

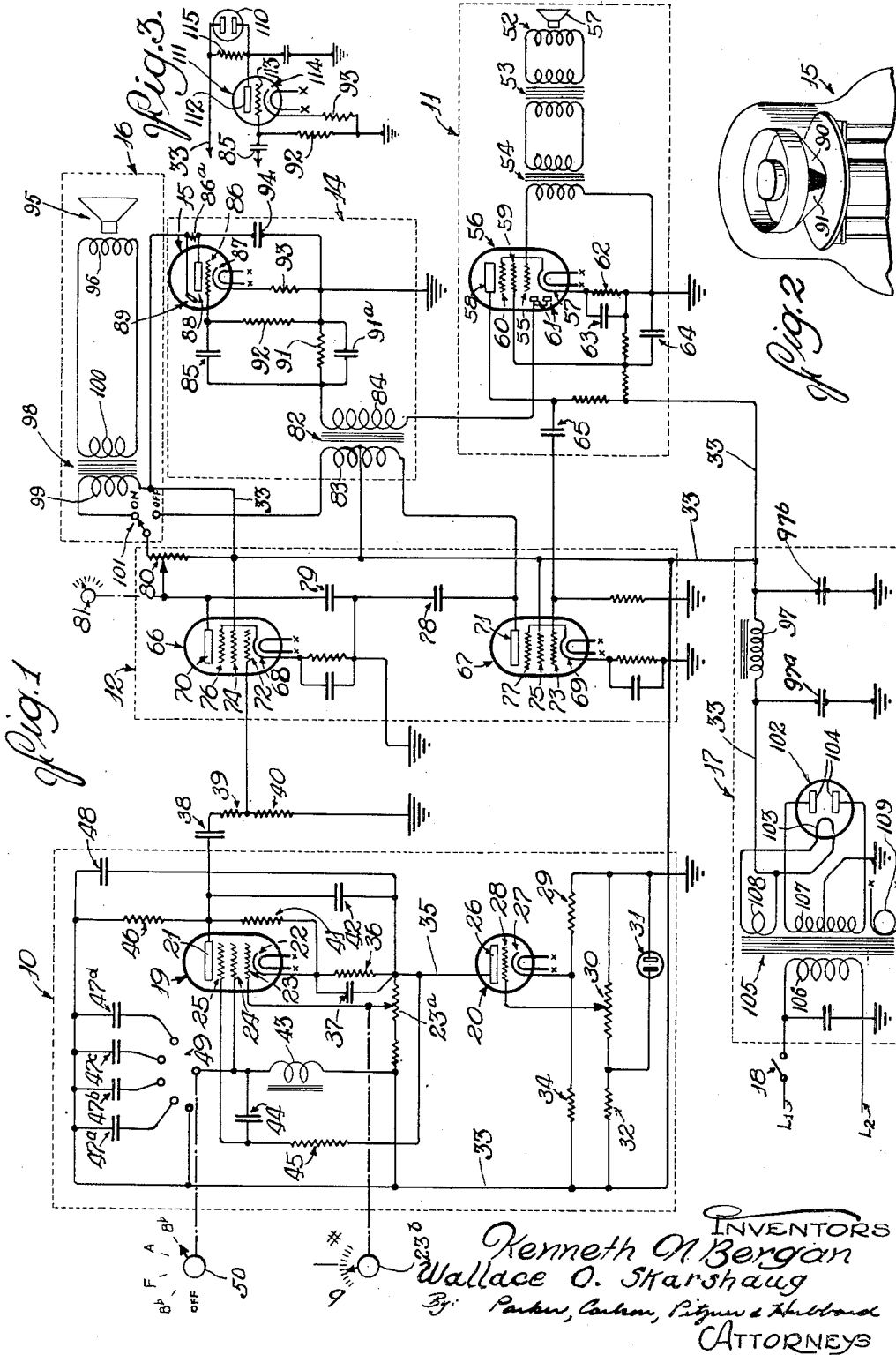
July 9, 1940.

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2,207,450

MUSICAL TUNING INSTRUMENT

Filed Aug. 3, 1938



## UNITED STATES PATENT OFFICE

2,207,450

## MUSICAL TUNING INSTRUMENT

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Application August 3, 1938, Serial No. 222,765

7 Claims. (Cl. 84-454)

The invention relates to musical tuners and more particularly to devices for determining the musical pitch of an instrument or voice or several of them.

