United States Patent

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[54] **TONE-GENERATING DEVICE FOR ELECTRONIC MUSICAL INSTRUMENT**
2 Claims, 3 Drawing Figs.

[52] **U.S. Cl.** **84/1.19,** 84/1.22, 84/1.23
[51] **Int. Cl.** **G10h 1/06**
[50] **Field of Search** ..... 84/1.01, 1.11, 1.19, 1.22, 1.03, 1.24, DIG. 4, 1.23, DIG. 7, DIG. 8

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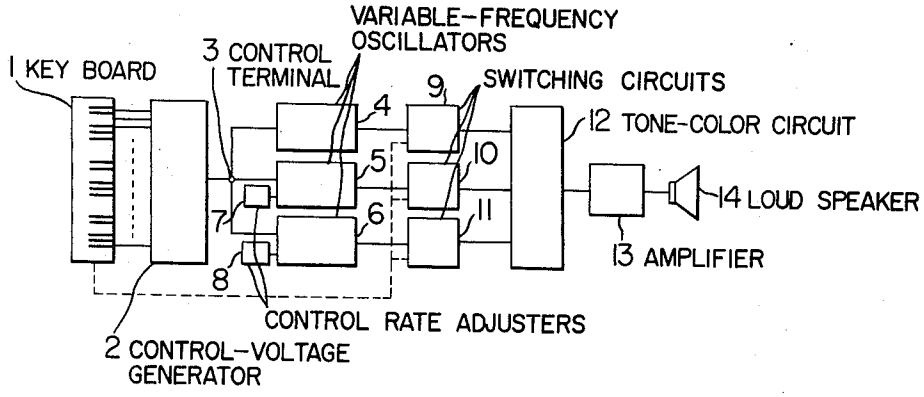
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ABSTRACT: An electronic musical instrument comprises a keyboard associated with a DC power source to produce a controlling DC voltage, a plurality of variable frequency oscillators which produce tone signals of variable frequency determined by the controlling DC voltage and which include a control rate adjuster so that the oscillators are always in harmonic relations very approximately, switching circuits for switching said tone signals, and means to convert the tone signals into sounds.



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SHEET 1 OF 2

FIG. 1

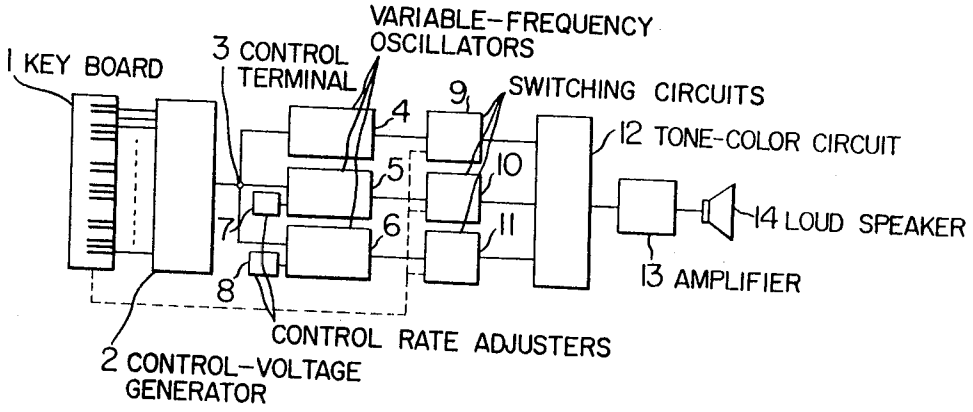
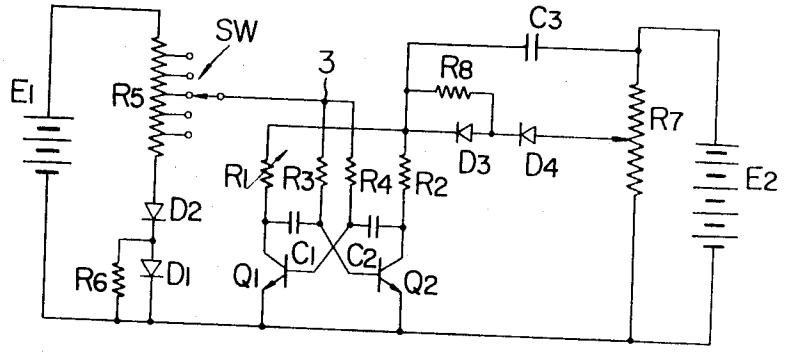


