United States Patent

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[54] **ELECTRONIC MUSICAL TONE GENERATOR EMPLOYING PITCH COMPENSATION**
3 Claims, 2 Drawing Figs.

[52] **U.S. Cl.** **84/1.01,** 84/DIG. 23, 84/1.21, 331/106

[51] **Int. Cl.** **G10h 5/00**

[50] **Field of Search** .... 84/1.01, 1.04, 1.12, 1.13, 1.21, 1.24, 1.26, DIG. 7, DIG. 8, DIG. 23; 331/106

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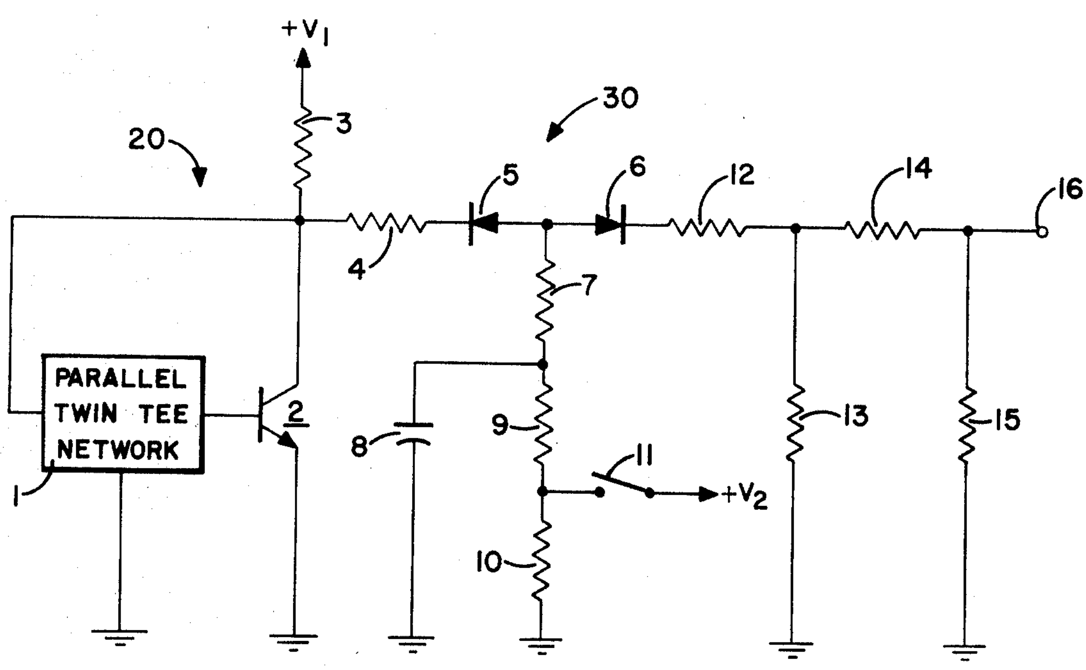
ABSTRACT: A continually operative tone oscillator has a keying network coupled to the output thereof. When the keying network is turned on, a capacitor gradually charges to a reference level. As the capacitor charges, the loading on the oscillator increases to simultaneously increase the frequency and the amplitude of the output tone. When the keying network is turned off, the capacitor discharges producing a gradual decay of the output tone. Simultaneously, the loading on the tone oscillator is decreased, thereby shifting the frequency thereof back to the original unkeyed value.



