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METHOD AND MEANS FOR TUNING MUSICAL INSTRUMENTS

Filed March 19, 1962

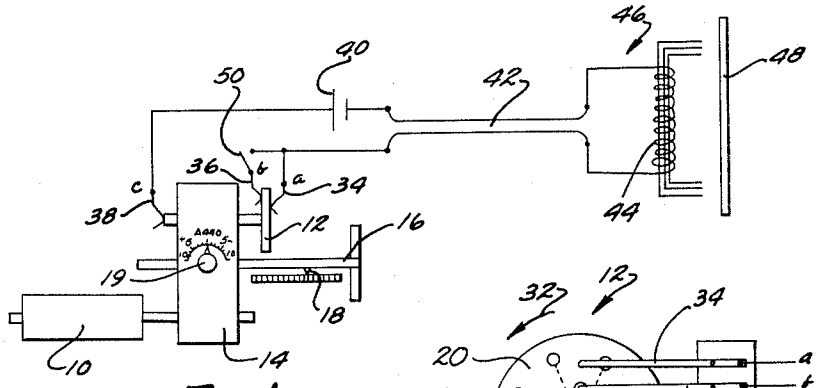


FIG. 1

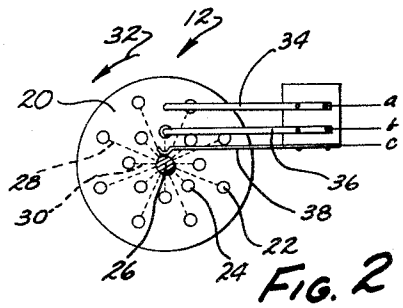


FIG. 2

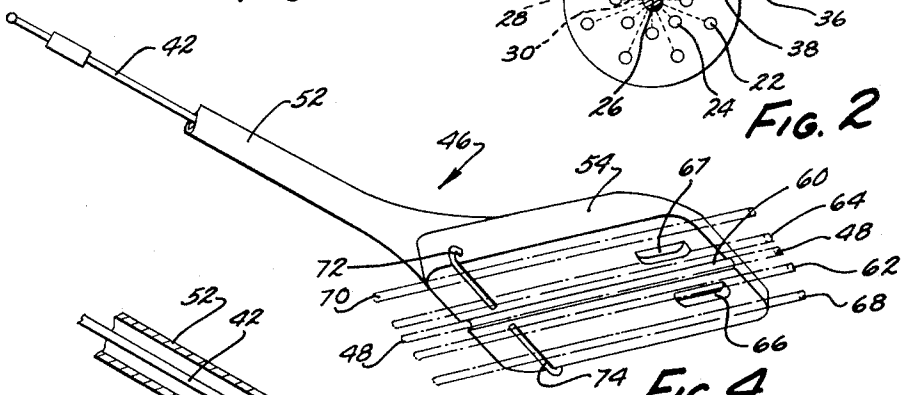


FIG. 4

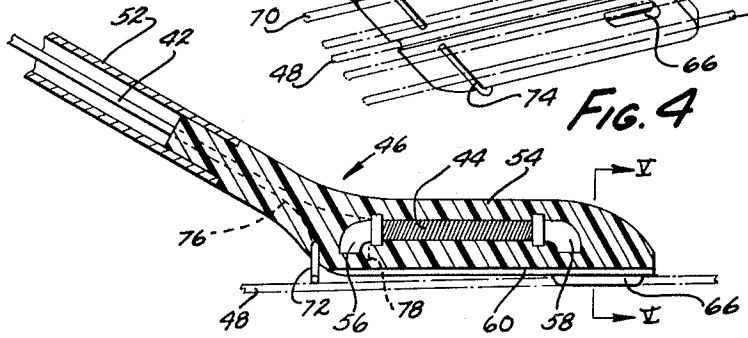


FIG. 3

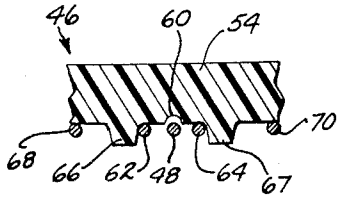


FIG. 5

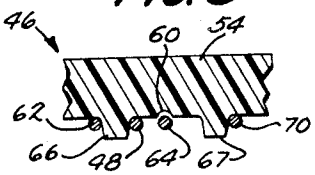


FIG. 6

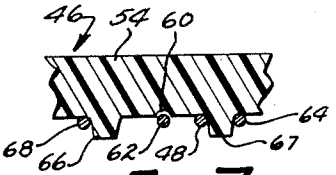


FIG. 7

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METHOD AND MEANS FOR TUNING MUSICAL INSTRUMENTS

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This invention relates to a novel method of tuning certain musical instruments, and to a device adapted to carry out the method.

Certain musical instruments, such as pianos for example, produce musical tones by causing a steel string to vibrate. The tension of the string is the primary factor in determining the pitch of the sound produced. Tuning such instruments correctly has heretofore been an art requiring unusual skill and a highly trained ear. In large instruments such as pianos, tuning was a long and laborious process even for such skilled tuners. As a general rule, it is customary for a tuner to tune the piano against itself, i.e. the tuner takes one of the middle A strings of the piano as a refernce and tunes all the other strings of the piano with relation to that string. This is the usual method because temperature changes and similar factors affect the pitch of the strings but preserve their frequency ratio, so that the piano still sounds properly tuned even though its pitch is not exactly correct. If an exact pitch is desired, however, the reference string may first be tuned correctly by tuning it against a tuning fork. The tuning itself is accomplished by aural comparison of an untuned string with a previously tuned string. Another string of the same pitch as the previously tuned string, or a string differing from it by an even octave, is tuned by the absence of interference beats. Fourth or fifths are tuned by observing the frequency of the interference beats and adjusting them properly. Since the interference beats are too fast to permit accurate counting, the training of the tuner's ear is a crucial factor in obtaining proper adjustment. For the same reason, no two pianos are ever tuned exactly the same way, because the tuning in last analysis is an approximation or an educated guess on the part of the tuner. Stroboscopic optical means have previously been used to eliminate this guesswork, but these optical devices have not found wide acceptance because in last analysis, a physiologically pleasing sound rather than scientific precision is the ultimate criterion in the tuning of musical instruments.