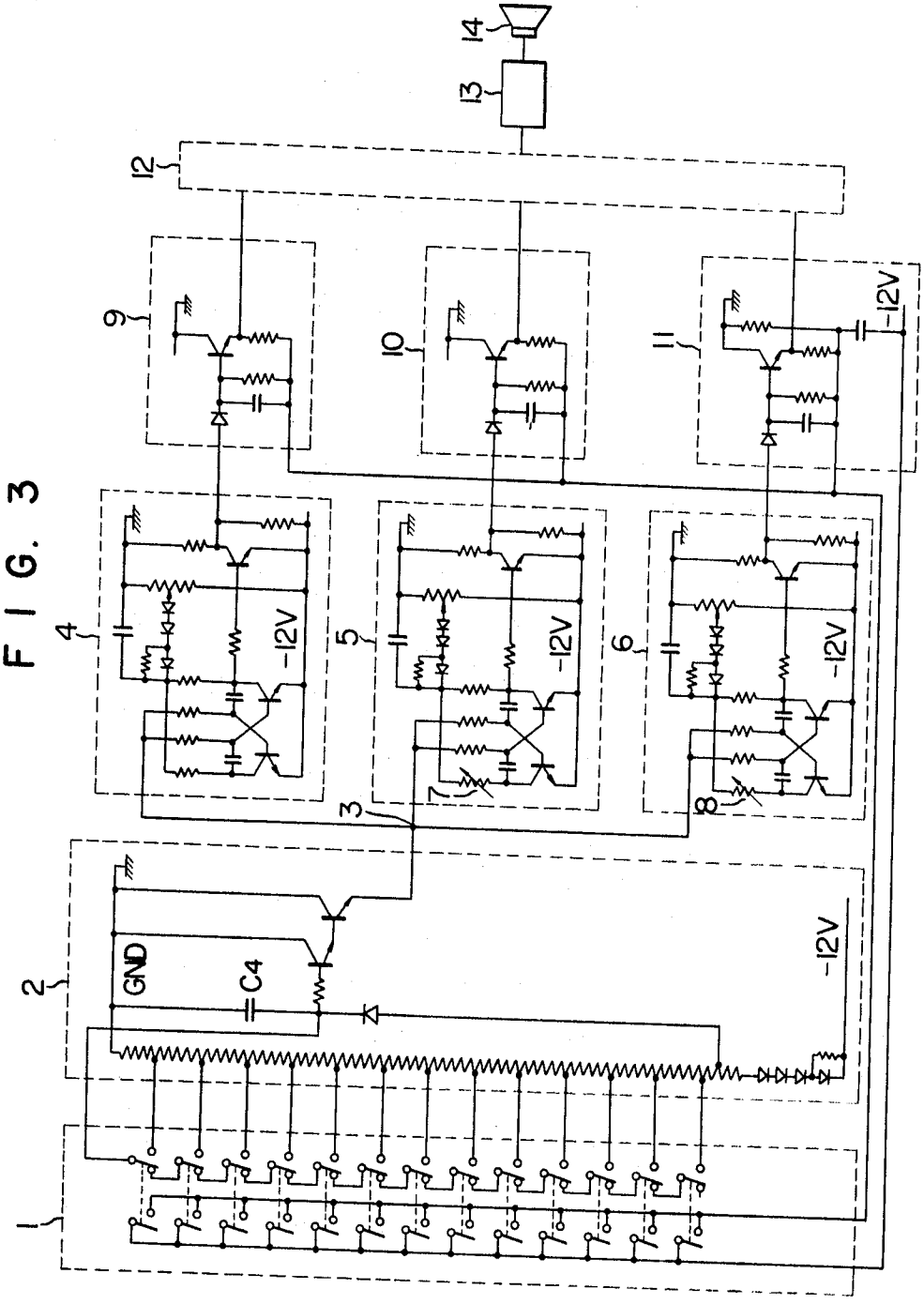
FIG. 2



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FIG. 3



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TONE-GENERATING DEVICE FOR ELECTRONIC MUSICAL INSTRUMENT

BACKGROUND OF THE INVENTION

This invention relates generally to electronic musical instruments, and more particularly to a device for generating musical tones in very approximate but not just exact harmonic relations for giving richness to musical sounds.

