second which is the correct playing frequency.

FIGURE 1 shows a neck of a guitar 10 having the E, A, D, G, B, and E strings 12, 14, 16, 18, 20, and 22, respectively. Frets 24, 26, 28 and 32 are mounted along the neck of the guitar for normal playing. In order to shorten the effective vibrating length of the "A" string to make the "A" string vibrate at 120 cycles per second when it is correctly tuned at its full length, a special fret shown in FIGURE 2 having a base plate 34 and a fret 36 mounted on the base plate is inserted between frets 24 and 26. Side 38 of the base plate 34 is approximately one and twenty-one sixty fourth inches ($1\frac{21}{64}$ "). The fret 36 is located near the center of the base plate 34 when the light source frequency is 60 cycles per second. The neck of the guitar 10 is aligned with a strobe light operating at 60 cycles per second or any other known frequency. Assuming a strobe light operating at 60 cycles per second is used, the "A" string tension is adjusted until an apparent standing wave appears. This indicates that the "A" string is vibrating at 120 cycles per second or at some multiple of 60 c.p.s. The fret 36 is then removed and now the string is operating at its playing frequency of 110 cycles per second if the string was vibrating at 120 cycles per second with the special fret.

FIGURE 3 shows a fret plate which can be used to tune all six strings of a guitar. It comprises a base plate 48 having frets 50, 52, 54, 56, 68 and 60. Side 62 of the base plate 48 is inserted flush with the top of the neck known as the nut. The distance between the frets and the top 62 (L1, L2, L3, L4, L5 and L6) is L_i where i denotes a string. The position of the frets on the base plate 48 is computed as follows:

$$(1) \text{ The } L_i = L - LF_0/F_1$$

$$(2) F_1 = RF_s$$

(3) L = total string length measured from top of plate 62 to the bridge.

(4) F_0 = desired frequency of the string when terminated at top 62 is at the nut of base plate 48 [for "A" string 110 c.p.s.]

(5) F_s = light source frequency

(6) F_1 = string frequency when terminated at one of the frets 50, 52, 54, 56, 58 and 60 on the base plate 48.

(7) R = a rational fraction times a multiple of F_s .

By using the fret shown in FIGURE 3, six strings of the guitar can be tuned using a single strobe light source operating on a single frequency.

Another technique for tuning a musical stringed instrument is to direct a spatially oscillating light source against the string.

Example

Referring to FIGURES 4, 5a and 5b, assume a perfectly tuned "A" string [110 c.p.s.] is effectively shortened to vibrate at 120 c.p.s. When a spatially oscillating light source 80 is directed against the string 42 as shown in FIGURE 5a, an apparent standing wave pattern 46 as shown in FIGURE 5b will be seen. The wave pattern 46 is observed when the string 42 frequency is vibrating at a rational fraction multiple of the spatially oscillating light frequency. All strings will have different patterns. The spatially oscillating light source in the example is moving downward making a complete sweep in $\frac{1}{60}$ of a second. The tension of an untuned "A" string will determine the direction in which the wave pattern 46 appears to be moving. The number of cycles which appears in the wave pattern 46 is also dependent upon the tension of the string 42. For tuning purposes, the lengths of the strings are computed as previously discussed. The results accomplished by this spatially oscillating light source technique are not possible by using an ordinary stroboscopic effect.

The vertical component of a television raster moves a beam of light down the screen $\frac{1}{60}$ of a second providing a spatially oscillating light source. FIGURE 4 shows a guitar neck 40 having an "A" string 43 which is vertically aligned with a television raster 44. When the "A" string 43 is plucked, a wave form 46 appears as shown in FIGURE 5b. When the "A" string 43 is pitched too high, the wave form 46 appears to move vertically upward. When the "A" string 43 is pitched too low, the wave form 46 appears to move vertically downward. This is a result of the ion beam in a television raster which zig-zags across the screen forming between 390 and 525 visible horizontal lines. These lines are successively formed in a vertically downward direction, and there is a complete downward sweep of the ion beam each $\frac{1}{60}$ of a second followed by a brief blanking of the entire screen. There effectively is a band of light that moves down the screen 60 times each second. The television raster, therefore, is a spatially oscillating light source.

