United States Patent

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[54] MUSICAL INSTRUMENT TUNING REFERENCE STANDARD

20 Claims, 4 Drawing Figs.

[52] U.S. Cl. 84/454, 84/1.01, 84/DIG. 18, 307/260
[51] Int. Cl. G10g 7/02
[50] Field of Search ..... 84/1.01, 1.11, 1.19, 454; 307/260; 340/384 E

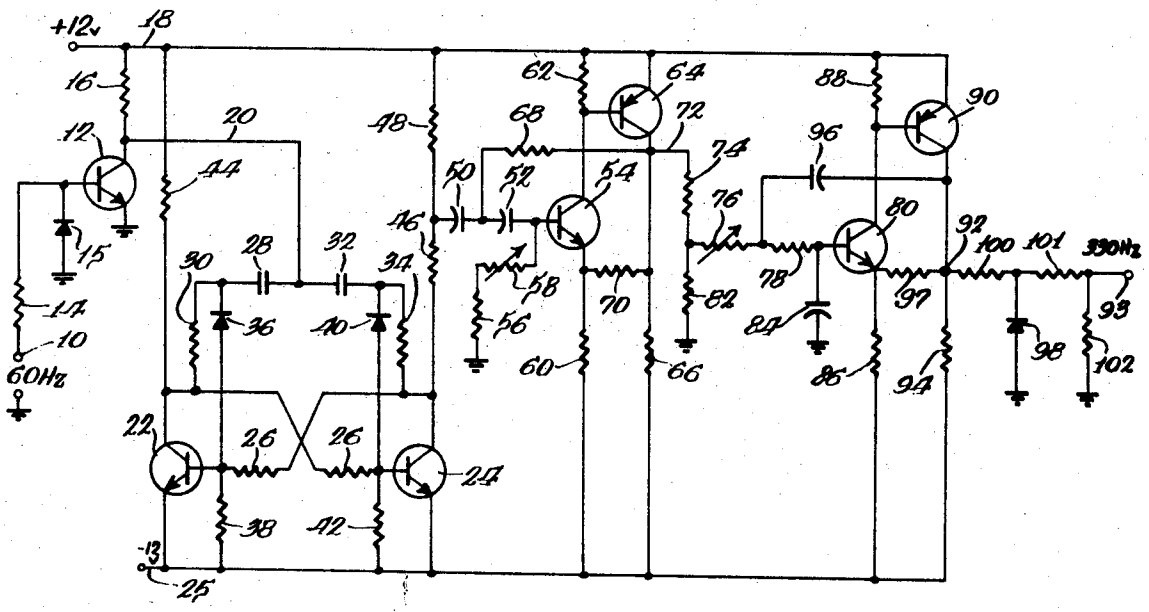
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ABSTRACT: A reference standard for supplying E at 330 Hz. for tuning a guitar or similar instrument. This is accomplished by taking the standard 60 Hz. powerline frequency, dividing it by two to get a 30 Hz. fundamental with odd harmonics and isolating the 11the harmonic by dynamic filtration. The final signal has the desirable range of harmonics accompanying the 330 Hz. fundamental. Variations are shown, including adapting the system for operation on 50 Hz. powerline frequency.