The present invention provides a simple, effective, and highly accurate method of tuning such instruments which requires little skill on the part of the operator and permits rapid and accurate tuning of a large number of strings.

The present invention accomplishes this result by taking advantage of the magnetic properties of the steel strings used in the construction of certain musical instruments. The method of tuning in accordance with this invention consists of creating an oscillating magnetic field of predetermined frequency in the immediate vicinity of the string to be tuned. If the frequency of the magnetic oscillations is exactly equal to the fundamental frequency of the string, or to a harmonic or subharmonic thereof, the string will resonate and emit an audible sound whose volume and clarity are maximum when the fundamental frequency of the string and the frequency of the magnetic field are precisely equal.

It is therefore the primary object of this invention to provide a novel method of tuning musical string instruments whose strings are made of magetizable material, by magnetically exciting the strings into resonant oscillations of a predetermined frequency.

It is a further object of this invention to provide a

mechanism by which magnetic oscillations of exactly controllable frequency can be produced for the purposes of this invention.

It is another object of this invention to provide a tuning probe which permits the magnetic excitation of a magnetizable string of a musical instrument without interference from adjacent strings of similar tonal characteristics.

These and other objects of the invention will become apparent from the following specification, taken in connection with the accompanying drawings in which:

FIG. 1 is a schematic representation of the apparatus of this invention;

FIG. 2 is a side elevation of a commutator such as might be used in carrying out this invention;

FIG. 3 is a vertical cross section of a tuning probe usable in carrying out this invention;

FIG. 4 is a perspective underside view of the tuning probe of FIG. 3;

FIG. 5 is a section along line V—V of FIG. 3 showing the position of the probe for tuning the center string of a three-string monotone string group of a piano;

FIG. 6 is a section along line V—V of FIG. 3 showing the position of the probe for tuning the right string of a three-string monotone string group of a piano; and

FIG. 7 is a section along line V—V of FIG. 3 showing the position of the probe for tuning the left string of a three-string monotone string group of a piano.