5 One object of the present invention is to provide a musical tuner which may be operated entirely inaudibly to give only a visual indication of the point at which the tone being tested, from an instrument or voice, attains a preselected  
10 pitch.

Another object of the invention is to provide a musical tuner capable of performing a silent pitch-indicating operation, of the general type noted above, and embodying means for indicating visually whether the tone being tested is sharp or flat.

Another object of the invention is to provide a highly flexible musical tuner of such character that it may be readily adapted for either silent  
20 or audible tuning, that is, tone testing operations in which a visual indication is given as to whether or not the tone being tested is on or off pitch with respect to a selected reference frequency and in which the reference frequency can  
25 be rendered audible or inaudible at will.

Still another object of the invention is to provide a musical tuner for indicating whether or not two or more tones being tested, such as those produced simultaneously from several instruments in an orchestra or voices in a chorus are  
30 of the same pitch.

A further object of the invention is to provide a musical tuner of the type noted above for comparing the pitch of a plurality of tones, embodying means operable at will, not only to indicate whether or not such tones are in pitch with each other, but also whether or not they are in pitch with a standard reference frequency of selected value.

40 A further object of the invention is to provide a novel form of beat discriminator circuit which is adapted for use in all apparatus of the type indicated.

More specifically, the invention also resides in the provision of beat discriminator circuit embodying a triode amplifier in which the incoming signals are subjected to grid rectification and carrier wave interference is eliminated by the use of capacity coupling between the anode and cathode of the triode.  
50

Further objects and advantages of the invention will become apparent as the following description proceeds, taken in connection with the accompanying drawing in which:

55 Figure 1 is a generally schematic wiring dia-

gram of a musical tuner embodying the invention.

Fig. 2 is a fragmentary detail view of a portion of a cathode ray type tube utilized as an indicator in the apparatus of Fig. 1.

Fig. 3 is a modified form of indicator circuit.

One of the prime virtues of the particular tuner illustrated is its adaptability for a large variety of tone testing operations. The three principal types of tuning contemplated are: first, 5 silent tuning in which only a visual indication is given as to whether or not a tone or tones being tested are of a selected pitch; second, audible tuning in which an audible reference tone is produced by the apparatus together with a visual  
10 indication as to whether or not a tone or tones being tested are of the same pitch as the reference tone; and, third, the testing for coincidence of pitch between two or more tones being tested. The variety of uses to which such a flexible instrument can be put is very large. For example, in  
20 tuning the instruments of a band or orchestra the apparatus can be conditioned to produce an audible tone of selected pitch and then conditioned for silent tuning during which time all of the members of the orchestra sound the same note on their respective instruments. The tuner will, in such case, indicate whether or not any of the instruments are off pitch so that the necessary retuning of the instruments can be rapidly made.  
25 Similarly, in music classes, whether voice or instrument, it is frequently useful to test the pupil's sense of pitch. For this purpose the instructor can condition the tuner for silent tuning and then observe by it whether or not the pupil sings or plays a tone of the selected pitch. In some instances, it may be desirable to provide a tuner of more limited application and in such case some of the elements may be omitted, as, for example, the audible tone mechanism, or other alterations may be made as the requirements of a particular case dictate. Although particular embodiments of the invention have been shown and described in some detail for purposes of illustration of the invention, there is no intention  
35 thereby to limit the invention to such embodiments, but, on the other hand, the appended claims are intended to cover all modifications and alternative constructions within the spirit and scope of the invention.  
40

As to the identity of the general elements of apparatus illustrated, it comprises: a reference frequency unit 10, for producing electrical impulses of predetermined frequency corresponding to a selected tonal pitch, and a test frequency  
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unit 11, which produces electrical impulses of the same frequency as that of the tone being tested. These two electrical impulses of controlled frequency are amplified in a vacuum tube amplifier 12 and imposed on a beat discriminating and indicator circuit 14, which includes a visual indicating device 15 shown herein as a cathode ray tube of conventional form. This latter device gives a visual indication as to whether or not the tone or tones being tested are of the same frequency of fixed value produced by the reference unit 10. The indicator can also be used to show coincidence of pitch between two or more tones being tested irrespective of their relation to any fixed or reference value. Also included in the apparatus is an audible tone monitor unit 16. This latter unit produces an audible tone or sound of the same pitch frequency as the fixed frequency electric current produced by the reference unit 10. Electric current is supplied to the various elements of the apparatus from a rectifier unit 17 connected to alternating current supply lines  $L_1$ — $L_2$  through an on-off switch 18. The entire tuner apparatus is preferably mounted as a unitary structure within a portable carrying case. Since the tuner is operated from an ordinary alternating current supply line and requires no batteries or other auxiliary sources of current it can be readily plugged in on any available lighting circuit or the like, thereby making possible its use in a home, school or auditorium, as the case may be.