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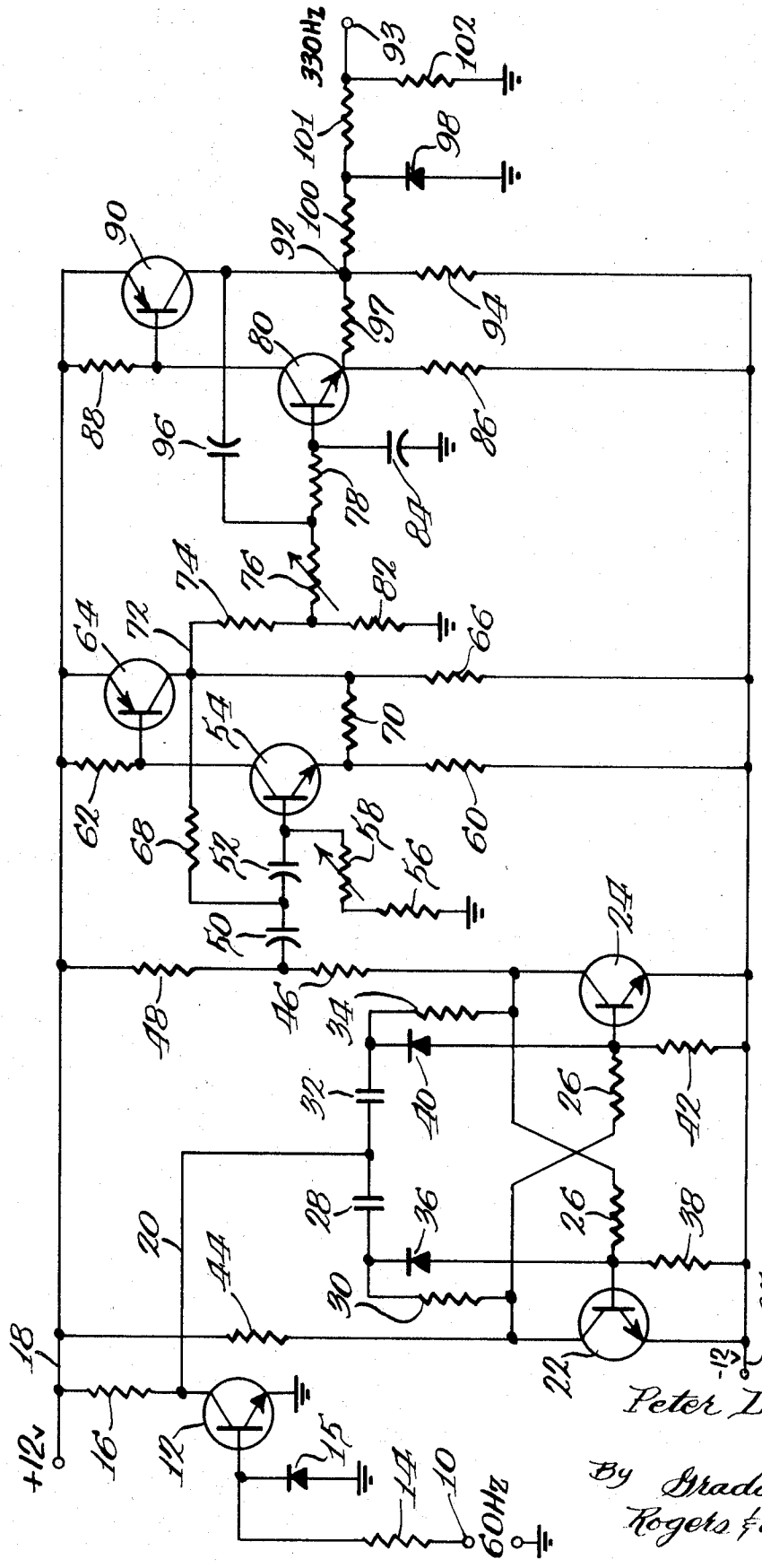
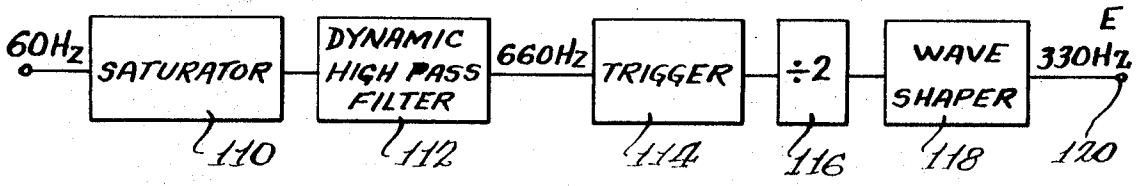


Fig. 1.

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Fig. 2.



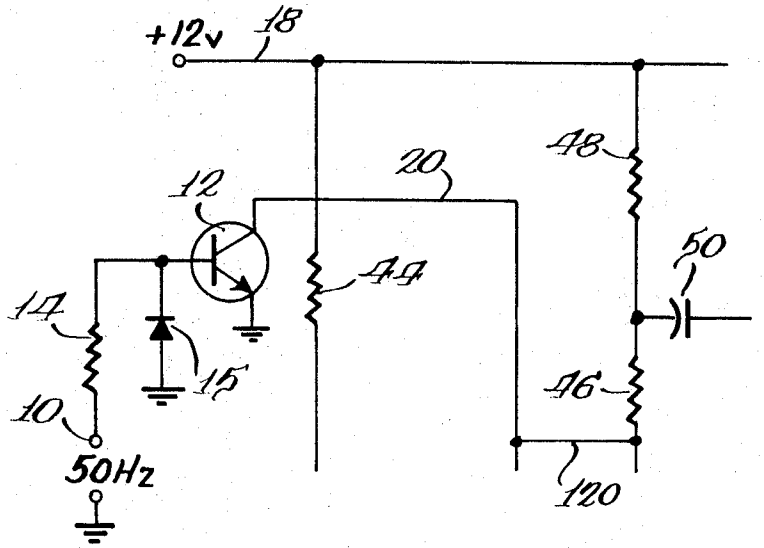


Fig. 3.

