Feb. 5, 1952 T. H. LONG 2,584,277

ELECTRONIC TUNING DEVICE

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Fig. 1

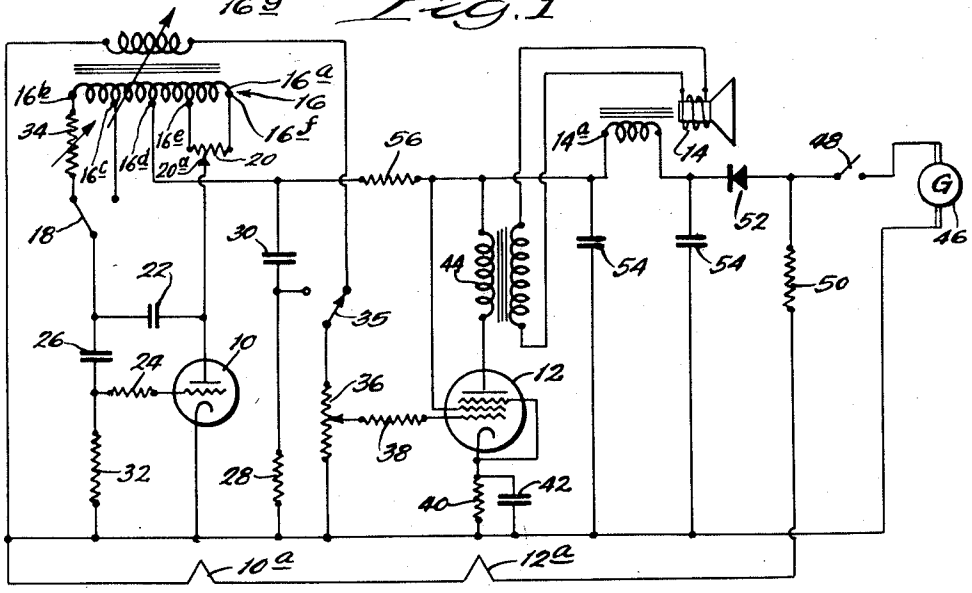
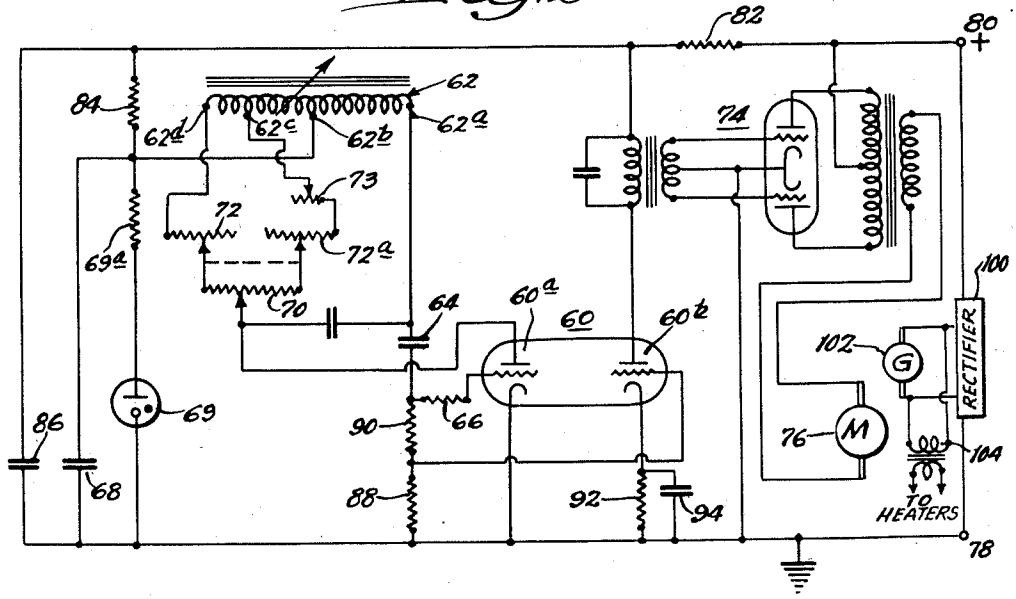


Fig. 2



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ELECTRONIC TUNING DEVICE

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11 Claims. (Cl. 250—36)

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My invention relates to an improved mechanism for producing oscillations suitable for tuning musical instruments.

When musical instruments, such as the string, woodwind and brass instruments of an orchestra, are tuned, it is desirable to have available a source of sound which is accurately calibrated to either "A" (440 cycles) or "B flat." Moreover, to accommodate the tuner to desired variations from the standard frequencies of these two notes, it is desirable to provide an accurately calibrated linear scale and associated adjusting mechanism for varying the frequency of the notes over a limited, accurately precalibrated range.

