United States Patent [19]

Lester et al.

[11] **3,876,936**

[45] **Apr. 8, 1975**

[54] **VISUAL AUDIO FREQUENCY COMPARATOR**

[75] Inventors: **Theodore V. Lester**, Schiller Park; **Donald C. Ryon**, Carol Stream, both of Ill.

[73] Assignee: **Motorola, Inc.**, Chicago, Ill.

[22] Filed: **Sept. 17, 1973**

[21] Appl. No.: **398,027**

[52] **U.S. Cl.**..... **324/79 R;** 324/82; 324/88; 84/454

[51] **Int. Cl.**..... **G01r 23/14**

[58] **Field of Search**.... 324/78 R, 78 Q, 79 R, 82 X, 324/88, 121, 91; 84/454

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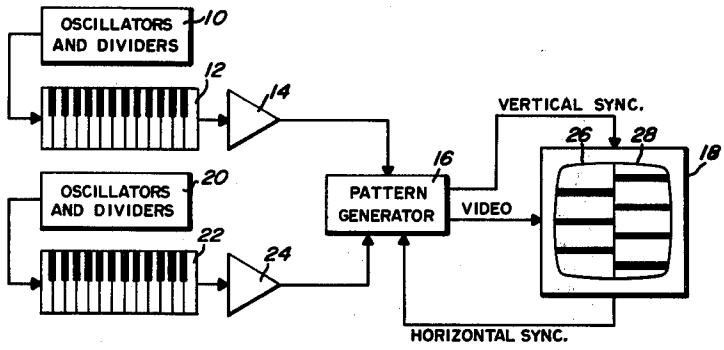
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Primary Examiner—Alfred E. Smith
Assistant Examiner—Rolf Hille
Attorney, Agent, or Firm—Eugene A. Parsons; Vincent J. Rauner

[57] **ABSTRACT**

A system for determining the frequency relationship between two notes of a musical instrument includes a split screen display device, and bar generating means connected to the instrument and display device for generating a first plurality of bars representative of the frequency of the first note on one portion of the display device and a second plurality of bars representative of the frequency of the second note on another portion of the display device. The vertical sweep circuit of the display device is synchronized to the frequency of one of the notes.

4 Claims, 6 Drawing Figures



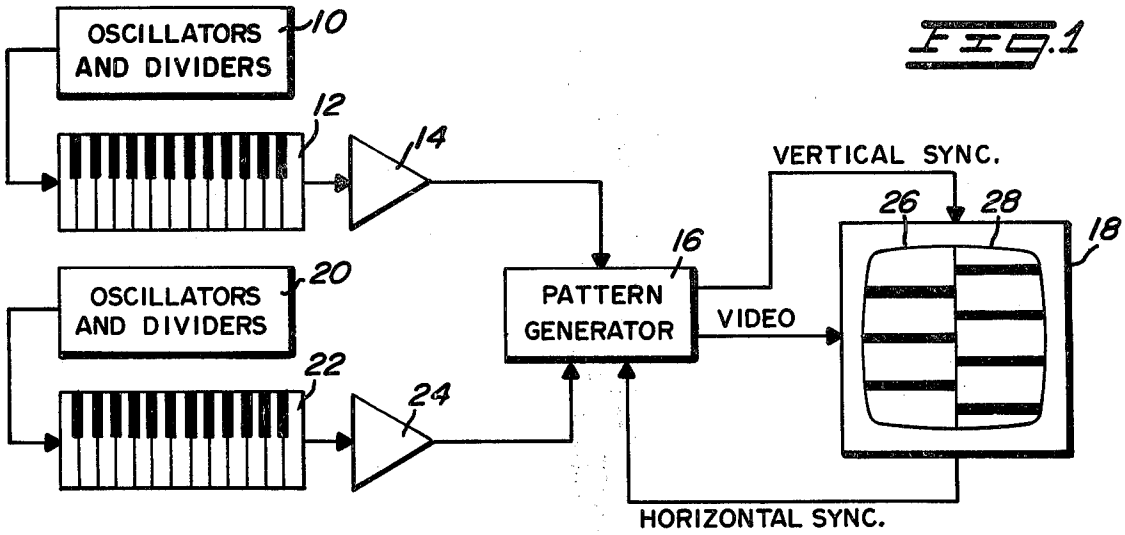

OSCILLATORS AND DIVIDERS
10
12
14
OSCILLATORS AND DIVIDERS
20
22
24
PATTERN GENERATOR
16
VERTICAL SYNC.
VIDEO
HORIZONTAL SYNC.
26
28
18

