

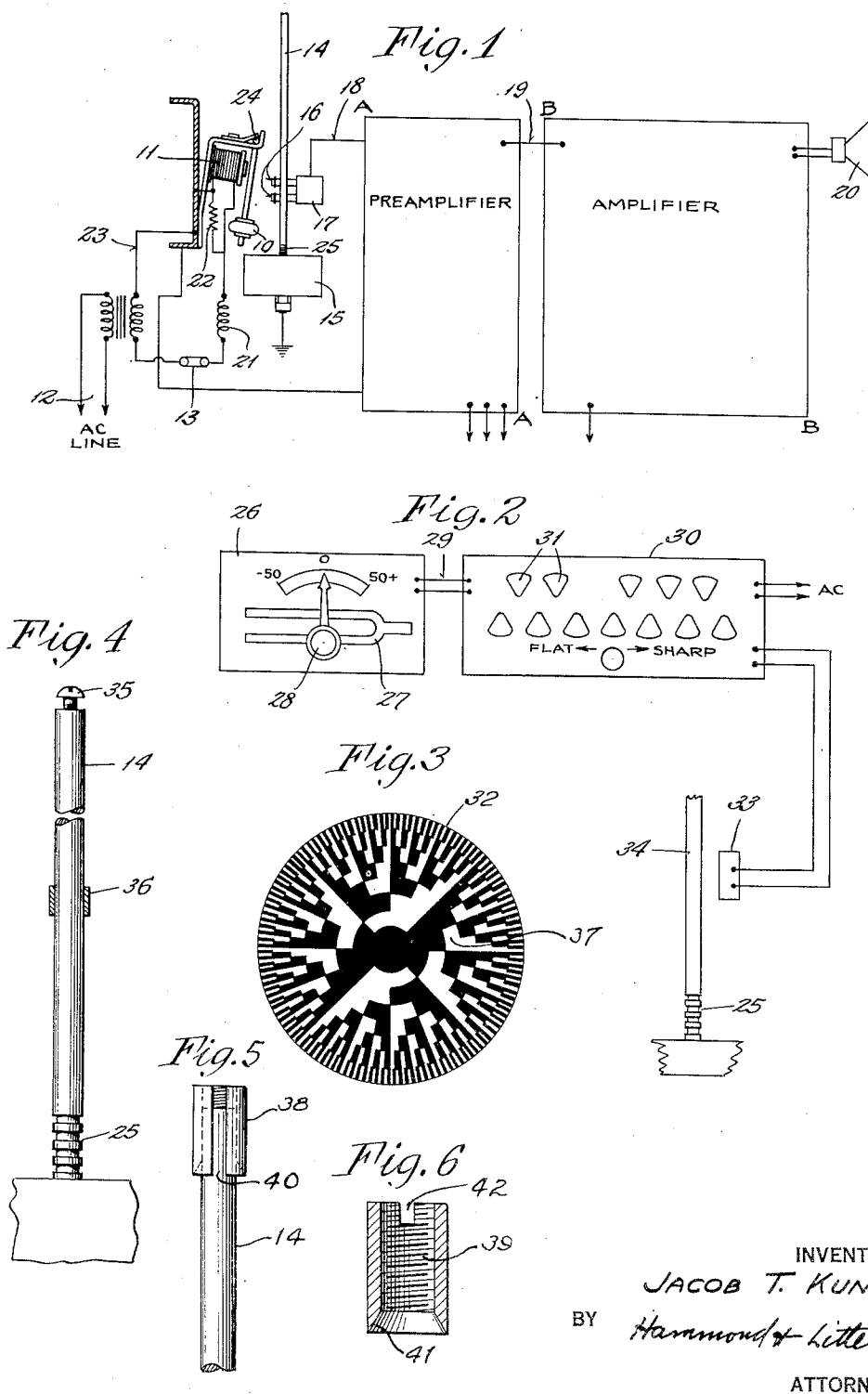
Feb. 20, 1951

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2,542,540

TUNING METHOD FOR MUSICAL INSTRUMENTS

Filed May 28, 1946



UNITED STATES PATENT OFFICE

2,542,540

TUNING METHOD FOR MUSICAL INSTRUMENTS

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Application May 28, 1946, Serial No. 672,820

4 Claims. (Cl. 84-456)

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This invention relates to a musical instrument and particularly to one having a plurality of vibratory bodies or rods which can be struck and set in motion to produce musical tones similar to those produced in an instrument commonly referred to as an electric carillon. In the present invention, the vibrations of the tuned bodies or rods are amplified electrically to faithfully reproduce the tones present in conventional cast bells. This application is especially concerned with the method and means for tuning the vibrators of such an instrument. As set forth in applicant's Patents No. 2,463,543 and No. 2,472,595 filed January 15, 1946 and issued March 8, 1949 and June 7, 1949 respectively, among the advantages of an electric carillon as compared with conventional cast bells can be enumerated saving in weight, limitation of effect due to climatic changes, volume and radiation control, and ease of playing. Merely as an example, an electric carillon of twenty-five notes made in accordance with the present invention will weigh about two hundred pounds, whereas conventional cast bells weigh as much as fifty thousand pounds.