Turning now to a more detailed consideration of the various general component elements of the apparatus outlined above, the reference frequency unit 10 may be of any desired type. By way of illustration, it has been shown herein as an audio-frequency vacuum tube oscillator embodying a triple grid pentode tube 19, type 6J7, and a triode tube 20, type 6C5. This type of oscillator is preferred because it has a high degree of frequency stability. It will be understood, however, that a large number of alternative oscillator circuits are available for this purpose. In the particular circuit shown, the pentode 19 includes the usual plate 21 indirectly heated cathode 22, as well as three grids 23, 24, and 25. Similarly, the triode 20 includes a plate 26 indirectly heated cathode 27, and grid 28.

The triode 20 is, in general, utilized to provide a predetermined fixed voltage supply for the grid bias on the pentode 19. The fixed voltage output of the triode 20 is maintained despite variations in alternating current power supply voltage which may, and in ordinary lighting circuits frequently do, occur in the supply lines  $L_1$ — $L_2$ . The cathode 27 of the triode 20 is connected to ground through a cathode bias resistor 29, and the grid 28 is connected to the cathode through a variable grid bias resistor 30. A neon lamp 31 is shunted across the resistor 30, and connected in series with a ballast resistor 32 across a high voltage supply line 33 and ground. It is a characteristic of neon lamps that they are essentially constant voltage devices or, in other words, the voltage drop across them remains substantially constant irrespective of variations in the external voltage on the circuit. Accordingly, the neon lamp 31 maintains a substantially constant voltage across the grid bias resistor 30. The cathode 27 of the triode 20 is connected to the high voltage line 33 through a large bias resistor 34 while the output or plate circuit of the

circuit of the pentode 19 through a conductor 35. The values of resistors 34 and 29 are so chosen that their ratio will equal the amplification factor of the triode. When so arranged, the regulation of the tube is extremely high.

In the pentode, or oscillator circuit proper, electrodes 23 and 25 are connected to act respectively as the anode and grid elements of an oscillator triode, with the cathode 22 forming the third element of the triode. This triode is coupled through the electron stream with the plate 21 in the tube output circuit. A condenser 44 connects the grid and anode elements of the oscillating triode and a grid leak resistor 45 connects the grid 25 to the negative or low voltage side of the circuit. An audio frequency tank or oscillator circuit is formed by an iron core choke 43 and a plurality of condensers 47<sup>a</sup> to 47<sup>d</sup>, arranged to be selectively connected in parallel with the inductive choke by a selector switch 49. To complete the circuit a load resistor 41 is connected between the pentode plate and cathode, a filter condenser 48 is connected between the high and low voltage supply lines 33 and 35, a bias resistor 46 is connected to the plate 21, the bias resistor 36 and bypass condenser 37 are connected in the cathode circuit, and the bias on the control grid 23 is varied by a variable resistor 23<sup>a</sup> for a purpose hereinafter described. To insure adequate coupling between the cathode and plate of the pentode a low capacity condenser 42 may be used to supplement the electron coupling. The output or plate terminal of the pentode 19 is connected to ground through load resistors 39 and 40 and a coupling condenser 38. Variations in the voltage drop through the resistor 40, caused by the oscillating output current of the pentode oscillator, are used to control the potential bias on a control grid of a vacuum tube included in the amplifier unit 12 for a purpose hereinafter described.

In order to condition the reference frequency unit 10 to produce any one of a predetermined series of frequencies, the selector switch 49 is utilized. When in its "off" position, the switch 49 by-passes all of the condensers 47<sup>a</sup>—47<sup>d</sup> to cut off all output from the oscillator. When shifted to its other positions, it closes corresponding circuits through selected ones of the condensers 47<sup>a</sup>—47<sup>d</sup>. The capacities of these latter condensers are so chosen with respect to the associated circuit constants that an output current from the oscillator circuit will be obtained which has a frequency equal to that of some particular corresponding set of notes in the diatonic scale. Preferably, if only four condensers are provided, the circuits are arranged so that the corresponding output frequencies will be that of B flat below middle C, F, A, and B flat an octave above the first B flat. The selector switch 49 is manipulated by a control knob 50 located on the exterior of the unit. A graduated scale may be provided with the control knob 50 so that the operator need only read the indicia of the musical note desired and turn the knob to the corresponding position. Of course, any number of tones may be provided by utilizing a corresponding number of condensers of the proper values. Also, if desired, other means of tuning such as a variable inductance could be used in some oscillator circuits.