Fig. 1

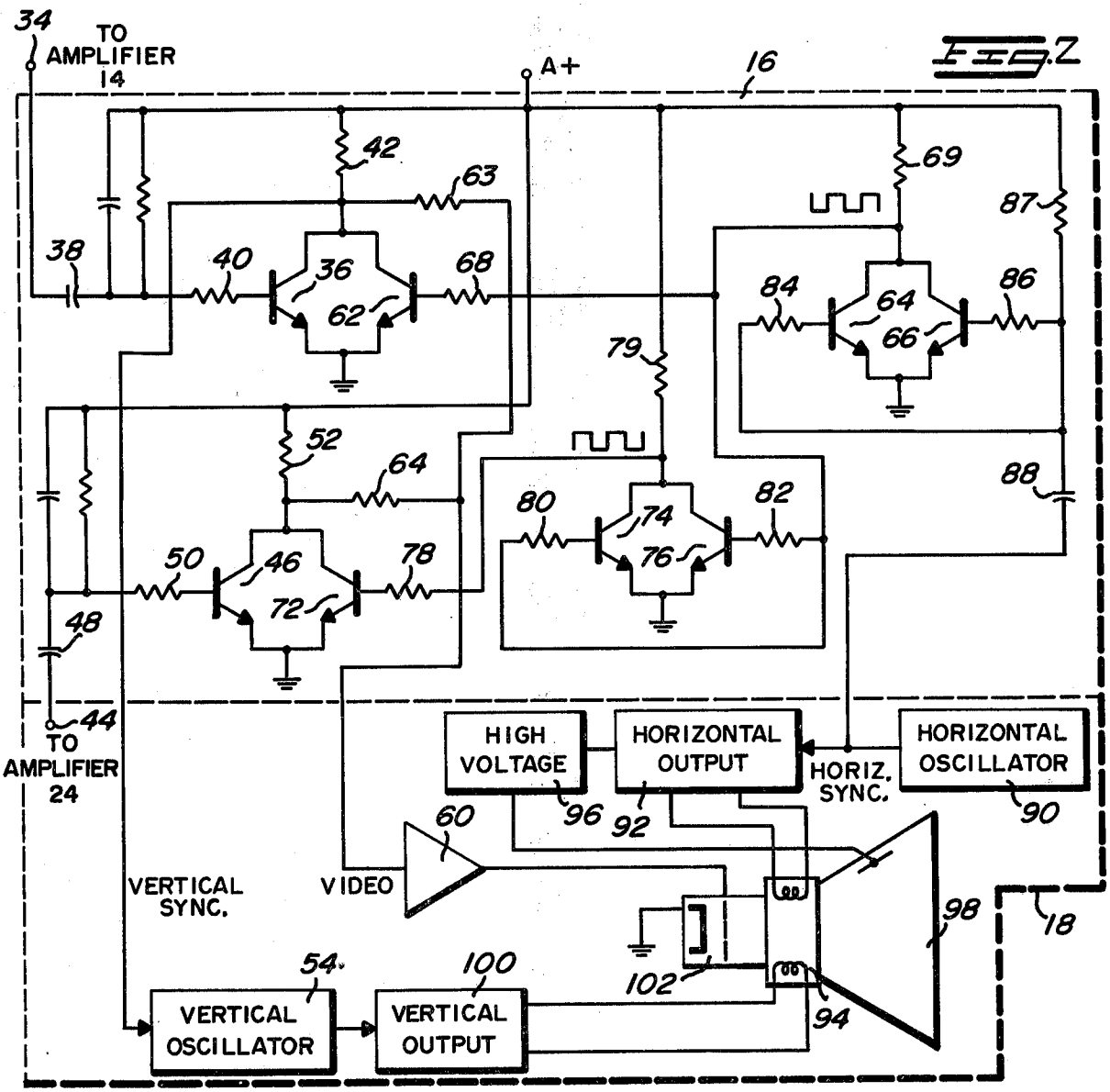
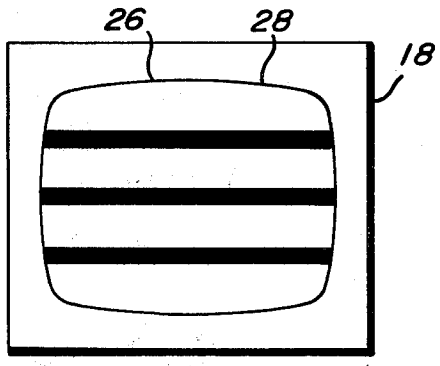
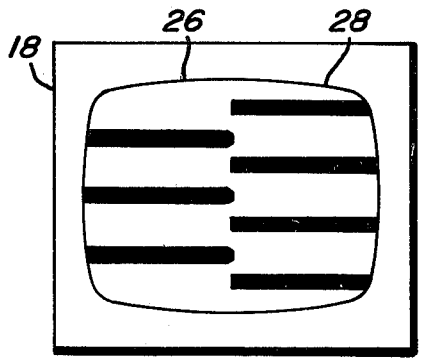