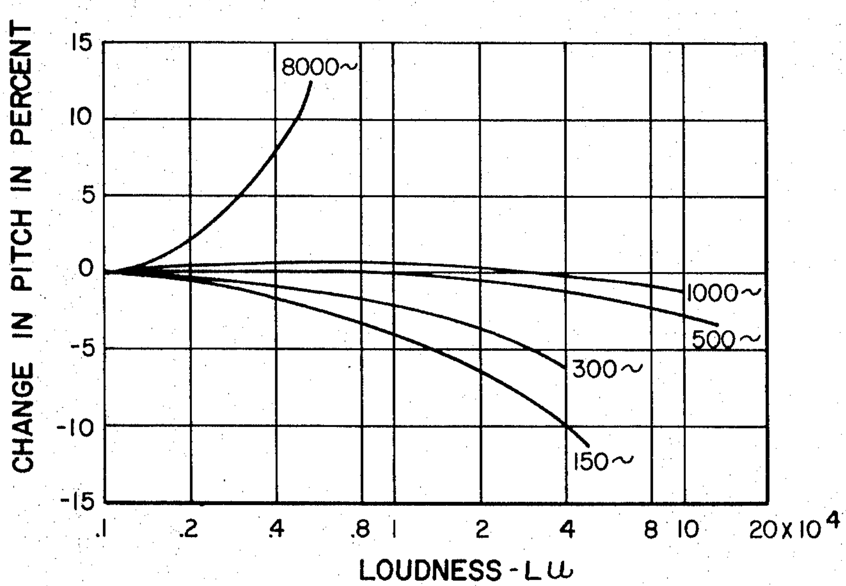


FIG. 1

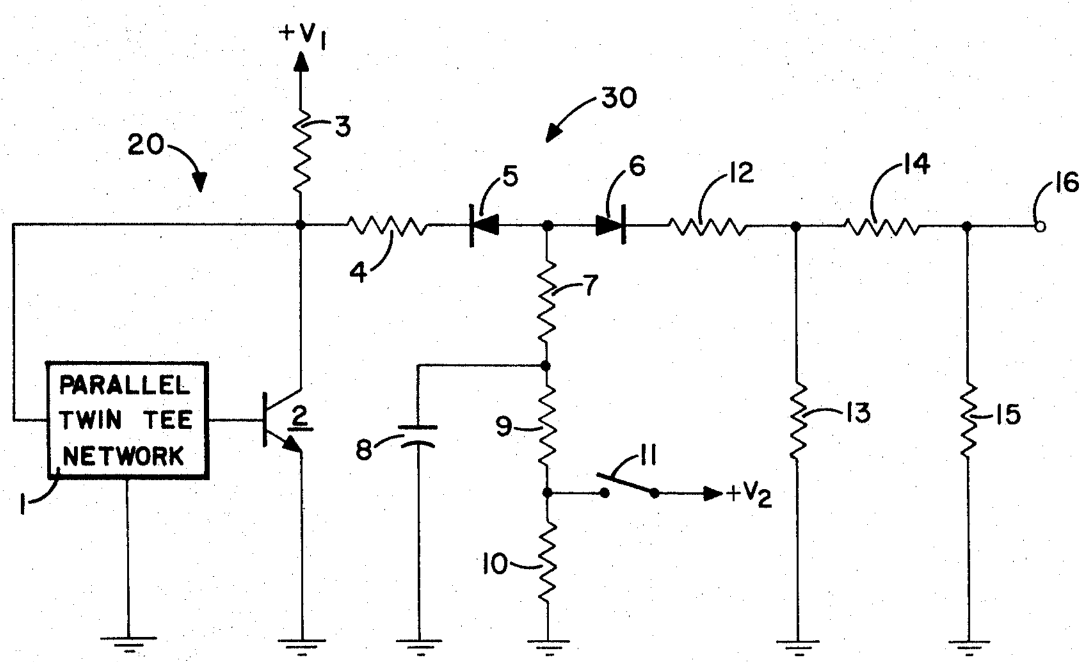


FIG. 2

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ELECTRONIC MUSICAL TONE GENERATOR EMPLOYING PITCH COMPENSATION

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to electronic musical instruments and, more particularly, to a tone generator and keying system therefor in which the frequency of the tone is varied as a function of the loudness thereof and useful for example, as a key circuit for an organ or electronic piano or the like.

2. Description of the Prior Art

It has been reported in the literature that the dynamic aspects of music, i.e. the perceived pitch of a tone, depend primarily upon the intensity of the tone. This has been confirmed by tests performed by S. S. Stevens, reported in the Journal of the Acoustic Society of America, Volume 6, No. 3, page 150, 1965. These tests have shown that at low frequencies, the pitch of a tone goes flat as the loudness level is increased. Conversely, at high frequencies, the pitch of a tone goes sharp as the loudness level is increased. As a result, when playing a musical instrument which produces fundamental frequencies in the bass region of the musical spectrum, the instrument is usually adjusted to play tones slightly sharp in frequency to compensate for the nonlinearity of the human ear which perceives the tone going flat as the loudness level is increased.

The difficulty with such an approach is that it does not truly compensate for the change in pitch of a tone as the loudness level increases and decreases. In other words, compensation is only achieved at a single loudness level and the pitch of the tone continues to appear to decrease and increase as the loudness level increases and decreases, respectively.