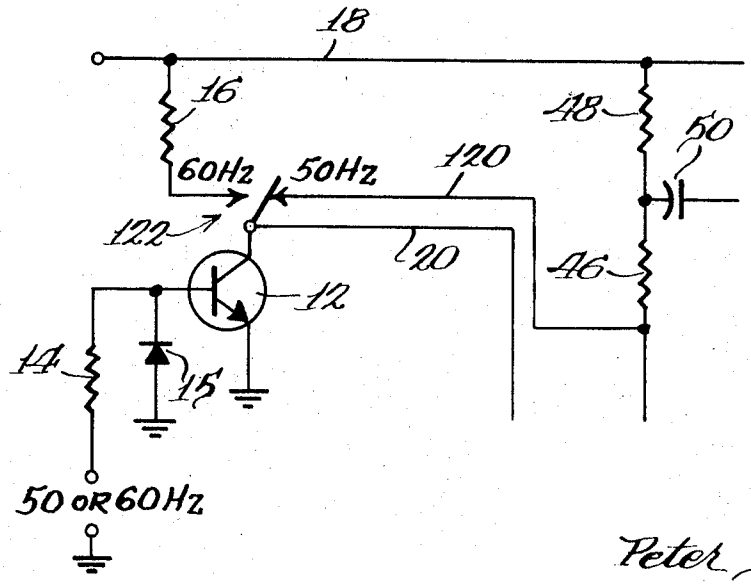


Fig. 4.

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MUSICAL INSTRUMENT TUNING REFERENCE STANDARD

BACKGROUND OF THE INVENTION

1. Field of the Invention

Tuning reference standards for tunable musical instruments such as guitars, for instance.

2. Description of the Prior Art

In the past many different types of tuning reference standards have been employed or suggested. Those most customarily used are other musical instruments of fixed pitch, pianos or organs, for instance, if they are present, or such portable devices as pitch pipes or tuning forks. Electronic oscillators have also been used, but are rather expensive if sufficiently precise. Just what note the standard is supplied for is not particularly important, but for a guitar or other fretted instrument it is preferable if the standard is such that one of the strings can be adjusted to zero beat therewith when the string is open, that is, when the string is not pressed against any of the frets.

SUMMARY OF THE INVENTION

At present one of the most popular tunable instruments is the electronically amplified guitar. This suggests that it would be an advantage to supply some sort of electronic tuning reference standard in connection with the amplifier, if this could be done at reasonable expense considering the precision required. Investigation of the problem disclosed to the applicant that the E string theoretically should be tuned to 329.6 Hz. when open (nonfretted). It also appeared that a reliable ultimate standard frequency generally available is the 60 Hz. powerline frequency. This ordinarily is held at 60 Hz. to within 0.66 Hz. line drift by the power companies and for musical purposes may be considered as nonvariable. The applicant also appreciated that if one took the line frequency of 60 Hz. and divided it by two with an ordinary flip-flop circuit, the result would be a 30 Hz. square wave, which comprises a fundamental accompanied by a declining series of odd harmonics. By proper filtration the eleventh harmonic of this 30 Hz. wave could be selected and by appropriate wave shaping, a declining series of harmonics could be added thereto, thereby giving a complex wave, with its fundamental at 330 Hz. This is only 0.4 Hz. removed from the theoretical E at 329.6 Hz. The total possible error including the line frequency drift using this approach is, therefore, one-half 0.66 Hz. (possible line drift) +0.4 Hz. or 0.73 Hz. or 0.22 percent. This is well within acceptable limits and for practical purposes can be assumed to be accurate.