In some instances it is desirable to vary the pitch of the reference frequency slightly above or below its standard value. For example, if a musician attempts to sound A on an instrument

and the indicator 15 shows that he is slightly off, then the reference frequency from the unit 10 is varied progressively until the indicator shows that the reference frequency exactly coincides with the musical tone being tested. Thereupon the operator of the tuner observes whether or not it was necessary to make the reference tone sharp or flat so as to match that of the instrument being tested. To this end a vernier control knob 23<sup>b</sup> is provided for controlling the variable resistor 23<sup>a</sup> in the control grid circuit of the pentode 19. By changing the grid biasing potential, through the medium of the variable resistor 23<sup>a</sup>, the pitch or frequency of the oscillator output is correspondingly increased or decreased. A scale associated with the control knob 23<sup>b</sup> shows whether the change has made the note sharp or flat. Since the output frequency of the oscillator is very sensitive to changes in the grid bias potential it is, for that reason, desirable to utilize the triode 20 and neon lamp 31, as previously described, to maintain a fixed or constant voltage between the high and low voltage lines 33 and 35 across which grid bias control resistor 23<sup>a</sup> is connected.

The test frequency unit 11 serves to convert the vibrations in air, caused by the musical note or tone being tested, into pulsating electric current of corresponding frequency. Any suitable microphone circuit may be utilized for this purpose. In the particular construction shown, a permanent magnet type loud speaker 51 has been used as a microphone and its actuating winding 52 is coupled through transformers 53 and 54 with the control grid 55 of a duplex-diode pentode 56, type 6B7. The pentode section of this tube is used as an amplifier for the microphone currents and the diode section is used as a rectifier in the beat discriminator circuit 14 as is hereinafter described in greater detail. The tube 56 embodies a cathode 57, plate 58, screen 59, suppressor 60, and diode plates 61. A cathode bias resistor 62 and by-pass condenser 63 connect the cathode 57 to ground while the by-pass resistor 64 connects the screen 59 to the cathode. The suppressor 60 is connected directly to the cathode. The output of the amplifying pentode section of the tube 56 is coupled through a condenser 65 with the amplifier 12.

The respective audio-frequency output currents of the reference frequency unit 10 and test frequency unit 11 are amplified by the amplifier unit 12 and this latter unit also embodies means for controlling the volume of the reference frequency unit output. The amplifier unit 12 may conveniently include two power-amplifier tubes 66 and 67, (type 41) connected in push-pull relation. These tubes embody respective cathodes 68 and 69, plates 70 and 71, control grids 72 and 73, screens 74 and 75, as well as suppressors 76 and 77. The cathodes are in each case connected to ground through the usual cathode bias resistor and by-pass condenser. The output of the reference frequency unit 10 is applied to the control grid 72 of the tube 66 and similarly the output of the test frequency unit is connected to the control grid of the tube 67. The plates 70 and 71 of the amplifier tubes are coupled in push-pull relation through series connected condensers 78—79 with their common terminals connected to ground. These condensers by-pass to ground and high frequency distortions that may occur in the pentode power amplifiers. In order to control the volume of output for the reference frequency unit, a variable volume control resistor

80 is connected in the output circuit of the tube 66. This volume controller is operated through the medium of a control knob 81, located exteriorly of the unit.

As a means of determining whether or not the musical note being tested is of the same frequency or pitch as the reference frequency produced by the unit 10, the amplified output currents of the units 10 and 11 are imposed on a beat discriminating circuit 14. As a preliminary to a consideration of this circuit, it should be noted that when currents of two different frequencies are superimposed in a circuit that strong beats or, in other words, high peaks in the oscillation will occur, although at a much lower frequency than that of either of the components, when the two superimposed frequencies are whole-number multiples of each other. In the event, however, that the two currents are of substantially identical frequency, there will be no such beats or periodic low frequency variations in the integrated sum of the component frequencies. This phenomena is utilized in the present apparatus for actuating an indicator device. To this end, an indicator is provided which will be actuated by any beats produced in the circuit but will remain unaffected if there are no beats. Since the absence of beats shows that the two frequencies are of the same value or pitch, a positive indication is obtained as to whether or not the musical tone being tested is in pitch with the standard or reference frequency.