In addition, it is desirable in a tuner intended for various types of instruments to have a selectable tone that may be chosen in accordance with the particular instrument being tuned, thus making possible a more accurate ear comparison of the relative pitches of the two tones than could otherwise be made.

It is therefore a general object of the present invention to provide an improved device to produce tones suitable for tuning musical instruments.

A more specific object of the present invention is to provide an improved device to generate tones suitable for tuning musical instruments and which is simple and inexpensive in construction while at the same time may be accurately calibrated and is capable of limited accurately calibrated variations from the normal reference frequencies.

Yet another object of the present invention is to provide an improved device to produce tones for tuning musical instruments and which is selectively operable to produce either of two accurately calibrated reference tones or accurately preselected variations therefrom.

It is still another object of the present invention to provide an improved device to produce reference tones for tuning musical instruments and in which the tone pitch is not influenced by the volume or intensity of the tone produced.

Further it is an object of the present invention to provide an improved source of energy for driving the rotating disks of a stroboscope type frequency measuring device and in which an adjustable oscillator is substituted for an adjustable tuning fork.

Another object of the present invention is to provide an improved source of energy for driving the rotating disks of a stroboscope type frequency measuring device and which may be accurately calibrated by one-point tests using a standard tuning bar of fixed frequency.

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Yet another object of the present invention is to provide an improved oscillator wherein changes in applied voltage do not alter the frequency of oscillation.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation, will best be understood by reference to the following description taken in connection with the accompanying drawing in which Figure 1 is a circuit diagram of one form of the invention and Figure 2 is a circuit diagram of another form thereof.

Referring now to Figure 1 there are shown at 10 and 12 a pair of electron tubes, tube 10 being a triode, such as one set of elements in a 12AU7 tube, and tube 12 being a pentode, such as a 50B5. Circuit connections with tube 10 define an oscillator whereas the circuits associated with tube 12 form an amplifier for the oscillations produced thereby. The amplified oscillations are applied to loud speaker 14 to generate tuning tones.

The inductor indicated generally at 16 has a main winding 16*a* with a total of five spaced taps, 16*b*, 16*c*, 16*d*, 16*e* and 16*f*. This winding, or a preselected portion thereof, is connected through switch 18 and potentiometer 20 to the capacitor 22 to define a resonant circuit having a reactance element (winding 16*a*) with five spaced taps.

Tube 10 is connected to the resonant circuit defined by inductance 16 and capacitor 22 to form a Hartley type oscillator circuit. To this end, the control electrode of tube 10 is connected to tap 16*b* or tap 16*c* by the circuit through resistance 24, capacitor 26, and switch 18; the anode of tube 10 is connected to tap 16*e* and tap 16*f* through potentiometer 20; and the cathode of tube 10 is connected to tap 16*d* through resistance 56 and capacitor 54.

Resistance 32 acts as a grid leak to maintain control electrode-cathode bias voltage on tube 10.

From the foregoing description it will be evident that the tube 10 is connected in an oscillator circuit in which the frequency of oscillation is determined by the resonant frequency of the resonant circuit defined by inductor 16*a* and capacitor 22 and hence the value of the inductor 16*a*.

The taps 16*b* and 16*c* are so positioned that the tube 10 oscillates at one preselected frequency, say "A" (440 cycles), when switch 18 is at the position shown in Figure 1 and at another preselected frequency, say "B flat," when the switch is in the other position.

An alternative method of obtaining a precise

semitone interval from A to B flat is that of adding a sixth tap to winding 16a. The turns between this sixth tap and 16b or 16c would be about one-quarter of one percent of the total turns of winding 16a. Resistance 34 would be replaced by a second potentiometer like potentiometer 20 and connected to the additional tap and to the cooperating tap 16b or 16c and to the corresponding terminal of switch 18.

One of the features of the present invention resides in the fact that the frequency interval between the two positions of switch 18 is accurately fixed without precisely fixing the position of the taps relative to each other. This is accomplished by the variable resistance 34 which is connected between switch 18 and tap 16b. I have discovered that varying the value of this resistance alters the frequency of the oscillations to a slight extent and permits compensation for the errors inherently associated with inaccuracies and variations in the winding 16a and the taps provided thereon.

The potentiometer 20 acts as a vernier tone adjusting device and permits preselected calibrated pitch changes over a small range of frequency. I have discovered that the pitch variation thus obtained is quite linear with movement of contact 20a and that the pitch variation from the center or normal frequency for particular movements of the contact is substantially the same regardless of the position of switch 18.