Basically, the invention uses a synchronous motor to drive a commutator through a variable speed transmission at a plurality of precisely selectable speeds. The commutator is arranged to close an electrical circuit a predetermined number of times per revolution of the commutator so as to energize and deenergize a solenoid connected in series with the commutator and with a direct current power source at a frequency directly proportional to the rotational velocity of the commutator. The solenoid is incorporated in a probe which can be placed over the strings of the instrument to be tuned in such a manner that the string to be tuned is free to vibrate within the magnetic field of the solenoid. Preferably, the probe is supported by the adjacent string on each side of the string to be tuned or by the sound box of the instrument, as design considerations may require for any particular instrument.

Referring now to the drawings, the numeral **10** in FIG. 1 denotes a synchronous motor of any well-known type whose rotational velocity can be very accurately maintained as a function of the sixty-cycle oscillations of the ordinary household current. The motor **10** drives the commutator **12** through a variable speed transmission **14** which may be of any known type and which is adjustable, as by a handle **16**, to twelve different positions corresponding to the twelve notes of the chromatic scale. Indicating means such as **18** may be provided to indicate to the operator to which note of the scale the transmission **14** is set.

A base speed adjustment or pitch control **19** is provided in the transmission **14** to vary the basic pitch by any precise amount on either side of 440 cycles without changing the ratios of the various steps of the transmission. This is necessary for several reasons: either external effects may have changed the basic pitch of a piano as explained hereinabove, or the tuner may wish to tune the instrument slightly sharp or slightly flat for artistic reasons, or the tuner may wish to spread the higher octaves and compress the lower octaves by predetermined amounts, again for artistic reasons.

An illustrative embodiment of the commutator **12** is shown in FIG. 2. The commutator **12** may consist of an insulating disc **20** into which are set an outer cir-

cular row of contacts 22 and an inner circular row of contacts 24. All the contacts are electrically connected to the shaft 26 as indicated at 28 and 30, respectively. Assuming that the commutator turns in the direction of the arrow 32, the contacts 22 will be wiped by wiper 34, and the contacts 24 will be wiped by wiper 36. Wiper 38 is in constant electrical contact with the shaft 26. The connections to wipers 34, 36 and 38 are designated as *a*, *b* and *c* respectively, which designations correspond to similar notations on the diagram of FIG. 1.

Referring now back to FIG. 1, it will be seen that the wipers 34 and 38, together with the commutator 12, form part of an electrical circuit which includes the battery or other direct current source 40, a cable 42, and a solenoid 44 located in the tuning probe 46 shown in FIGS. 3 and 4, which in operation is placed adjacent the string 48 to be tuned. A switch 50 permits insertion of the wiper 36 into the electrical circuit of the device for a purpose described in the "Operation" section hereof.

FIGS. 3 and 4 show a tuning probe adapted to be used in the device of this invention. The probe 46 includes a handle 52 which serves as a conduit for the cable 42, and a body 54 of nonmagnetic material, preferably plastic, in which the solenoid 44 is embedded. When the probe 46 is placed over a string 48 (shown in phantom lines in FIGS. 3 and 4) which is to be tuned, the pole pieces 56, 58 of the solenoid 44 overlie the string 48 but do not touch it. The string 48 is received in the groove 60 of the probe 46. Thus, the string 48 is free to vibrate when the probe 46 is placed onto the two adjacent strings 62, 64 (FIG. 4) which support it during the tuning operation. Mutes 66, 67 are provided to mute the strings 62, 64 while the string 48 is being tuned.