In the particular form of beat discriminating circuit illustrated, a transformer 82 is provided having a center-tapped primary winding 83 and a secondary winding 84. The outputs of the amplifier tubes 66—67 are connected across respective halves of the primary winding 83. The alternating potential appearing in the secondary winding 84 of the transformer has a mean value which is a function of the relative frequency of components of the primary current. In particular, if the components of the primary current are all in phase so that a steady, generally sinusoidal variation in secondary potential is obtained, the mean value of the secondary potential will be constant. On the other hand, if the frequencies of the primary current components differ from each other, the mean value of the secondary potential will vary at a frequency corresponding to the beat frequency of the components. To put it another way the components of primary current are combined to form a carrier wave of audio-frequency and the envelope of the carrier wave is determined by the frequency relation of the components. If the frequencies of the components are equal the envelope will be rectilinear, but if they are not equal the envelope will be a periodically varying curve. The periodicity of the envelope is the "beat frequency" of the components.

The output of the transformer 82 is rectified by the diode section of the tube 56 so as to produce a direct current which pulsates at the same frequency as alternating voltage produced in the transformer secondary winding 84. For this purpose, one terminal of the transformer secondary winding 84 is connected to the diode plates 61 of the tube 56. The other terminal of the transformer secondary is coupled by a condenser 85 with a control grid 86 of the cathode ray tube 15. The pulsations in secondary current due to the audio-frequency carrier wave are filtered by a network shown as including a bias resistor 91 and by-pass condenser 91<sup>a</sup> connected between the

transformer output and ground. Accordingly the only variations in current or pulsations applied to the coupling condenser 85 are beat frequency pulsations or ripple in the direct current. The beat discriminator circuit 14 herein illustrated is so sensitive that the indicator 15 will show even very small variations in the mean value of a carrier wave having a comparatively large amplitude.

Special advantages result from the use of a cathode ray tube as an indicator, as will be hereinafter pointed out in great detail. Of even greater importance, however, are the advantageous results achieved by the use of the novel circuit associated with the indicator. This novel circuit is, in fact, applicable not only to cathode ray tube indicators but to other types as well. The cathode ray tube 15 is of conventional form, being preferably a type 6E5 and embodies, in addition to the control grid 86, an indirectly heated cathode 87, plate 88 and target 89. A fluorescent screen 90 (Fig. 2) is lighted by the electron stream and a segmental shadow or dark image 91 appears on the inner surface of the conical screen, the width or angle of this image being a function of the biasing potential on the grid 86. Changes in the width of the image 91 cause the device to resemble a blinking eye. When the potential on the grid is from five to eight volts negative with respect to the cathode, the image 91 disappears entirely, or in common engineering parlance "the eye closes."

The circuits herein shown are so arranged that the "eye" will remain open and steady, i. e. retain an image 91 of fixed width on the fluorescent screen when there are no beats imposed on the beat discriminator circuit 14, and similarly, the "eye" will flash, i. e. the image 91 will successively decrease in size until it disappears, or almost so, and then widen out again when beats are imposed on the circuit.

The novel beat discriminator circuit 14 is characterized first, by the initial rectification described above which separates most of the audio-frequency carrier wave from the beat and second, by the use of grid rectification on a triode tube whose grid is capacity coupled with the output of the first rectifier. In the present instance the plate 88, grid 86 and cathode 87 of the cathode ray indicator tube 15 itself have been used as the triode, but it will be understood by those skilled in the art that a separate triode tube could be connected to a structurally separate indicator such as a neon lamp (Fig. 3). In the particular illustrative circuit shown (Fig. 1) the upper terminal of the transformer secondary winding 84 is connected to ground through the bias resistor 90 and a by-pass condenser 91 for filtering purposes as was previously noted. Also, the grid 86 and cathode 87 are connected to ground and to each other, through their respective bias resistors 92 and 93. The resistors 92 and 93, which interconnected the grid 86 and cathode 87, are of particular importance since they complete a circuit for grid rectification as is described more in detail below. The plate 88 is connected to the high potential line 33 through a load resistor 85, the target 89 being connected to the opposite terminal of this resistor.