34
TO AMPLIFIER 14
A+
16
42
63
38
40
36
62
68
69
87
84
64
66
86
79
52
64
88
80
74
82
50
46
72
78
48
44
TO AMPLIFIER 24
HIGH VOLTAGE
HORIZONTAL OUTPUT
HORIZ. SYNC.
HORIZONTAL OSCILLATOR
96
92
90
60
VERTICAL SYNC.
VIDEO
98
18
102
94
54
100
VERTICAL OSCILLATOR
VERTICAL OUTPUT

Fig. 2



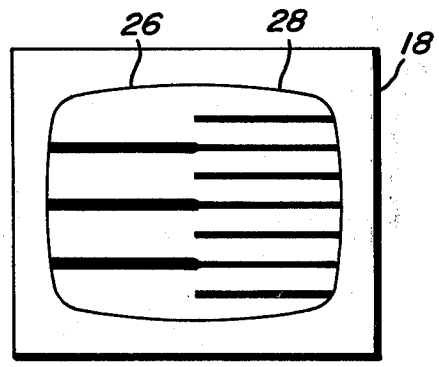
SAME FREQUENCY AND PHASE

Fig. 3



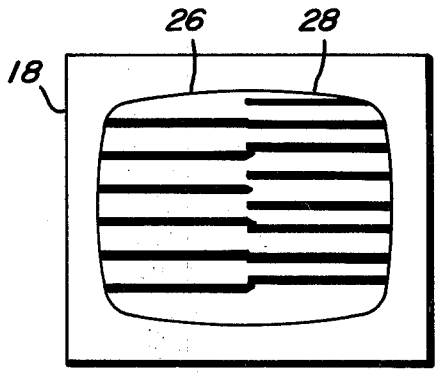
SAME FREQUENCY – 180° OUT OF PHASE

Fig. 4



2:1 OCTAVE

Fig. 5



5:4 A THIRD INTONE INTERVAL

Fig. 6

VISUAL AUDIO FREQUENCY COMPARATOR

BACKGROUND

1. Field of Invention

This invention relates generally to frequency comparison systems, and more particularly to systems for determining the frequency relationship between two notes provided by a musical instrument.

There are many applications wherein it is necessary to compare the frequency of one signal to another. One such application is in an electronic musical instrument wherein it is necessary to compare the frequencies of various notes sounded by the instrument for tuning, demonstration or experimentation purposes.

2. Prior Art

Several techniques for determining the frequencies of signals are known. Such techniques include the use of tuned reeds which vibrate when the frequency of the signal applied thereto is equal to the resonant frequency of the reed, beat note systems wherein the frequency of the note is compared with the frequency of an oscillator having a known frequency and visual comparison systems employing Lissajous figures.

Whereas these techniques provide a way to determine frequencies of signals, the reed and standard oscillator systems are costly and only provide an accurate frequency determination at discrete points and do not provide a direct frequency comparison between two signals. The Lissajous display systems provide a direct comparison, but the display cannot be readily interpreted unless the ratio between the signals applied thereto is an integral number, and interpretation of Lissajous figures becomes extremely difficult when frequencies of a musical scale, which have a non-integral frequency relationship therebetween, are compared.

SUMMARY

It is an object of the present invention to provide an improved visual frequency comparison circuit for comparing the frequency of musical notes.

It is a further object of the invention to provide a frequency comparison circuit that readily provides a comparison between signals having a non-integral frequency relationship therebetween.

It is a further object of this invention to provide a visual frequency comparison system that has a low cost and is readily interpreted by personnel untrained in electronics.