One of the objects of the present invention is to provide a method and means for tuning properly the twenty-five rods so that each of said rods will have a desired even harmonic pattern and that upon striking the same, bell or chime tones will be produced correctly when picked up, electrically amplified, modified, and broadcast by a loudspeaker.

Another object of the invention is to provide a rapid and economical means for adjusting the length of the vibrator elements in the tuning thereof.

In previous devices, the relationship between the fundamental note and the harmonic pattern of the various rods varied with each rod so that the instrument did not produce the music of perfect bells. By means of the present invention, each of the vibratory members is tuned to a certain predetermined tone and then the harmonics of each rod further tuned so that there will be an even harmonic pattern producible in each of said rods.

A good bell note or tone is one wherein the hum tone, the fundamental tone, a minor third, a fifth, and an octave above the fundamental appear. The fundamental tone is the most prominent tone at the instant of striking and is taken as the point from which the other tones are measured, it being noted that the fundamental tone in a bell is not the lowest frequency present. The hum note or hum tone is an octave below

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the fundamental tone. The minor third and fifth are between the fundamental and the octave above the fundamental. A good bell note can be produced if a rod clamped at one end has the third tone tuned to a standard tone for the particular rod and then the third tone treated as the fundamental with the second tone of the rod as the hum tone. Following this, the other desired partials and/or tones are brought into correct relationship. When such a tuned rod is struck and the vibrations translated to electrical vibrations, the first tone of the rod can be filtered out by suitable filtering means in the electric circuit, the circuit being shown in detail in said aforementioned co-pending applications.

These and other objects of the invention will become apparent from the following description and drawings which are merely exemplary.

In the drawings:

Fig. 1 is a diagrammatic view partly in section of a tuned rod and striker together with the pick-up means.

Fig. 2 is a diagrammatic view of one type of instrument which can be used in tuning the carillon.

Fig. 3 is an enlarged detail view of one of the dials of the instrument of Fig. 2.

Fig. 4 is a broken view of a rod with one type of length adjusting device thereon.

Fig. 5 is a fragmentary view of another type of adjusting means.

Fig. 6 is a sectional view of the adjusting means of Fig. 5.

In the preferred form of the invention, an instrument having twenty-five notes, or two octaves, tuned to the chromatic scale is employed, but it is to be understood that an instrument with any number of notes, or vibratory bodies, may be used.

In Fig. 1, striker or hammer 10 is held in an energized position by magnet 11, said magnet normally being energized by a source of power 12 through normally closed switch 13, said switch being opened when a key of the console or keyboard is operated. The rod or vibrator 14 is carried in the heavy base 15, heavy base 15 being resiliently supported in any suitable manner, such as on rubber supports. Condenser or collector plates 16 are mounted on a collector plate supporting bar 17, said plates being connected with a wire 18 to preamplifier A-A, rod 14 being connected with a wire 18 to preamplifier A-A, rod 14 being connected to the ground through support 15. The preamplifier A-A is connected by wire 19 with amplifier B-B,

said amplifier being connected to a loudspeaker 20. Inductance 21, resistance 22, and the capacitance of the relatively long leads 23 will suppress any disturbance in the striker release mechanism, resistance 22 being shunted across the magnet 11 to reduce the reactance of the circuit to the radio frequencies generated by an opening of switch 13. When switch 13 is opened, magnet 11 will release striker 10 allowing the striker to swing on its pivot and strike rod 14. The vibrations of a rod 14 cause a variation in the electrical capacity between the collector plates 16 and the rod 14, plates 16 and rod 14 being given a suitable polarizing or operating potential as described in said aforementioned co-pending applications.

In tuning the various rods of the carillon, it is desirable to obtain the note or tone appearing in a good bell, namely, a hum tone, a fundamental, a minor third, a fifth, and an octave above. When a rod or bar is clamped rigidly at one end with an unsupported free end, there will be certain predetermined frequency ratios between the overtones and the fundamental, these ratios having been established by physicists such as Rayleigh in Theory of Sound. As indicated in Table I, these ratios in a rod clamped at one end are not even multiples of the fundamental.