When using a type 6E5 cathode ray tube it has been found desirable to make the resistor 92 of approximately three megohms and the resistor 93 of approximately two hundred ohms to achieve grid rectification. Any beat frequency ripple in the rectified current from the transformer sec-

ondary winding 84 imposes a varying potential on the coupling condenser 85 so that a corresponding pulsating potential appears in the circuit of the grid 86. The grid and cathode 87 act, however, as diodes of a rectifier. More particularly, the grid 86 can become more negative with respect to the cathode 87, during the negative half cycles of the beat frequency pulsations, but it cannot become more positive with respect to the cathode because when it tends to do so current flows between the grid and cathode so that a rise in the potential on the grid is prevented. The flow of such a current between grid and cathode is, of course, only possible when the values of the resistors 92 and 93 are so chosen to permit it and, hence, it will be appreciated that the particular values chosen for these resistors are important. The visible effect of such grid rectification action is to prevent the image 91 on the screen 90 from opening up beyond a fixed width, although the image is permitted to close. In other words, the "eye" can blink closed, but it cannot open beyond a predetermined amount.

By utilizing a condenser 94 of very low capacity to couple the plate 88 and cathode 87 the necessity of a low pass filter to eliminate the audio-frequency carrier wave interference effects from the plate is obviated. In other words, the coupling condenser 85 between the transformer 82 and cathode ray tube 15 passes not only the beat frequency pulsations, but also to some extent the audio-frequency carrier wave pulsations. If the indicator is to respond only to beat frequency pulsations then the effect of the audio-frequency carrier wave pulsations must be eliminated. This latter elimination function could conceivably be performed by a low pass filter. Such a device would, however, be undesirable in the instant apparatus, since a large inductance would need to be included in it and the circuit would be much less sensitive to beat frequency pulsations than the improved arrangement herein disclosed. Instead of using a low pass filter the condenser 94 is utilized for by-passing the audio-frequency carrier wave interference directly to ground. The capacity of this condenser is preferably about 0.05 micro-farads.

By utilizing a cathode ray tube as the indicator for the tuner the cost of the apparatus is minimized since the elements of this single tube constitute a triode amplifier, a diode rectifier for controlling the action of the indicator and a visual indicator. Furthermore, such a cathode ray tube is rugged in construction as compared to such measuring devices as a galvanometer and is, moreover, very sensitive in operation. The cathode ray tube may be conveniently connected to the remainder of the apparatus by flexible leads so that it may be mounted on a music rack or other convenient position for the use of a teacher or orchestra leader. Moreover, the cathode ray tube lends itself to the use of a simple condenser arrangement such as that described above, for eliminating the audio-frequency carrier wave from the indicator circuit.

An alternative indicator circuit is shown in Fig. 3. In this circuit a neon lamp 110 is utilized as a visible indicator and is operated from a triode vacuum tube 111. The circuit is almost identical with that for the cathode ray tube 15 and the triode 111 functions in the same general manner as the triode elements of the tube 15. In particular, the plate 112, of the triode 111, is connected to the high potential or "+B" line 33, the grid 113 is coupled to the control circuit by the

condenser 85, and the grid and cathode 114 are connected together and to ground by bias resistors 92 and 93. The latter complete a grid rectification circuit as before. The neon lamp 110 is connected across a dropping resistor 115 in the output or plate circuit of the triode and a by-pass condenser, of preferably about 0.05 micro-farads connects the plate terminal of the lamp to ground. With such an indicator circuit, any beat frequency pulsations applied to the coupling condenser 85 cause the lamp 110 to flash off and on in synchronism. This, of course, indicates that the frequencies being tested are off pitch just as before. If the frequencies being tested are in pitch then, of course, there are no beat pulsations and the lamp 110 glows steadily.

The electrical impulses from the oscillator or reference frequency unit 10 may be converted into an audible sound or signal by the monitor unit 16. This tone monitor unit has been shown herein as comprising an electro-dynamic loud speaker 95 provided with an actuating winding 96 and a field winding 97 (included in the power unit 17). This loud speaker 95 is coupled with the amplifier 12 and beat discriminator circuit 14 by a transformer 98 having a primary winding 99 and secondary winding 100. One terminal of the primary winding 99 is connected directly to the high voltage supply line 33 while the other terminal is connected to one fixed contact of a selector switch 101. When the selector switch 101 is in the position shown the transformer primary winding 99 is connected across the volume control resistor 30 so that the output of the amplifier tube 66 is impressed on the transformer 98 and through it to the loud speaker 95. On the other hand, when the selector switch 101 is shifted to its second position with the lower contact closed the loud speaker transformer 98 is open-circuited and the output of the amplifier tube 66 connected directly to the discriminating circuit transformer 82. Hence, by the simple manipulation of the selector switch 101 the reference frequency produced by the tuner can be made either audible or inaudible.