Further in accordance with the present invention, the resistance value of potentiometer 20 is chosen at a value introducing minimum disturbance to the oscillation of tube 10. Specifically, this resistance is substantially the geometric mean value of the maximum resistance at which oscillations occur at all positions of potentiometer 20 and the minimum resistance at which oscillations occur on all positions of potentiometer 20. Thus, if the former value is 5600 ohms, and the latter value 86 ohms, the resistance of the potentiometer may be chosen at 500 ohms which is sufficiently close to this geometric mean value for effective operation.

In addition to winding 16a, the inductor 16 has an auxiliary or output winding 16g. The latter winding is magnetically coupled to winding 16a and is connected to one terminal of switch 35.

The moving terminal of this switch is connected to potentiometer 36 which on its opposite end is connected back to winding 16g.

The other terminal of switch 35 is connected to the common connection of capacitor 30 and resistance 28.

Switch 35 acts as a tone selector to produce oscillations across potentiometer 36 having either of two tones. When this switch is in the position shown in Figure 1, the tone is nearly of sine wave form and simulates the tone of a flute. When switch 35 is in the other position the tone is richer and corresponds more nearly to a reed instrument. Thus either tone may be selected in accord with the instrument being tuned to achieve most effective tuning.

The effect of resistance 28 is to preload the oscillator 10 when switch 35 is adjusted to the "reed" position. This prevents the pitch variations that would otherwise be associated with volume variations as the movable member of potentiometer 36 is shifted. These frequency variations tend to result from the variations in impedance seen by tube 10 when potentiometer 36 is adjusted and winding 16a is connected directly thereto.

The tube 12 operates as an amplifier to apply oscillations from oscillator 10 to the speaker 14. The function of resistor 40 and capacitor 42 is to provide cathode-control electrode bias for this tube. Transformer 44 feeds the alternating component of the cathode-anode space current wave of this tube to the speaker 14 and, in addition, matches the impedance of speaker 14 to the output impedance of tube 12.

The unit of Figure 1 is energized from source 46 which may, for example, be a source of 110 volt, 60 cycle, alternating current. When switch 48 is closed, the heaters 10a and 12a of tubes 10 and 12 are energized through resistance 50. In addition, cathode-anode space path voltage is applied to these tubes by rectifier 52 and the filter defined by capacitors 54 and the field coil 14a of speaker 14. Resistance 56 serves to provide a reed tone signal and render the tone frequency relatively independent of tube characteristics, applied voltage, etc.

In a practical tone tuning device embodying the circuit of Figure 1, the following component elements may be used:

Tube 10	one set of elements of a 12AU7 type tube.
Tube 12	50B5 type tube.
Resistance 32	470,000 ohms
Resistance 24	470,000 ohms
Resistance 28	47,000 ohms
Resistance 34	300 ohms
Resistance 38	220,000 ohms
Resistance 40	150 ohms
Resistance 50	370 ohms
Resistance 56	10,000 ohms
Potentiometer 20	500 ohms
Potentiometer 36	500,000 ohms
Capacitor 26	0.01 mfd.
Capacitor 22	0.03 mfd.
Capacitor 30	0.003 mfd.
Capacitor 42	8. mfd.
Capacitor 54	40. mfd.
Transformer 16	
Winding 16g	175 turns
Winding 16a	
Between taps 16f and 16e	73 turns
Between taps 16e and 16d	1217 turns
Between taps 16d and 16c	1252 turns
Between taps 16c and 16b	146 turns

The inductance of reactor 16 is adjusted by varying the air gap or by similar means until the oscillation frequency with potentiometer 20 at midposition and switch 18 connected to tap 16c is B flat (466.16 cycles per second). Switch 34 is then turned to contact resistance 34 and the value of that resistance adjusted until the oscillation frequency is A (440 cycles per second).

The modified structure of Figure 2 is intended to generate alternating waves suitable for driving a synchronous motor for a stroboscopic frequency measuring device. In this structure, the elements of section 60a of tube 60 are connected to inductor 62 to define an oscillator circuit of the Hartley type. This inductor has four spaced taps, 62a, 62b, 62c and 62d. Tap 62a is connected to the control electrode of section 60a of tube 60 by capacitor 64 and resistance 66. Tap 62b is connected to the cathode by capacitor 68.

The anode of section 60a of tube 60 is variably connected to taps 62c and 62d by potentiometer 70 and the ganged pair of resistors 72 and 72a.