Table I

(1) No. of tone	(2) Frequency Ratio	(3) Freq. of Specific Note	(4) Desired Frequency	(5) Resultant Tone (3 as Fundamental)
1 (Basic)-----	f	10	-----	1+2- 72 or 3-2-113
2-----	6.26f	62	87.5 (Hum Tone)---	3-175
3-----	17.55f	174	175 (Fund.)-----	2+3-237
Minor Third-----	-----	-----	-----	2+3+2-299
Fifth-----	34.34f	343	350-----	4-343

As an example, assuming that the first or basic tone has a frequency of 10, the frequency of the second, third, and fourth tones will be 62, 175, and 343, respectively. If the third tone be taken as the fundamental, it will be noticed that the fourth tone is slightly under the octave above or twice the frequency of the fundamental. The second or hum tone, which is an octave below, is not one-half of the frequency of the fundamental. The desired frequency of the various partials with the third tone as the fundamental including the minor third and fifth is indicated in column (4) of the table. The hum tone is produced as a result of the combination of tone 3 minus tone 2 or 113 vibrations per second, this being accomplished through the phenomenon of beats as is well known. Similarly, the minor third is arrived at by a combination or beat note between tones two and three and the fifth is a combination between the minor third and the hum tone. The resultant tones are not as close as is desired to the tones set forth in the desired frequency column.

It has been ascertained that the tones are brought closer to a desired even harmonic pattern by cutting a groove or grooves 25 near the point where the rod is clamped in a collet and exteriorly thereof. There may be more or less grooves than the number shown. The exact reason for this phenomenon is not precisely known although it may have some analogy in the fact that when circuits or vibrating members are made unstable or are given the opportunity

to vibrate with even harmonics, they will so do.

As will be noted from the last column of Table I, the grooving causes the relationship between the notes to come very close to the desired even harmonic pattern. The base frequency is determined by the strongest tone present in the rod, or which is being picked off the rod, this being 175 cycles per second in the example of Table I. Grooving of the rod permits tone 4 to vibrate substantially at 350 cycles instead of 343 and also permits the rod to vibrate or produce a hum tone of 87.5 cycles per second instead of 62 or 113 cycles per second. Thus the grooving causes the relationship between the fundamental tone and the octave to fall into an even relationship.

Actual tests have shown that the partials in an unnotched rod can be off as much as 30 or 40 cents in a rod, a cent being defined as an interval between any two tones whose frequency ratio is the twelve hundredth root of two, whereas the rods can be tuned by grooving to show a deviation of only 5 or 6 cents. When a deviation of about 12 cents is present, dissonance usually becomes noticeable between the rods and tones in the rods.

In tuning the rods, various types of apparatus may be used, one form being similar to that manufactured by C. G. Conn., Ltd., of Elkhart, Indiana, wherein there is a tuning fork unit indicated schematically at 26, the tuning fork element being shown diagrammatically at 27. A pointer and scale 28 is connected to a suitable mechanism (not shown) for adjusting the frequency of the fork in any well-known manner, this not forming part of the present invention. Fork 27 is designed and adjusted to operate at some standard frequency, such as 440 cycles per second, when the pointer is at the center or zero position as shown in Fig. 2. By moving the pointer either side of zero, the vibrations of the fork can be increased or decreased 50 cents. The fork unit 26 is connected by leads 29 to a stroboscope unit 30 having a neon or similar type lamp, said stroboscope unit having a plurality of dials which have windows 31 in front thereof, each of said dials being made similar to that shown at 32. The specific construction of the stroboscope unit is not part of the present invention so it will be described only in general terms. The dials are mounted on shafts which are geared together and connected to a motor, said motor having its speed governed by the fork unit 26 so that the dials will rotate at speeds having a predetermined relationship to the speed of the fork unit and to each other. The twelve dials are arranged so as to represent the twelve notes of a chromatic octave. Each dial may have seven rings of alternate light and dark segments the inner ring having two dark and two light segments and each succeeding ring progressing outwardly having twice as many segments.

In tuning a rod, a microphone 33 is placed near rod 34 and said microphone is connected to the stroboscope unit 30 and lamp therein as is well known. When the rod 34 is struck, the stroboscope lamp will produce a light pattern in accordance with the vibrations received.

When the number of flashes of the neon tube per second is the same as the number of dark segment passing per second on some ring on one of the dials, that ring will appear to be stationary as is well known in stroboscopic devices. As an example, the ring 37 of Fig. 3 having a 16-segment ring, if rotated at 27.5 revolutions per

second, will appear stationary when there are 440 light flashes per second. The seven rings on each dial provide for 7 octaves in the particular instrument being described.

In order to tune one of the rods to a particular standard, the length thereof may be changed in any suitable manner such as by cutting off the rod. Another method is to employ a screw 35 which may be used to shorten or lengthen the effective length of rod 14.

A preferred form for adjustment of the length of the rod is shown in Figs. 5 and 6, wherein a

produce a substantially even harmonic pattern.