The power supply unit 17 is of conventional form and embodies a full wave rectifier tube 102 provided with a cathode 103 and anodes 104. Current is supplied to the rectifier tube 102 through a step-up transformer 105 comprising a primary winding 106, connected across supply lines  $L_1$ — $L_2$  and a second winding 107 having its end terminals connected to the respective vacuum tube anodes 104. A center tap on the secondary winding 107 is grounded. Heater current for the rectifier tube cathode or filament 103 is supplied from a transformer secondary winding 108 and the high voltage output on "B" voltage of the rectifier tube is supplied to the various vacuum tubes in the tuner apparatus through the high voltage conductor 33. The "A" current, or heater current, for the various vacuum tubes in the apparatus is supplied from a low voltage tertiary winding 109 on the transformer 105. The connections from this winding to the various cathode heaters have been omitted in order to simplify the wiring diagram. A filter for the "B" circuit is formed by filter condensers 97<sup>a</sup> and 97<sup>b</sup>, together with the field winding 97 of the loud speaker 95, this winding being used as an audio-frequency choke.

The operation of the tuner illustrated is very simple in so far as manipulatory operations as performed by the operator are concerned. As in the case of an ordinary radio receiver, the in-

ternal circuits may appear to be rather complicated but the manipulations performed by an operator are few in number and require no particular skill. In conditioning the tuner for operation the supply lines  $L_1$ — $L_2$  are first of all connected to a suitable alternating current supply circuit by an ordinary plug connection and the on-off switch 18 is closed. Next it will be assumed that the operator wishes to test B flat below middle C on some band instrument such as a horn. For such purpose the selector switch 50 is turned to the left until its pointer registers with the B flat on the left side of the graduated scale and the knob 23<sup>b</sup> is turned to its mid-position. Furthermore, the selector switch 101 is moved to its "off" position if the tuning is to be silent insofar as the tuner is concerned. The musician then sounds B flat on the horn being tested at some point reasonably close to the microphone 57. If the tone sounded on the horn is of exactly the proper pitch, that is, B flat, then the "eye" of the indicator tube 15 remains open or, in other words, the image 91 is steady. If the note sounded on the horn is sharp or flat, however, the "eye" of the indicator tube 15 will blink, since the frequency of the electrical impulses from the unit 11 will differ from the reference frequency output of the unit 10 and as a consequence a beat frequency variation in potential will be applied to the cathode ray tube control grid 86. Upon observing such a blinking of the visual indicator tube 15 the operator of the tuner may then turn the control knob 23<sup>b</sup> slightly back and forth until the indicator tube 15 stops blinking. Upon achieving such a point of balance in the input and reference frequencies the position of the control knob 23<sup>b</sup> is observed so that the operator knows whether the note sounded on the horn was sharp or flat and approximately how much. The testing of the pitch of other instruments or voices is carried on in the same manner. In the event that a bowed stringed instrument is being tested it has been found that it is often difficult for anyone but a skilled player to maintain a note of exactly constant pitch by pulling a bow across the strings. Accordingly, it is better to pluck the strings of such an instrument to tune it with the tuner herein illustrated. When the string of a violin is plucked, for example, the "eye" of the indicator 15 blinks once and then remains steady if the string is properly tuned to the reference frequency for which the selector 50 is set. If the violin string is out of tune, however, the "eye" of the indicator 15 will continue to blink just as in the case of an out-of-pitch note from any other instrument. A plurality of instruments or voices or both can be tested simultaneously through following the same procedure. In such case, however, if any one of the group is off pitch the "eye" of the indicator tube 15 will blink so that they will thereafter have to be tested individually in order to determine which instrument or voice is the offender.

In some instances it is desirable that the musicians be able to hear a monitor tone of the selected pitch in order to aid them in tuning their instruments or placing their voices. For this purpose the selector switch 101 is shifted to its "on" position and thereafter the loud speaker 95 produces a tone or signal of a pitch determined by the setting of the selector 50. The visual indicator 15 remains in operation, however, so that the same observations can be made as before as