The manner in which the mutes 66, 67 can be used to mute all but the string to be tuned in a monotone group of three piano strings 62, 48, 68 is shown in FIGS. 5 through 7. The figures depict the three positions of the probe 46 for tuning, respectively, string 48, string 68, and string 62. 68 and 70 in these figures are the outside strings of the next adjacent group of strings on each side of the group to be tuned. It will be seen that in each position of the probe, two of the strings 62, 48, 68 are wedged against the walls of the mutes 66 or 67, while the third one is free to vibrate in the groove 60.

If the instrument to be tuned is a piano, it is customary for the strings 62, 48, 64 to be mounted on a metallic mounting strip which electrically connects all the strings together. In that case, the probe 46 may be provided with contact fingers 72, 74 which are connected, respectively, to wires 76 and 78 in FIG. 3. It will be understood that if this is done, the electrical circuit to the solenoid 44 is closed only when the contact fingers 72, 74 are in contact with strings 62, 64 and a continuous electrical path is established between the contact fingers 72, 74 through the string 62, the metallic mounting strip (not shown) and the string 64. The purpose of this arrangement is to save direct current energy and prevent overheating of the probe, by energizing the solenoid 44 only when the probe is actually in position on the strings.

Operation

The device of this invention operates on the principle that if a resonant magnetizable body is subjected to a magnetic field oscillating at a frequency equal to its fundamental frequency, or to a harmonic or subharmonic thereof, the body will go into resonant oscillation at its fundamental frequency. For example, the middle "A" string of a musical instrument has a fundamental frequency of 440 c.p.s. In order to cause a steel "A" string to resonate, it is therefore necessary to subject

it to a magnetic field oscillation at 440 c.p.s. or a multiple or submultiple thereof.

In any chromatic scale, if the fundamental frequency of a given note is k cycles per second, the fundamental frequency of the same note in the next higher octave is exactly $2k$ cycles per second. Since resonant oscillations can be caused not only by excitation at the fundamental frequency, but also by excitation at a harmonic or subharmonic frequency, magnetic oscillations of a frequency f=440 c.p.s. will cause the "A" string in any octave to resonate. Mathematically, therefore, a piano string will oscillate whenever its fundamental frequency satisfies the equation $k=2^n f$, in which n is any integer. In the illustrative embodiment shown in this application, magnetic oscillations at 440 c.p.s. are produced by closing the electrical circuit of the solenoid 44 four hundred and forty times per second by driving the commutator 12 at a speed such that wiper 34 rides over four hundred and forty contacts 22 each second. For the other notes of the chromatic scale, the rotational speed of the commutator 12 would be proportionately less or more.

Specifically, if the synchronous motor 10 rotates at precisely 3600 r.p.m., and if there are eight contacts 22 on the commutator 12, the ratio of transmission 14 for the note "A" of the tempered chromatic scale must be

$$r=\frac{60\times 8}{440}=1.0909$$

in which r is the transmission ratio expressed in motor revolutions per commutator revolution, "60" represents the number of motor revolutions per second, "8" is the number of contacts 22 on the commutator 12, and "440" is the desired frequency in cycles per second.

For the various notes of the tempered chromatic scale, the frequencies and transmission ratios are as shown in the following table:

Note	Fundamental frequency	Transmission ratio
B	493.84	0.9718
A#	466.16	1.0297
A	440.00	1.0909
G#	415.28	1.1558
G	391.92	1.2247
F#	369.92	1.2976
F	349.20	1.3745
E	329.60	1.4563
D#	311.12	1.5428
D	293.60	1.6349
C#	277.12	1.7321
C	261.60	1.8348

Twelve transmission ratios are sufficient for tuning an entire piano because the fundamental frequency of any given note is always twice the fundamental frequency of the same note in the next lower octave. Therefore, since the string can be excited by magnetic oscillations not only of its own fundamental frequency, but also of any harmonics or subharmonics thereof, the entire tuning range of a piano can be covered by the twelve-step device described. However, in order to slightly increase the useful range of the tuner (the more remote the exciting harmonic is from the fundamental, the lower the amplitude of the resonant oscillations will be), a second ring of contacts 24 may be provided on the commutator (FIG. 2) at angular positions midway between the angular positions of the contacts 22. As shown in FIG. 2, these contacts 24 are wiped by the wiper 36, and it will be readily seen that if the wiper 36 is connected in parallel with wiper 34 by closing switch 50, the solenoid 46 will be excited at exactly twice the frequency it would be if the wiper 36 were disconnected.