In order to obtain richness and wide variety in musical sounds, various types of tone-generating devices are heretofore known. A typical one of them is a so-called coupler means wherein an output frequency from a certain oscillator is admixed with higher harmonics obtained from separate oscillators, the oscillating frequency in each of the oscillators being a multiple or a submultiple of the one frequency by a number as, for instance, an even integer. As a variable frequency tone generator, there is known a variable frequency oscillator, the frequency of which is determined and controlled by a DC voltage which is applied to the control terminal and is varied by depressing a different key on the keyboard.

The inventor conducted thorough study about musical sounds and has drawn a conclusion that when a musical sound having naturalness is desired, each of the harmonic frequency components is preferably deviated a little from the exactly correct harmonic integer relationship. This deviation is more important when it is desired to obtain a broad and rich sensation of sounds such as those rendered from a pipe organ or in an orchestra where various musical instruments are played in ensemble.

For realization of the above-described frequency deviations of the harmonic components from the correct integer multiple relationship to the fundamental frequency, a plurality of separate variable frequency oscillators may also be employed, and the frequencies of the oscillators may be controlled simultaneously employing a single control voltage.

However, when these frequencies are controlled through a wide range by a single control voltage, sounds inducing unnatural and dissonant sensation have been frequently obtained, since the control rates (mathematically, d(frequency)/d(control voltage)) which mean the variation characteristics of frequencies in these oscillators in response to the single control voltage are, in an ordinary case, not equal to each other, and the harmonic relationship in these frequencies obtained from the respective oscillators becomes far from the integer relationship. Such a drawback is further aggravated by the fact that the variation rates of the oscillation frequencies of the variable frequency oscillators depending on the variation of the control voltage may be different widely by the lack of uniformity of the parts employed in these oscillators. For instance, the variation rate of the oscillating frequency in an astable multivibrator or in an astable blocking oscillator depending on the control voltage may be widely changed by the allowance variation of the base-emitter voltage V_{BE} of the transistor included therein.

To eliminate the above described disadvantages, the component parts must be selected carefully, or a plurality of control voltages individually adapted to the corresponding oscillators must be employed. However, such procedures are excessively troublesome and uneconomical.

SUMMARY OF THE INVENTION

Therefore, the principal object of the present invention is to provide a novel device for generating musical tones for an electronic musical instrument, whereby the above described drawbacks of the conventional tone generators are substantially overcome.

Another object of the present invention is to provide a novel organization of the tone-generating device wherein a plurality of oscillators are controlled from a single control voltage applied thereto.

Still another object of the present invention is to provide a novel sound-generating device for an electronic musical instrument wherein the harmonic frequencies obtained from the plurality of oscillators are slightly deviated from the exact harmonic relationship, whereby musical tones resembling those of a natural musical instrument can be obtained.

These and other objects of the present invention can be achieved by a device for generating sounds to be employed in an electronic musical instrument having keys, which device comprises a control voltage generator associated with the keys and generating when a key is depressed, a DC control voltage representing a tone name of the key being depressed; a plurality of variable frequency oscillators connected to the control voltage generator, each oscillating a tone signal having a frequency determined by the control voltage and substantially harmonically related to each other upon receipt thereof, and each except one including a control rate adjuster for varying the changing rate of the oscillation frequency in response to the change of the control voltage; switching circuits connected to the oscillators and associated with the keys for receiving and keying output signals from the oscillators upon depression of the key; a tone color circuit connected to the switching circuits for receiving the tone coloring output signals from the switching circuits; and an amplifier and a loudspeaker for converting output signals from the tone color circuit into sounds.

The nature, principle, and utility of the invention will be more clearly apparent from the following description with respect to a preferred embodiment thereof, when read in conjunction with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

In the accompanying drawing,

FIG. 1 is a block diagram showing a tone-generating device constituting one embodiment of the present invention,

FIG. 2 is an actual circuit diagram showing the construction of a preferred embodiment of a DC voltage-controlled variable frequency oscillator to be used in this device, and

FIG. 3 is a circuit diagram showing the whole construction of one embodiment of this invention.

DETAILED DESCRIPTION

Referring now to FIG. 1 in the accompanying drawings, it is seen that a tone generating device according to the present invention comprises a keyboard **1**, a control voltage generator **2** including a DC power source and a voltage divider, a control terminal **3**, three variable frequency oscillators **4**, **5**, and **6** for generating signals having frequencies determined by the control voltage, control rate adjusters **7** and **8** for controlling relations between the oscillation frequencies and the control voltage of the variable frequency oscillators **4**, **5**, and **6**, switching circuits **9**, **10**, and **11** which open or close the output signals from the variable-frequency oscillators under the operation of the keyboard **1**, a tone color circuit **12** which mixes the output signals from the switching circuits **9**, **10**, and **11** and filters so that a desired tone color is obtained, an amplifier **13**, and a loudspeaker **14**.