In accordance with a preferred embodiment of the invention, a split screen video monitor is employed. A bar generator is used to generate a plurality of bars indicative of the frequency of one of the notes in one area of the split screen and a second plurality of bars indicative of the frequency of a second note in another portion of the split screen. The vertical sweep circuit of the video monitor is synchronized to the frequency of one of the notes, thereby providing a stationary bar pattern on one portion of the screen. The frequency of the signal displayed in the other portion of the screen is compared to the fixed pattern by comparing the relative number of bars and the position and movement of the bars with respect to the fixed bar pattern.

DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1 is a block diagram of the visual frequency comparison circuit according to the invention shown connected to an electronic organ;

FIG. 2 is a diagram, partially in schematic form and partially in block diagram form, of the visual display device according to the invention; and

FIGS. 3–6 are drawings showing the bar patterns obtained for various frequency ratios of signals applied thereto.

DETAILED DESCRIPTION

Referring to greater detail to FIG. 1, there is shown a portion of a musical instrument including oscillators and dividers **10, 20** and keyboards **12, 22** connected, respectively, thereto. A pair of amplifiers **14, 24** have inputs thereof connected to the keyboards **12,22** and outputs connected to a pattern generator **16.** The pattern generator **16** is connected to display means such as a video monitor **18** and generates bars in first and second portions of a split screen **26** and **28.** Vertical synchronization for the monitor **18** is applied thereto from the pattern generator **16,** and horizontal synchronization is applied from the monitor **18** to the pattern generator **16.**

In operation, the keyboard **12** passes a first tone from the oscillators and dividers **10** to the input of the amplifier **14.** The amplified signal from amplifier **14** is processed by the pattern generator **16** and a video signal which is substantially a square or rectangular wave having the same frequency as the frequency of the first tone is applied to the monitor **18** to generate the bar pattern in the area **26.** Similarly, a signal from the oscillators and dividers **20** is passed by the keyboard **22** to the amplifier **24.** The pattern generator **16** generates a video signal in response to the signal from the amplifier **24** to generate the bar pattern in the area **28.** A vertical synchronization signal is applied to the monitor **18** to synchronize the vertical sweep of the monitor to a submultiple of the frequency of the signal from the amplifier **14.** A horizontal synchronization signal is obtained from the horizontal synchronization circuitry of the monitor **18** and controls a gate circuit in the pattern generator **16** to alternately pass signals from the amplifiers **14** and **24** to the video portion of the monitor **18** to generate the patterns appearing in areas **26** and **28.** A more detailed explanation of the operation of the pattern generator **16** and the monitor **18** follows.

Referring to FIG. 2, there is shown a schematic diagram of one embodiment of the pattern generator **16** and a more detailed block diagram of a typical monitor **18.** The pattern generator **16** has an input point **34** which is connected to the output of the amplifier **14.** The input point **34** is also connected to the base of a transistor **36** through a capacitor **38** and a resistor **40.** Similarly, an input point **44** is connected to the output of the amplifier **24** and to the base of a transistor **46** through a capacitor **48** and a resistor **50.** The collectors of the transistors **36** and **46** are connected to a power supply A+ through resistors **42** and **52,** respectively, and to the input of a video amplifier **60** in the monitor **18** through a pair of resistors **63** and **64,** respectively. The collector of the transistor **36** is also connected to the vertical oscillator **54.** A pair of transistors **62** and **72** have the collectors and emitters thereof connected to the collectors and emitters of the transistors **36** and **46,** respectively, and the emitters of the transistors **36,** 46, 62 and **72** are connected to a ground or common

potential. The base of the transistor **62** is connected by means of a resistor **68** to the collectors of a pair of transistors **64, 66,** each having an emitter connected to ground. Similarly, the base of the transistor **72** is connected through a resistor **78** to the collectors of a pair of transistors **74** and **76,** whose emitters are also connected to ground. The collectors of the transistors **74** and **76** are connected to the power supply A+ through a resistor **79.** The collectors of the transistors **64** and **66** are also connected to the power supply A+ through a resistor **69** and to the bases of the transistors **74** and **76** through resistors **80** and **82,** respectively. The bases of the transistors **64** and **66** are connected to the output of a horizontal oscillator **90** in the monitor **18** by means of resistors **84** and **86,** respectively, and a capacitor **88.** Resistor **87** is adjusted to split the screen in the exact center of the raster.