Inasmuch as the probe 46 is arranged to mute the strings adjacent to the string being tuned, each string of a piano or other instrument can be tuned individually, without interference from adjacent strings of a monotone group. The tuning operation is simple and is carried

out as follows: the basic pitch is first adjusted by properly setting the pitch control 19, whereupon the transmission 14 is set to the proper note of the scale by adjusting handle 16 until the indicator 18 shows the desired note. The probe 46 is then placed over the string to be tuned, and the tension of the string is adjusted until the string produces an audible sound. The tension at which the string produces the maximum amplitude and clarity of sound is the correct adjustment. The adjustment for resonance is quite critical, and it is therefore very easy to quickly tune the string to the exact tension required.

It should be understood that although an illustrative embodiment of the invention has been described herein to comply with the requirement of the patent statutes, the concept of this invention does not necessarily require the exact physical structures described herein. Particularly, other types of electrical impulse generators or other types of magnetic probes than described herein may be used without departing from the spirit of the invention, as the requirements of any particular use may dictate. Consequently, I do not desire to be limited by the embodiment shown herein, but only by the scope of the following claims.

I claim:

1. A device for tuning musical instruments having a plurality of parallel magnetizable electrically conductive electrically interconnected strings, comprising: means for selectively generating electrical impulses at predetermined frequencies; a solenoid connected to said generating means; and probe means for holding said solenoid in spaced relationship to a string to be tuned while allowing said string to vibrate freely, said probe means carrying a pair of contact bars interposed in series in the electrical circuit connecting said solenoid and said generating means, said contact bars being arranged to close said electrical circuit through strings adjacent to the string being tuned when said probe is in its proper operating position over the string to be tuned.

2. A tuning device for musical instruments having magnetizable strings, comprising: a motor; a commutator; means operatively connecting said motor and said commutator for selectively driving said commutator at a plurality of predetermined speeds; electrical contact means engaging said commutator to close an electrical circuit a predetermined number of times per revolution of said commutator, said electrical circuit including a source of direct current and a solenoid; and means for positioning said solenoid in spaced relationship to a string to be tuned while permitting said string to vibrate freely.

3. A device for tuning musical instruments having a plurality of magnetizable strings, comprising: a synchronous motor; a commutator; a multi-step transmission connecting said motor and said commutator to selectively rotate said commutator at a plurality of speeds having predetermined ratios, each speed being associated with a separate note of a musical scale; means for collectively varying said speeds while maintaining their ratio; means to operate said transmission for step-by-step selection of said speeds; first contact-and-wiper means cooperating with said commutator to close a first electrical circuit a predetermined number of times per revolution of said commutator; a portable probe; a source of direct current and a solenoid connected in series with said first electrical circuit, said solenoid being contained in said probe; and means in said probe operative when said probe is placed over a string to be tuned for holding said solenoid at a predetermined spacing from said string and allowing said string to vibrate freely while muting at least one string adjacent to it.

4. The device of claim 3, further comprising second contact-and-wiper means cooperating with said commutator to close a second electrical circuit midway between each closing of said first electrical circuit; and switch means for selectively connecting said second electrical circuit in parallel with said first electrical circuit.

5. A tuning device for musical instruments having magnetizable strings, comprising: means for selectively generating electrical impulses at a plurality of predetermined frequencies; a solenoid connected to said generating means; and means for holding said solenoid in spaced relationship to a string to be tuned while allowing said string to vibrate freely, said means including muting means for preventing vibration of strings next adjacent to said string to be tuned.

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