SUMMARY OF THE INVENTION

According to the present invention, this problem is overcome by providing a tone generator whose frequency has a first value before the tone is sounded and whose frequency increases from its original value as the tone is keyed on. Furthermore, when the tone generator is keyed off, the present circuit simultaneously permits the intensity of the tone to decay gradually to inaudibility while the tone frequency gradually returns to its original value. In this manner, true compensation of a tone may be achieved such that the ear perceives a constant pitch tone as the loudness level increases and decreases.

Briefly, the present invention comprises a tone generator and a keying network coupled to the output thereof. When the keying network is turned on, a capacitor gradually charges to a reference level. As the capacitor charges, the loading on the tone generator increases to simultaneously increase the frequency of the tone generator and increase the amplitude of the tone signal which is transferred by the keying network to the output of the system. When the keying network is turned off, the capacitor discharges producing a gradual decay of the output signal. Simultaneously, the loading on the tone generator is decreased thereby shifting the oscillator frequency back to its original unkeyed frequency.

It is, therefore, an object of the present invention to provide a tone generator which continuously compensates for the change in pitch of a tone as a function of the intensity thereof.

It is a further object of the present invention to provide a tone generator whose frequency increases from its original unkeyed frequency as the loudness of the tone increases.

It is a still further object of the present invention to provide a tone generator in which the output frequency thereof gradually decreases as the intensity thereof decreases.

Still other objects, features and attendant advantages of the present invention will become apparent to those skilled in the art from a reading of the following detailed description of the preferred embodiment constructed in accordance therewith, taken in conjunction with the accompanying drawings wherein:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a series of curves showing the relationship between the pitch of a tone and the loudness level thereof; and

FIG. 2 is a schematic diagram of the present tone generator and keying system.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings and, more particularly, to FIG. 1 thereof, tests have indicated that the pitch of a tone depends upon the loudness thereof. In these tests, the loudness of the tone is varied and compared with a reference tone. In FIG. 1, the ordinate is the percentage change in pitch and the abscissa is the loudness of the tone, expressed in loudness units. From FIG. 1 it is seen that the lower the frequency, the greater the percentage change in pitch as the loudness increases. As the frequency of the tone increases, there is a less drastic decrease in the percentage change in pitch as loudness increases. A point is reached, at a frequency of approximately 1,000 cycles per second, where the pitch of the tone begins to increase as the loudness increases.

Referring now to FIG. 2, there is shown a circuit for use in the bass region of the musical spectrum in which the output frequency increases as the loudness increases and in which the frequency decreases as the loudness decreases.

The circuit of FIG. 1 includes a continually operative tone oscillator, generally designated **20**, and a keying network generally designated **30**, for conducting the output of oscillator **20** to an output terminal **16**. Oscillator **20** comprises a conventional parallel twin tee filter network **1**, the output of which is connected to the base of a bipolar transistor **2**. The emitter of transistor **2** is connected to a source of reference potential, such as ground. The collector of transistor **2** is connected via a load resistor **3** to a first source of positive reference voltage $+V_1$ and back to the input of parallel twin-tee network **1**.

Keying circuitry **30** comprises a resistor **4** on one end of which is connected to the collector of transistor **2** and the other end of which is connected to the cathode of a diode **5**. The anode of diode **5** is connected to one end of a resistor **7** and to the anode of a second diode **6**. The other end of resistor **7** is connected to one end of a capacitor **8**, the other end of which is connected to ground, and to one end of a resistor **9**. The other end of resistor **9** is connected to one end of a resistor **10**, the other end of which is connected to ground, and to one terminal of a single pole, single throw switch **11**. The other terminal of switch **11** is connected to a second source of positive reference voltage $+V_2$.

The cathode of diode **6** is connected to one end of a resistor **12** the other end of which is connected to one end of a resistor **14**, the other end of which is connected to output terminal **16**. A resistor **13** is connected between the junction of resistors **12** and **14** and ground, and a resistor **15** is connected between terminal **16** and ground.

In operation, twin-tee network **1**, transistor **2** and load resistor **3** comprise a continually operative tone oscillator which provides a tone frequency at the collector of transistor **2**, the frequency being primarily determined by the component values in network **1**. It should be noted, however, that although a parallel twin-tee filter network and a bipolar transistor as the active amplifying element are a preferred form of oscillator, it will be apparent that other types of oscillator circuits may be used to accomplish the same result.