Although circuitry is given hereafter to accomplish the above, and there may be some specific novelty therein, it is stressed that many different circuit arrangements will occur to those skilled in the art for accomplishing the purpose. The invention, therefore, is believed to reside largely in the realization that the eleventh harmonic of one-half the 60 Hz. line frequency is the E string frequency of a guitar.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 of the drawing is a circuit diagram of mechanism for practicing the invention;

FIG. 2 is a diagram of a variation thereof;

FIG. 3 illustrates an adaptation of the circuit of FIG. 1 to 50 Hz.; and

FIG. 4 illustrates a variation which adapts the circuit of FIG. 1 to both 60 Hz. and 50 Hz.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The 60 Hz. line frequency is applied at terminal **10** which is connected to the junction of the cathode end of diode **15** and the base of transistor **12** through resistor **14**. The anode end of diode **15** is connected to ground. Therefore, the positive side of the rectified 60 Hz. frequency appears at the base of transistor **12**. The emitter of transistor **12** is grounded and the collector thereof is connected through resistor **16** to +12 v. line **18**. The value of resistor **14** should be selected such that transistor **12** saturates so as to have a 60 Hz. inverted polarity square wave output at the collector. With the collector output connected to the lower end of the load resistor **16**, the output voltage, therefore, becomes negative, or less positive, relative to its previous positive value, when a positive input signal is fed to the base of transistor **12**.

The collector is connected by lead **20** to the midpoint of a frequency divider bistable flip-flop comprised of transistors **22** and **24** and associated circuitry. The emitters of transistors **22** and **24** are connected to a −12 v. line **25** and the bases and collectors are cross-connected through identical resistors **26**. The midpoint, lead **20**, is connected by capacitor **28** and resistor **30** in series to the collector of transistor **22** and by capacitor **32** and resistor **34** in series to collector of transistor **24**. The junction between capacitor **28** and resistor **30** is also connected to transistor **22** base through steering diode **36** and the base is connected to lead **25** through resistor **38**. Identical connections through steering diode **40** and resistor **42** are supplied at the opposite side of the circuit. The diodes are oriented as shown with the positive terminals connected to the bases. With the output signal that appears at the collector of transistor **12** being applied simultaneously to transistors **22** and **24**, the use of negative pulse steering diodes eliminates switching time delays. The collector of transistor **22** is connected to the positive lead **18** through resistor **44** and the collector of transistor **24** is connected through resistors **46** and **48** in series to lead **18**.

This flip-flop operates in conventional manner so that the input frequency is divided by two and a 30 Hz. square wave appears at the junction between resistors **46** and **48**. The remainder of the circuit selects the eleventh harmonic and performs a wave shaping function.

The junction between resistors **46** and **48** is connected through capacitors **50** and **52** in series to the base of transistor **54**. The base is also connected to ground through resistor **56** and variable resistor **58** in series. The emitter is connected to lead **25** through resistor **60** and the collector to line **18** through load resistor **62**.

The collector of transistor **54** is connected to the base of a second transistor **64** the emitter of which is connected to B+ lead **18** and the collector to −12 v. line **25** through resistor **66**. There is also a feedback connection from the collector of transistor **64** through resistor **68** back to the common point between capacitors **50** and **52** and a connection from the collector of transistor **64** through resistor **70** to the emitter of transistor **54**. The output of this portion of the circuit is at the collector of transistor **64**.

With appropriate values in this circuit to be given presently, the input to transistor **54** acts as a high pass filter and the two transistors act as an amplifier which because of the feedback paths tends almost to oscillate at the eleventh harmonic, 330 Hz., when the variable resistor **58** is properly adjusted for maximum output voltage at the mentioned frequency. The output from this portion of the circuit appears at lead **72** connected to the collector of transistor **64**. The active filtered signal which appears at lead **72** is at the frequency of 330 Hz., however, modulated at 30 Hz. The pulsed wave train modulation pattern is free of quiescent regions and appears as a repetitious series of damped waves, wherein, the peaks decline in amplitude, with 11 cycles per second present per modulation cycle.

The damped wave train at the proper frequency in lead **72** is connected through resistors **74**, **76** and **78** in series in that order to the base of a transistor **80**. Resistor **76** is variable. The junction between resistors **74** and **76** is connected to ground through resistor **82**, and the base of transistor **80** has a high frequency path to ground through capacitor **84**. The input resistor-capacitor mesh to transistor **80**, therefore, acts as a low pass filter and discriminates against frequencies above the fundamental at 330 Hz.