The vibrators can be formed from brass or other suitable metal and should be as symmetrical and homogenous as possible, circular rods being shown herein. As explained in said aforementioned co-pending applications, the adjustment of the collets holding the rods also will influence the vibratory movement of the rod.

As an example of the tuning of the lowest and highest pitch rods of one form of twenty-five note or two octave carillon, reference is made to Table II.

Table II

Name of Tone	Freq. Ratio	Low G—196			High G—784		
		Desired Tones	Resultant Tones		Desired Tones	Resultant Tones	
1 (Basic Tone)-----	f		11.1			44.6	
Hum Tone-----	6.26f	98	69.5	80.5 1+2	392	279.5	324.1 1+2
Fund-----	17.55f	196	196	196 3	784	784	784
Third (Minor)-----		251		255.5 2+3	1045		1063 2+3
Fifth-----		326		335.0 (2+3)+2	1306		1332 (2+3)+2
Octave-----	34.34f	392	381.7	381.7 4	1568	1540	1540

split metallic sleeve 38 may have shallow threads 39 in the bore thereof. A slit 40 is provided and the sleeve may be made slightly smaller than the diameter of the rod 14, the sleeve metal being sufficiently resilient to allow placing on the rod. The leading edge 41 may be beveled so as to facilitate placing of the length adjusting sleeve 38 on rod 14. The sleeve 38 may be forced over the end of rod 14 and then further adjusted by the use of a suitable spanner wrench inserted into grooves 42 so as to turn the sleeve on rod 14. The resiliency of the sleeve will cause the shallow threads 39 to engage the rod 14 and cut shallow threads therein so that upon turning, the sleeve 38 will be moved longitudinally relative to rod 14 and thus adjust the length thereof to provide the desired number of vibrations for the selected tone of the rod. Such an adjusting means will provide a rapid and economical means of tuning the rods.

A sliding weight or sleeve 36, or a number thereof, may be used along the length of the rod to adjust any of the intermediate nodal points if desired although it is not absolutely necessary. The weight is particularly useful in adjusting the hum tone and fundamental and will, among other things, serve to shorten or lengthen the frequency of vibration of the particular section. A similar effect can be secured by notching the rod in the correct place but the sliding weight is to be preferred because it can be more easily adjusted.

After the rod has been adjusted so that the third, or selected tone, has the proper number of vibrations as shown by the appropriate dial and ring thereof, the dial ring can be selected for each of the other harmonics or partials, and, if a weight is to be used, it can be moved to cause the pattern of harmonics to be as close as possible to that desired. As mentioned previously, the grooving of the rods will allow the rod to

For the particular pitch scale of the carillon mentioned, the amplifier circuits can be arranged so that the low frequency response of the system will be attenuated approximately 8 to 10 decibels at a frequency of 100 cycles per second. This makes the first tone of a rod inaudible. In addition, the base may be cut to the extent of 15 to 20 decibels through the attenuated low frequency response of a suitably selected horn or loudspeaker.

Various modifications and different types of tuning or indicating means may be used in the described invention without departing from the spirit thereof as defined in the appended claims.

I claim:

1. The method of tuning an electric musical instrument such as a carillon or the like, having a plurality of vibratory rods comprising the steps of setting a rod into vibration, translating vibrations of the rod into a stroboscopic source of light, stroboscopically comparing the frequency of one of the selected tones of said rod with a selected frequency, adjusting the length of said rod to bring said frequencies into synchronism, then comparing the other tones of said rod with selected frequencies of said stroboscope, and cutting grooves and adjusting weights on the rod to bring said other tones into synchronism therewith to produce a substantially even harmonic pattern in each rod relative to the said selected tone.

2. In combination, an elongated fixed-free musical instrument vibratory rod, supporting means for the fixed end of said rod, and a sleeve having screw threads on the interior bore thereof screw-threadedly engaged tightly with an initially smooth portion of said rod, said sleeve being turnable on said rod and cutting threads thereon as it is advanced therealong.

3. In combination, an elongated fixed-free musical instrument vibratory rod, supporting

means for the fixed end of said rod, and a longitudinally split resilient sleeve having an interior bore, said sleeve having screw threads on the interior bore thereof screw-threadedly engaged tightly with an initially smooth portion of said rod, said sleeve being turnable on said rod and cutting threads thereon as it is advanced therealong.

4. In combination, an elongated fixed-free musical instrument vibratory metal rod, supporting means for the fixed end of said rod, and a sleeve having shallow screw threads on the interior bore thereof screw-threadedly engaged tightly with an initially smooth portion of said rod, said sleeve being turnable on said rod and cutting threads thereon as it is advanced therealong, the metal of said rod substantially completely filling said threads engaged therewith.

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