The output of the horizontal oscillator **90** is also connected to a horizontal output circuit **92** which drives the horizontal sweep coils of a yoke **94** and a high voltage circuit **96** which is connected to the anode of a display device such as a cathode ray tube **98.** A vertical output circuit **100** of the monitor **18** has an input connected to the output of the vertical oscillator **54** and an output connected to the vertical sweep windings of the yoke **94.** The output of the video amplifier **60** is connected to the grid **102** of the cathode ray tube **98** to modulate the raster produced on the face of the cathode ray tube **98** by the horizontal output circuit **92** and the vertical output circuit **100.**

In operation, a tone signal applied to the input point **34** is amplified and amplitude limited by the transistor **36** to provide a substantially rectangular wave to the input of the amplifier **60** when the transistor **62** is rendered nonconductive. Similarly the transistor **46** amplifies signals from the input point **44** for application to the amplifier **60** when the transistor **72** is nonconductive. The transistors **62** and **72** serve to shunt the signals from the respective transistors **36** and **46** to ground when either of the transistors **62** and **72** is conductive.

The horizontal oscillator **90** provides oscillations at a relatively high horizontal sweep frequency which may be 15,750 Hz or other suitable frequency to the horizontal output circuit **92** which provides a ramp function to the horizontal coils of the yoke **94** to horizontally sweep the beam across the face of the cathode ray tube **98.** The flyback pulses from the horizontal output stage **92** are transformed to a high voltage and rectified by the high voltage circuit **98** to provide the anode voltage for the cathode ray tube **98** in a conventional fashion. The output of the horizontal oscillator **90** is also coupled through the capacitor **88** to the bases of the transistors **64** and **66** which are effectively connected in parallel. A single transistor may be used in place of the transistors **64** and **66,** however because integrated circuit comprising four dual input gates was used in the fabrication of the pattern generator **16,** one of the gates consisting of transistors **64** and **66** was connected as an amplifier as shown.

Because the output of the horizontal oscillator **90** is capacitively coupled to the transistors **64** and **66,** both transistors are rendered conductive when the value of the alternating current component of the signal from the horizontal oscillator **90** is sufficient to forward bias both transistors. When the value of the alternating current component is less than the value required to forward bias the base-emitter junctions of the transistors **64** and **66,** both transistors **64** and **66** are rendered nonconductive. The output at the collectors of the transistors **64** and **66** is therefore substantially a square or rectangular wave having a frequency equal to the frequency of the signal generated by the horizontal oscillator **90.**

The square wave signal from the transistors **64** and **66** is applied to the base of the transistor **62** to render the transistor **62** conductive when the square wave is at its high state and to render the transistor **62** nonconductive when the square wave is in its low state. The signal from the transistors **64** and **66** is also applied to the bases of the transistors **74** and **76** which have a similar configuration to the transistor pair **64, 66,** and which serve as a phase inverter to generate a second wave 180° out of phase with the square wave applied thereto. The signal from the collectors of the transistors **74** and **76** is applied to the base of the transistor **72** to render the transistor **72** alternately conductive and non-conductive, transistor **72** being conductive when transistor **62** is non-conductive and vise versa.

Since the transistors **72** and **62** are alternately rendered conductive, one of the signals from the transistors **46** and **36** is alternately shunted to ground while the signal from the other of the transistors **46** and **36** is applied to the video amplifier **60.** The aforementioned action causes the beam of the cathode ray tube **98** to be modulated by the video amplifier **60** in response to the signal from the transistor **36** during the first portion of each horizontal sweep, and in response to the signal from the transistor **46** during the remainder of the sweep, thereby generating the split screen effect.

The signal from the transistor **36** is also applied to the vertical oscillator **54** to provide a synchronization pulse thereto which causes the vertical oscillator to operate at a frquency which is a submultiple of the frequency of the signal from the transistor **36.** The vertical oscillator **54,** which generally operates at a lower frequency than the frequency of the horizontal oscillator **90,** causes the vertical output circuit **100** to apply a ramp signal to the vertical winding of the yoke **94** to cause the beam of the cathode ray tube **98** to be vertically swept at a submultiple of the frequency of one of the tones applied to the frequency comparator. The synchronization causes the bar display corresponding to the tone to which the system is synchronized to appear as a series of stationary horizontal bars, the number of bars being determined by the frequency ratio of the tone signal and the operating frequency of the vertical oscillator **54.** The number of bars appearing in the display area for the other of the signals is determined by the frequency ratio between that signal and the frequency of the vertical oscillator **54** and serves to provide a frequency comparison between the two signals applied to the comparator according to the invention.