The emitter of transistor **80** is connected to lead **25** through resistor **86** and the collector is connected to the lead **18** by resistor **88**. The collector of transistor **80** is connected to the base of a second stage transistor **90**, the emitter of which is connected to line **18**. The collector of transistor **90** is connected to output lead **92** and to line **25** through resistor **94**. Feedback paths are provided from the collector of transistor **90** to the emitter of transistor **80** through resistor **97** and from the collector of transistor **90** through capacitor **96** to the midpoint between resistors **76** and **78**.

The circuit of transistors **80** and **90** is essentially similar to that of transistors **54** and **64** excepting that the circuit of transistors **80** and **90** emphasizes the 330 Hz. frequency and discriminates against spurious signals at a frequency above 330 Hz. by attenuating at 12 db. per octave whereas the circuit with transistors **54**—**64** emphasizes the 330 Hz. frequency and introduces some spurious higher frequencies in doing so. Resistor **76** is adjusted for maximum reliable signal output operation with a minimum of resistance, which provides the desired locked-to-the-line coupling and the smoothest output wave at terminal **92**. The adjustable resistors **58** and **76** will adjust about the midpoint, for proper setting, with the related optimized RC components.

The circuit as so far described would give a good approximation of a sine wave at line **92**. Preferably, this is changed so as to produce some harmonic development, since the tone produced by such a signal is easier to tune to. This is accomplished by the resistor **100** and diode **98** connected to ground. The diode shunts the signal at output **92** and produces a nonsymmetrical wave. The value of the resistor **100** can be selected as desired to produce a pleasing tone. Connected to the junction formed by resistor **100** and diode **98** are two series resistors, **101** and **102**, which are also connected to ground. The resistors form a voltage divider with terminal **93** taken between the resistors at the required output voltage. The output terminal **93** with the 330 Hz. signal thereon may be connected to its own amplifier and speaker of conventional design, or as usually will be the preferred arrangement, it can be connected into the normally present guitar amplifier circuit so as to make use of the guitar amplifier and speaker.

The values of the components in the representative circuit shown and discussed are as follows:

Transistors **64** and **90**, type 2117

Other transistors, type 2108

Diodes **15** and **98**, type 2603, and **36** and **40**, type 2601

Resistors in ohms:

68		200
70, 97		240
48		470
82	K	1
66, 94	K	3.9
16, 44, 46	K	5.6
74, 78	K	22
100	K	33
60, 86	K	39
102	K	47
76	K	50
38, 42	K	56
30, 34, 58, 62, 88, 101	K	100
26, 56	K	150

Capacitors in microfarads:

28, 32 (disc)	.001
84 (mylar)	.001
50, 52	.075
96	.47

The circuit described in detail above divides the input 60 Hz. signal by two and then extracts and wave shapes the eleventh harmonic to arrive at a stable frequency of 330 Hz. Although we prefer this arrangement, it is also, of course, possible to take the eleventh harmonic of the input frequency and subsequently divide the resulting 660 Hz. frequency by two and wave shape the resulting 330 Hz. E signal so as to obtain a similar end result. To accomplish this, FIG. **2**, the input essentially sine wave signal is saturated at **110**, as in the transistor **12** circuit in the previous embodiment. The saturated signal is fed into a dynamic high pass filter **112** similar to the one shown at **54**, but adjusted to give a 660 Hz. signal modulated at 60 Hz. rather than 330 Hz. signal modulated at 30 Hz. This 660 Hz. signal is applied to a pulsed clipper or trigger circuit **114** which may be of conventional type. The output from this circuit which has a steep wave front is fed to a bistable flip-flop **116**, such as at **22–24** which divides the frequency by two to give 330 Hz. which can be wave shaped as at **118** to give a signal at **120** substantially identical to that at **93**.

Although it is not the primary objective, the circuit of FIG. **1** can easily be converted to serve as a tuning reference when the available power line frequency is 50 Hz. rather than 60 Hz., thereby making the systems as supplied for 60 Hz. useful in many countries where 50 Hz. is standard. This is accomplished by converting the circuit to supply the seventh harmonic of 50 Hz. which is 350 Hz., very close to true musical F at 349.228 Hz. To make the conversion it is necessary merely to install a connection between lead **20** and the junction between resistor **46** and transistor **24** and to remove or disconnect load resistor **16**. Note that when lead **20** is connected to resistor **46**, resistors **48** and **46** serve as the load in place of resistor **16**. The connection from lead **20** through resistor **46** to the input of transistor **54** bridges the frequency divider **22–24** and the saturated 50 Hz. signal is, therefore, applied directly to transistor **54**. The only other changes necessary are to adjust the settings of resistors **58** and **76** to accommodate the higher frequency.