FIGURE 6 shows a neck 64 of a guitar with a special fret plate 66 and a space 68. When the instrument is being tuned, the special fret plate 66 is inserted into the space 68 with the fret portion 70 on top. After the string has been tuned, the special fret plate 66 is turned over and stored in the space 68 with the fret 70 engaging slot 72.

FIGURE 7 shows another embodiment. A guitar neck 74 has a special fret 76 which is raised and lowered by the lever 78. Whenever the instrument is being tuned, the fret 76 is raised by the lever 78, and when the instrument is being played, the lever 78 is pushed upwards along the wall of the neck 74 and the fret 76 retracts to a position flush with the top of the neck 74.

While I have shown and described certain preferred embodiments of the invention and have illustrated present preferred methods of practicing the same, it is to be distinctly understood that the invention is not limited thereto but may be otherwise variously embodied within the scope of the following claims.

I claim:

1. A method of tuning stringed musical instruments which comprises:

(a) providing a stroboscopic light source which operates on a given frequency;

(b) altering the effective vibrating length of the string to be tuned to a length which if the string were at the desired playing frequency it would vibrate at a rational fraction of a multiple frequency of the strobe light;

(c) positioning the strobe light in alignment with the string to be tuned;

(d) adjusting the tension in the string to be tuned so that a standing wave form appears as viewed against the strobe light; and

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(e) returning the string to its original length whereby the string will then vibrate at the desired playing frequency.

2. A method of tuning stringed musical instruments which comprises:

- (a) providing a spatially oscillating light source which operates on a given frequency; 5
- (b) altering the effective vibrating length of the string to be tuned to a length which if the string were at the desired playing frequency it would vibrate at a rational fraction of a multiple frequency of the light; 10
- (c) positioning the light in alignment with the string to be tuned so that a running wave form appears; 15
- (d) adjusting the tension in the string to be tuned so that a standing wave form appears as viewed against the light, the direction the wave form appears to be running is dependent upon the tension on the string; and 20
- (e) returning the string to its original length whereby the string will then vibrate at the desired playing frequency. 25

3. A method of tuning stringed musical instruments which comprises:

- (a) providing a strobe light source which operates on a given frequency; 25
- (b) inserting a fret under the string to be tuned at the body of the stringed instrument, the fret shortens the effective vibrating length of the string to a length which if the string were at the desired playing frequency it would vibrate at a rational fraction of a multiple frequency of the strobe light; 30
- (c) positioning the strobe light in alignment with the string to be tuned; 35
- (d) adjusting the tension in the string to be tuned so that a standing wave appears as viewed against the strobe light; and 40
- (e) removing the fret from the body of the stringed instrument. 45

4. A method of tuning stringed musical instruments which comprises:

- (a) providing a television raster light source; 40
- (b) inserting a fret under the string to be tuned at the body of the stringed instrument, the fret shortens the effective vibrating length of the string to a length which if the string were at the desired playing frequency 45

would vibrate at a rational fraction of a multiple frequency of the television raster light source;

- (c) positioning the television raster in alignment with the string to be tuned;
- (d) adjusting the tension in the string to be tuned so that a standing wave appears as viewed against the television, the direction the wave form appears to be running is dependent upon the tension on the string; and
- (e) removing the fret from the body of the stringed instrument.

5. A method of tuning stringed musical instruments which comprises:

- (a) providing a television raster light source; 15
- (b) inserting a fret under the string to be tuned at the body of the stringed instrument, the fret shortens the effective vibrating length of the string to a length which if the string were at the desired playing frequency would vibrate at a rational fraction of a multiple frequency of the television raster light source; 20
- (c) positioning the television raster in alignment with the string to be tuned; 25
- (d) adjusting the tension in the string to be tuned so that a standing wave appears as viewed against the television; and 30
- (e) removing the fret from the neck of the stringed instrument. 35

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