Resistors 72 and 72a cooperate to provide a vernier frequency adjustment by means of which

small variations of frequency can be made without altering the scale calibration of the principal frequency control 70. It is thus possible to correct for frequency variations associated with temperature change, tube ageing, etc. by a one-point calibration with a fixed frequency tuning bar. This does not alter the scale of control 70 and hence effectively calibrates the unit for operation over the entire useful range of operation.

Potentiometer 70 is provided with an appropriate dial and scale. Preferably this is accomplished by the use of a preprinted scale and tolerance variations in the total resistance value of controls 70, 72 and 72*a* are compensated by resistance 73 which is adjusted at the factory.

The resistors 72 and 72*a* are mechanically connected to be moved simultaneously by a common adjusting element such as a knob. However, they are interconnected in opposite senses so that the value of one resistance is increased as the value of the other is reduced.

Oscillations from section 60*a* of tube 60 are fed to section 60*b* thereof, from which the amplified oscillations are applied to the push pull amplifier indicated generally at 74. The latter furnishes driving power for the motor 76 which drives a marked disk at speed determined by the frequency of the oscillations. This disk, when illuminated by timed light flashes, permits accurate frequency measurements. A system of this type is described in R. W. Young Patent 2,286,030, assigned to the same assignee as the present invention.

When the tuning mechanism is calibrated in the field, the stroboscopic pattern is controlled by a fixed frequency tuning bar and control 70 set at the scale position corresponding to the frequency of the bar. Controls 72 and 72*a* is then adjusted until the stroboscopic pattern is stopped.

When the frequency range of control 70 is only one or two percent, the frequency-resistance characteristic is linear. If the frequency range is a semitone or more appreciable curvature exists in this characteristic, it is then desirable to have control 72 change at a different rate than control 72*a* to maintain a constant total range of control uninfluenced by the setting of the verniers 72 and 72*a*.

In the structure of Figure 2, the gaseous discharge tube 69 cooperates with resistance 69*a* and resistance 84 to reduce voltage variations on the oscillator circuit to an amount just compensating for heater current changes, thus preventing line voltage changes from influencing oscillator frequency. Cathode-anode space path voltage for amplifier 74 and tube 60 is derived from terminals 78 and 80 to which a source of D.-C. potential is connected. Resistances 82 and 84 and the capacitor 86 serve to reduce this voltage for tube 60 and to isolate the voltages applied to the various elements therein.

The terminals 78 and 80 are energized from rectifier 100 by the alternating voltage source 102. The heaters of tubes 60 and 74 are likewise energized from source 102 but through transformer 104. If for any reason the voltage of source 102 should vary, the voltage applied to the heaters of tube 60 would likewise vary and thus tend to alter the frequency of oscillation of section 60*a* of that tube. Simultaneously, however, the cathode-anode space path voltage applied to section 60*a* of tube 60 is altered by reason of the variation of the output voltage of rectifier 100 and the action of gaseous discharge tube 69. This variation tends also to alter the frequency of oscillation but in opposite sense of the variation associated with the changed heater current. The values of resistances 69*a* and 84 are so chosen that these effects compensate with the result that changes in voltage of source 102 do not influence the frequency of oscillation.

Resistances 88 and 90 act as a voltage divider to feed to section 60*b* of tube 60 a portion of the voltage produced by section 60*a*. Resistance 92 and capacitor 94 act to produce a cathode control electrode bias voltage for section 60*b* of tube 60.

Amplifier 74 is of conventional construction embodying a pair of push-pull triode tubes and input and output transformers. The latter is connected to the synchronous motor 76.

In both of the diagrams the oscillator plate is shown connected to that side of the tank circuit that includes the potentiometer arrangement. Either of these circuits will operate equally well with the leads from the tank circuit to the oscillator plate and grid blocking capacitor interchanged.

From the foregoing description it will be evident that I have invented an improved tone generator requiring only standard component elements with the usual tolerances but which is nevertheless capable of producing accurately preselected frequencies which may be varied over a desired tuning range. Moreover, either of two tones and two sounds may be reproduced as desired.

In the appended claims I have referred to the tube electrode to which the movable contact 20*a* of the resistance 20 is connected as a "terminal" which is selectively connectable to taps 16*e* and 16*f* to cause oscillator operation at either of two frequencies. The similar "terminal" in the structure of Figure 2 is the anode 60*a* of the tube 60.

While I have shown and described two specific embodiments of my invention, it will, of course, be understood that I do not wish to be limited thereto but intend by the appended claims to cover all variations and alternative constructions as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In an oscillator of the type having a tuned circuit with a reactance element having spaced taps selectively connectable to a terminal to adjust the oscillator for operation on either of two frequencies, the improvement which comprises a resistance connected between said taps and having a movable contact member, and means connecting said contact member to said terminal.