In making this adjustment, resistor **58** will be moved from approximately its midpoint to about one-third of its resistance value. This reduces the total resistance 58+56 by 11.1 percent. Resistor **76** is also adjusted to reduce its value similarly. These two adjustments take care of the frequency increase of 6.06 percent (from 330 Hz. to 350 Hz.). The portion of the circuit affected by this change is shown in FIG. **3** where the bridge across the frequency divider is indicated at **120** and resistor **16** of FIG. **1** has been eliminated.

Of course, the elements of the frequency divider could be eliminated from the circuit if the circuit is to operate from a 50 Hz. supply, but usually it is less expensive to make the systems all alike and convert the few that are to be used where 50 Hz. is standard. If desirable, to accommodate both standards, a single pole double throw switch **122**, FIG. **4**, can be connected so that when in one position it connects lead **20** to resistor **16** for 60 Hz. and in the other position connects lead **20** to lead **120** for 50 Hz. Switches, not shown, can also be installed to switch in and out preset resistors of appropriate values at **58** and **76**.

From the above it will be apparent that the system illustrated and described provides an E signal at 330 Hz. for tuning purposes that is as precisely regulated as is the 60 Hz. power circuit with which it is used. For all practical purposes they may be considered as absolute regulation and is in fact more precise than most tuning standards customarily used. Also the system has the advantage of being easily convertible for operation on 50 Hz. standard frequency.

Having described the invention what I claim is:

1. A circuit for providing a musical instrument tuning reference signal comprising circuit means for receiving the standard alternating current power line frequency at 60 Hz., means for dividing said powerline frequency by two to provide a signal at 30 Hz. said dividing means acting on said signal to provide said 30 Hz. signal with a series of odd harmonics, and means for extracting the eleventh harmonic from said dividing means signal to provide a tuning reference musical E signal at 330 Hz.

2. The circuit of claim 1 in which the means for extracting the eleventh harmonic is a feedback amplifier conditioned so as almost to oscillate at 330 Hz.

3. The circuit of claim 1 in which said dividing means is a bistable flip-flop.

4. The circuit of claim 3 in which the means for extracting the eleventh harmonic is a feedback amplifier conditioned so as almost to oscillate at 330 Hz.

5. The circuit of claim 1 including means for distorting said 330 Hz. signal to add a series of even and odd harmonics thereto.

6. The circuit of claim 5 in which the means for extracting the eleventh harmonic is a feedback amplifier conditioned so as almost to oscillate at 330 Hz.

7. The circuit of claim 5 in which the distorting means is a diode.

8. The circuit of claim 7 in which the means for extracting the eleventh harmonic is a feedback amplifier conditioned so as almost to oscillate at 330 Hz.

9. The circuit of claim 5 in which said dividing means is a bistable flip-flop.

10. The circuit of claim 9 in which the means for extracting the eleventh harmonic is a feedback amplifier conditioned so as almost to oscillate at 330 Hz.

11. The circuit of claim 9 in which the distorting means is a diode.

12. The circuit of claim 11 in which the means for extracting the eleventh harmonic is a feedback amplifier conditioned so as almost to oscillate at 330 Hz.

13. A circuit for providing a musical instrument tuning reference signal comprising an input for receiving a standard alternating current powerline frequency, and means responsive to said frequency for adding a harmonic series to said input frequency and harmonic selecting means to provide an output signal at a selected harmonic of the input signal which selected harmonic is at substantially the fundamental frequency of a note of the musical scale.

14. The circuit of claim 13 in which the means for adding a harmonic series is a saturated amplifier.

15. The circuit of claim 13 in which the harmonic selecting means is a feedback amplifier having tuning means to condition said amplifier almost to oscillate at a selected frequency in the range between 330 Hz. and 350 Hz.

16. The circuit of claim 13 in which the harmonic selecting means is a feedback amplifier conditioned so as almost to oscillate at 660 Hz.

17. The circuit of claim 16 including means for dividing the frequency of the signal from said feedback amplifier by two.

18. The circuit of claim 13 in which the input frequency is 50 Hz. and the harmonic selecting means selects the seventh harmonic.

19. The circuit of claim 18 in which the means for adding a harmonic series is a saturated amplifier.

20. The circuit of claim 18 in which the harmonic selecting means is a feedback amplifier conditioned so as almost to oscillate at 350 Hz.