Referring to FIG. **3,** the bar pattern generated in the areas **26** and **28** of the monitor **18** indicates that the frequencies being compared by the visual frequency comparison system according to the invention have both the same frequency and phase because the number of bars in both the regions **26** and **28** is equal and the bars lie in the same horizontal line.

The pattern shown in FIG. **4** indicates that the two signals have the same frequency since the spacing between the bars in each of the areas **26** and **28** is equal,

however, the signals are 180° out of phase since the bars in the two regions do not line up but are interleaved.

FIG. **5** shows the pattern obtained when the frequency ratio of the signals applied to the comparator is **2:1** as evidence by the spacing between the bars in the area **28** being one-half the spacing between the bars in the area **26.** Similarly, FIG. **6** shows a 5:4 ratio, five bars being present in area **28** for every four present in the area **26.**

The display provided by the system according to the invention is also useful for comparing signals having only a slight frequency offset therebetween. Since the vertical sweep of the monitor **18** is synchronized to the signal displayed in the area **26,** the bars in the area **26** will remain stationary. The bars in the area **28** will remain stationary when the frequency of the signal displayed in area **28** is related to the frequency of the signal displayed in area **26** by a ratio of small whole numbers such as, for example, 1:1, 2:1 or 5:4 as shown in FIGS. **3–6.** If the aforementioned ratio does not occur, the bars in the area **28** will roll upward or downward with respect to the bars in the area **26.** An upward movement shows that the signal displayed in area **28** has a slightly higher frequency, or a sharp relationship to the signal displayed in area **26,** while a downward movement shows a lower or flat pitch.

For example, an upward movement of the bars in area **28** of FIG. **3** shows that the frequency of the signal displayed in area **28** is slightly higher than the frequency of the signal displayed in area **26.** Similarly, an upward movement of the bars in area **28** of FIG. **5** shows that the frequency ratio is slightly greater than 2:1 while an upward movement in the area **28** of FIG. **6** indicates a slightly greater ratio than 5:4. Thus, the frequency relationship between the two signals may be readily ascertained by counting the ratio of the bars displayed in area **26** and **28** and noting whether the bars in area **28** move upward or downward with respect to the bars in area **26.**

The inventors have found that the system according to the invention provides an effective and accurate way to make frequency comparisons particularly of the type of comparisons necessary for tuning musical instruments.

Whereas the embodiment of the invention described in the foregoing shows apparatus for generating a plurality of horizontal bars, it should be obvious to those skilled in the art that vertical bars can also be generated by simply rotating the display tube by 90°, by causing the horizontal rather than the vertical oscillator to operate at a submultiple frequency of one of the tone frequencies applied thereto, or by other means. Also, another display device such as a solid state display device may be used in place of the cathode ray tube **98.** It should, however, be noted that these and other modifications readily apparent to those skilled in the art still fall within the scope and spirit of the invention.

We claim:

1. A system for comparing the frequencies of first and second musical notes including in combination:

means for receiving a first alternating current signal having a predetermined frequency relationship to the frequency of said first musical note;

means for receiving a second alternating current signal having a predetermined frequency relationship to the frequency of said second musical note;

display means for visually displaying bars in response to alternating current signals applied thereto, the number and position of the bars displayed being proportional to the frequency and phase, respectively, of the alternating current signals applied to said display means said display means including a display device, and a high frequency sweep circuit and a low frequency sweep circuit coupled to said display device, one of said sweep circuits being horizontal and the other being vertical for generating a raster on said display device; and

gating means connected to said first and second alternating current signal receiving means and to said display means for alternately applying signals, representative of one of said first and second alternating current signals, to said display means an output of said high frequency sweep circuit being connected to said gating means for causing said gating means to alternately apply one of said first and second alternating current representative signals to said display means for a portion of each high frequency sweep.

2. A system as recited in claim **1** wherein said low frequency sweep circuit is connected to said first signal receiving means, said low frequency sweep circuit being responsive to said first signal receiving means for synchronizing the frequency of operation of said low frequency sweep circuit o a submultiple of the frequency of said first signal.

3. A system as recited in claim **2** wherein said first and second signal receiving means include a limiting amplifier for generating signals having a substantially rectangular wave shape in response to said first and second alternating current signals applied thereto.

4. A system as recited in claim **3** further including means for modulating the raster generated by said horizontal and vertical sweep circuits, said modulating means being connected to said gating means and to said display device for modulating the raster in response to said first and second alternating current signals.

* * * * *