2. In an oscillator of the type having a tuned circuit with a reactance element having spaced taps selectively connectable to a terminal to adjust the oscillator for operation on either of two frequencies, the improvement which comprises a resistance connected between said taps and having a movable contact member, and means connecting said contact member to said terminal, and variable resistance elements simultaneously adjustable in opposite sense interposed between each end of said resistance and said taps.

3. In an oscillator of the type having a tuned circuit with a reactance element having spaced taps selectively connectable to a terminal to adjust the oscillator for operation on either of two frequencies, the improvement which comprises a resistance connected between said taps and having a movable contact member, and means con-

necting said contact member to said terminal, the value of said resistance being substantially the geometric mean value of the maximum value capable of causing oscillations at all adjustments of the movable contact member and the minimum value capable of causing oscillations at all adjustments of the movable contact member.

4. In an oscillator of the type having a tuned circuit with an inductance having spaced taps selectively connectable to a terminal to adjust the oscillator for operation on either of two frequencies, the improvement which comprises a variable resistance interposed between one tap and the terminal.

5. In combination, an electron tube having cathode, anode, and control electrodes, a resonant circuit having a reactance element with four spaced taps, means connecting one end tap to said control electrode, means connecting the adjacent tap to said cathode, a resistance connected between the other two of said taps, and a movable terminal on said resistance connected to said anode.

6. In combination, an electron tube having cathode, anode, and control electrodes, a resonant circuit having a reactance element with four spaced taps, means connecting one end tap to said control electrode, means connecting the adjacent tap to said cathode, a resistance connected between the other two of said taps, and a movable terminal on said resistance connected to said anode, the value of said resistance being substantially the geometric mean value between the maximum value at which oscillations are achieved on all settings of said movable terminal and the minimum value at which oscillations are achieved on all settings of said movable terminal.

7. In combination, an electron tube having cathode, anode, and control electrodes, a resonant circuit having a reactance element with five spaced taps, means connecting the center tap to said cathode, and means connecting said anode and said control electrode each to one of the end taps respectively, said last means including a potentiometer connected to a pair of taps including one end tap and the adjacent tap and having its movable contact connected to one of the electrodes of said tube, and a switch having terminals connected to another pair of taps including the other end tap and the adjacent tap and a switchable contact member connected to another of the electrodes of said tube.

8. In combination, an electron tube having cathode, anode, and control electrodes, a resonant circuit having a reactance element with five spaced taps, means connecting the center tap to said cathode, and means connecting said anode and said control electrode each to one of the end taps respectively, said last means including a potentiometer connected to a pair of taps including one end tap and the adjacent tap and having its movable contact connected to one of the electrodes of said tube, a switch having terminals connected to another pair of taps including the other end tap and the adjacent tap, a moving contact member on said switch connected to another of the electrodes of said tube, and a resistance interposed between one of said switch terminals and the corresponding tap.

9. In a device to generate oscillations suitable for tuning musical instruments, an electron tube having cathode, anode and control electrodes, a resonant circuit having a reactance element with five spaced taps, means connecting the center tap to said cathode, switch means selectively operable to connect either end tap and tap adjacent thereto to said control electrode, a variable resistance interposed between said switch means and the end tap to which it is connected, a potentiometer connected to the other end tap and tap adjacent thereto and having its movable contact connected to said anode, an output circuit for the device including a potentiometer connected to said resonant circuit, an electron tube having cathode and control electrodes, means connecting one end of said last potentiometer to said cathode and the movable contact thereof to said control electrode, and a resistance interposed between said last movable contact and said last control electrode.

10. In an oscillator having an inductor in which oscillations are produced and adapted to energize an output circuit of variable impedance, a winding inductively coupled to said inductor, switch means selectively operable to connect said winding to said output circuit or a point on said inductor to said output circuit, whereby variations in impedance of said output circuit vary the frequency of oscillation when said inductor is connected thereto, and a resistance connected across a portion of said inductor to minimize said variations.

11. In an oscillator of the type having a vacuum tube having cathode, anode, and control electrodes connected to a reactance element to produce oscillations, the improvement which comprises a pair of spaced taps at one end of said reactance element, a potentiometer connected to said taps and having its movable element connected to one of said electrodes, said potentiometer having a calibrated dial, resistances interposed between said potentiometer and said taps and simultaneously adjustable in opposite sense, and an additional adjustable resistance interposed between one side of said potentiometer and the corresponding tap to compensate for tolerances in the value of said potentiometer and said first resistances.

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