In the unkeyed condition, with switch **11** open, diodes **5** and **6** are back-biased preventing the output of oscillator **20** from reaching output terminal **16**. Upon closure of switch **11**, which may be activated by a pedal or manual key, capacitor **8** gradually charges to approximately the value of reference voltage $+V_2$. As this occurs, the voltage level at the junction between diodes **5** and **6** increases to a valve which is greater than the voltage at the collector of transistor **2** thereby rendering diodes **5** and **6** conductive. It should here be noted that resistors **4** and **12** isolate diodes **5** and **6**, respectively, from transistor 2 and output terminal 16, respectively. Resistor 7 is a signal load resistor which also keeps timing capacitor 8 from shorting the output of oscillator 20 to ground. Resistor 9 determines the rate of growth of the tone when switch 11 is closed by controlling the charging rate of capacitor 8.

As the charge on capacitor 8 increases, the load on the collector of transistor 2 increases, thereby slightly raising the collector DC voltage. The increased loading on the collector of transistor 2 causes the frequency of oscillator 20 to increase proportionately. The amount of increase of collector loading and DC voltage rise may be controlled by proper selection of the component values of resistors 7, 9 and 10. The component values should be chosen such that the rate of increase in oscillator frequency increases as the amplitude increases causes the pitch to remain constant to the human ear as the loudness level increases.

With capacitor 8 fully charged, diodes 5 and 6 are in their "on" state and the tone from oscillator 20 is passed on to output terminal 16 at maximum amplitude. Resistor 13 provides a return path to ground for diode 6. Resistor 14 operates as an isolation element which permits the connecting together of a plurality of generators and keying circuits as used in a polyphonic instrument. Resistor 15 is a load resistor which would be common to the keying circuits of other generators in such a polyphonic system.

When keying switch 11 is opened, the charge on capacitor 8 discharges primarily through resistors 9 and 10 although there will be additional discharge through diodes 5 and 6 and the remaining circuit elements. This discharge continues until diodes 5 and 6 are turned off. The gradual discharge of capacitor 8 results in a slight decrease in the DC voltage on the collector of transistor 2 together with a decrease in the loading on the collector. The result is a gradual decay of the signal at output terminal 16 together with a shift in oscillator frequency back to its original unkeyed value. Thus, the frequency shift closely follows the change in loudness of the decaying signal and compensates for the nonlinear way in which the human ear determines pitch by loudness.

While the invention has been described with respect to a preferred physical embodiment constructed in accordance therewith, it will be apparent to those skilled in the art that various modifications and improvements may be made without departing from the scope and spirit of the invention. For example, although a circuit has been shown for increasing the pitch of a tone as the loudness level increases, it will be obvious to those skilled in the art that keying network 30 may be modified to decrease the pitch as the loudness level increases for use in the high regions of the musical spectrum.

I claim:

1. An electronic musical tone generator employing pitch compensation especially adapted for use in the bass region of the musical tone spectrum including:

a voltage-controlled tone generator providing a musical tone signal at a predetermined frequency;

an output terminal;

a pair of back-to-back diodes being coupled between said voltage-controlled tone generator and said output terminal for blocking said musical tone signal from said output terminal;

a reference voltage

biasing means being coupled between said back-to-back diodes, said biasing means including a charging RC network for biasing said diodes at a predetermined rate for causing said diodes to conduct and for applying a steadily increasing voltage to said voltage controlled tone generator to increase the frequency thereof; and

switch means coupled between said source and the RC network of said biasing means for causing the amplitude of the charge on said RC network to steadily rise when closed to increase the frequency of said tone generator and for causing the amplitude of the charge on said RC network to steadily decrease when said switch means is opened to decrease the frequency of said tone generator.

2. The electronic musical tone generator as defined in claim 1, wherein said voltage-controlled oscillator includes:

a second reference voltage source;

a transistor including a collector output being coupled to said output terminal through said diodes and also being coupled to said second source, said transistor including an emitter coupled to a ground reference and a base; and

a filter network being coupled between the collector and the base of said transistor.

3. The electrical musical tone generator as defined in claim 1 wherein said switch means being a key of an electronic musical instrument.

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