to whether or not the instruments or voices being tested are actually in pitch with the monitor tone. The adaptability of the tuner for either silent or audible tuning is particularly important for various specialized uses. For example, music teachers often find it desirable to test a pupil's sense of pitch and this can only truly be tested when a tone is played or sung by the pupil in the absence of any reference tone or audible guide. Furthermore, the overtones or harmonics produced by various instruments are sometimes so widely different from each other that there is some difficulty in determining by ear whether or not they match exactly the pitch of an audible reference tone. By utilizing the visual indicator apparatus, however, there is never any doubt on the point. The tuner apparatus illustrated may also be utilized for a third type of pitch testing operation in which no reference tone or impulses are used. In this third type of operation the tones from two or more instruments or voices are compared directly to each other rather than being compared to some reference pitch. For this type of operation the selector 56 is turned to its "off" position so as to disable the oscillator unit 10. The sound waves from the several instruments or voices being tested enter the microphone 57 and set up an input current which is made up of a series of components, one for each instrument or voice in the group. If these components are all of the same frequency then there will be no beat frequency imposed on the indicator tube control grid 86 and hence the "eye" of the tube will remain steady and open. In the event, however, that any of the tones sounded are off pitch with respect to each other there will be a beat frequency imposed on the control grid 86 and the "eye" of the indicator tube 15 will blink. In general, it will be seen that the tuner described is highly adaptable to a large variety of pitch testing operations and that all of them may be carried out with only very simple manipulations of the controls for the tuner.

We claim as our invention:

1. A musical tuner, comprising, in combination, means for producing electrical impulses at a frequency corresponding to the pitch of a predetermined tone in a musical scale, means for producing periodic electrical impulses at a frequency corresponding to the pitch of a musical tone being tested, an indicator including a cathode ray tube embodying a control grid, and means responsive to the beat frequency between said two first named frequencies for controlling biasing potential on said control grid.

2. A musical tuner comprising, in combination, means for producing electrical impulses at a frequency corresponding to the pitch of a predetermined tone in a musical scale, means for producing periodic electrical impulses at a frequency corresponding to the pitch of a musical tone being tested, a transformer embodying inductively coupled primary and secondary windings, said primary winding including two series-connected sections, means for applying said first named electrical impulses to one of said primary winding sections and for applying the second named electrical impulses to the other section of said transformer primary winding, an indicator including a cathode ray tube embodying a control grid, means for rectifying the potential in said transformer of said secondary winding, and means including a capacity coupling between said transformer secondary winding and said grid for applying to said control grid a biasing potential

varying in accordance with the beat frequency between said two first named frequencies.

3. A musical tuner comprising, in combination, an input circuit, means for setting up in said input circuit a periodic alternating potential made up of two components one corresponding in frequency to the pitch of a musical tone being tested and the other corresponding to the pitch of a predetermined tone in a musical scale, means for rectifying the current in said input circuit, a triode vacuum tube including an anode and cathode and control grid, means including a capacity coupling between said input circuit and grid for applying to the latter a biasing potential varied in accordance with variations in the mean value of the potential in said input circuit, means including a resistance connected between said grid and cathode for establishing a diode rectification circuit therebetween, and an indicator device actuable in response to variations in the electron stream flowing to said plate under the control of said grid.

4. In an apparatus for indicating the presence of low frequency variations in the mean value of an oscillatory carrier wave, the combination of a triode vacuum tube embodying a cathode and an anode and a control grid, an input circuit, a capacity coupling between said input circuit and said control grid, means including a resistance connection between said grid and cathode for establishing a diode rectification circuit therebetween, and an indicator device actuable in response to variations in the electron stream flowing to said plate under the control of said grid.

5. In an apparatus for indicating the presence of low frequency variations in the mean value of a periodic carrier wave, the combination of a cathode ray tube embodying a cathode and an anode and a control grid and an image screen, the size of the image on said screen being a function of the variations in grid potential from a selected value, an input circuit, a capacity coupling between said input circuit and said control grid, and means including a resistance connection between said grid and cathode for establishing a diode rectification circuit therebetween to prevent the potential in said grid from varying in more than one sense from said selected value.

6. In an apparatus for indicating the presence of low frequency variations in the mean value of an audio-frequency carrier current, the combination of a triode vacuum tube embodying a cathode and anode and control grid, an input circuit, a coupling between said input circuit and said control grid, an indicator device actuated in response to variations in the electron stream flowing to said plate under the control of said grid, and means including a capacitive coupling between said plate and ground for by-passing any audio-frequency interference from said plate directly to ground.

7. In an apparatus for indicating the presence of low frequency variations in the mean value of an audio-frequency carrier current, the combination of a cathode ray tube embodying a cathode and anode and control grid and image screen, an input circuit, a capacitive coupling between said input circuit and said control grid, and means including a low capacity coupling between said plate and ground for by-passing any audio-frequency interference from said plate directly to ground.

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