With this construction of the tone generating device, when a certain key in the keyboard **1** is depressed, a control-voltage from the control voltage generator **2** having a valve representing a tone name of the depressed key is applied to the control terminal **3**, whereby the variable frequency oscillators **4**, **5** and **6** are oscillated respectively at the frequencies determined by the control voltage. The output signals from the variable frequency oscillators **4**, **5** and **6** are thereafter sent to the switching circuits **9**, **10**, and **11**. Since the switching circuits **9**, **10**, and **11** are conducting at the time the corresponding key is operated, the output signals are then sent to the tone color by mixing the output signals from the variable frequency oscillators and passing the thus mixed output signals through a filter included in the tone color circuit **12**.

Now suppose the oscillating frequencies of the variable frequency oscillators **4**, **5**, and **6** having an integer relationship (of, for instance, 110, 220, and 330 Hz. respectively). Since each of the variable-frequency oscillators is oscillating inde-

pendently at the above-mentioned frequency (each of the frequencies is not maintained exactly in the above-described integer relationship as in the case wherein these frequencies are obtained from a frequency division system), the tone sensation of the resultant sound produced by mixing the output signals from the variable frequency oscillators includes harmonic components having slightly deviated frequency relationship from that of the above-description, whereby a kind of beat sounds are heard in the output obtained from the tone color circuit **12**, and the above described rich and broad tone sensation is thereby obtained.

The control rate of the variable frequency oscillators **5** and **6** with respect to the frequency control voltage can be adjusted by the control rate adjusters **7** and **8**, so that the oscillation frequencies of the oscillators **5** and **6** are changed by a substantially same rate as the frequency change of the oscillator **4** when the control voltage is changed through a wide range, whereby the harmonic relationship (not of a exact integer, but of a very approximate integer) of the three frequencies is maintained to be substantially constant throughout the scale compass of the electronic musical instrument. A typical example of the voltage-controlled variable frequency oscillator provided with the control rate adjuster is shown in detailed in FIG. **2**.

In FIG. **2**, the oscillator is constructed by an astable (free-running) multivibrator including transistors Q_1 and Q_2, resistors R_1, R_2, R_3 and R_4, and capacitors C_1 and C_2. The power for operation is supplied from a DC power source E_2 through resistors R_7 and R_8 and diodes D_3 and D_4, a capacitor C_3 being a bypass for AC signal. The control DC voltage for determining the oscillation frequency is supplied from a DC power source E_1 through resistors R_5 and R_6, diodes D_1 and D_2 and a switch SW to a control terminal **3** of the multivibrator. The resistor R_5 together with the switch SW, and the resistor R_7 function to change the oscillation frequency of the oscillator. When the switch SW is in contact with the higher tap position of the resistor R_5 and thereby the higher control voltage is applied to the terminal **3**, the oscillation frequency becomes higher. When the sliding contact of the variable resistor R_7 is set nearer to the positive side of the power source E_2, the oscillation frequency becomes lower. The variable resistor R_1 functions to change the control rate of the oscillation frequency in response to the change of the voltage of the terminal **3**. When the resistor R_1 is set at the higher value, the oscillation frequency is varied more widely to the same change of the control voltage by the switch SW. In designing the circuit, the tap positions of the resistor R_5 are determined to oscillate the respective tone pitch signals in the chromatic musical scale, using a standard circuit model with the resistors R_7 and R_1 set at proper standard values. In manufacturing the device at a factory in a mass-production quantity, the resistors R_5 are prepared having taps at such positions determined by the designing, and then the switch is brought into contact with the taps one by one to see whether the frequency intervals are too wide for the chromatic scale or too narrow. If too narrow, the resistor R_1 is varied to have a higher value until the intervals become correct for the chromatic scale. This variable resistor R_1 constitutes the control rate adjusters having the important function in this invention. And next, the absolute value of the oscillation frequency is examined. If it is too higher e.g. 240 Hz. for the note A_3=220 Hz. the sliding contact of the variable resistor R_7 is brought more positive to lower down the frequency. The adjustment by the resistor R_1 and the resistor R_7 is carried out a few times alternately, and then the switch SW can selectively determine the oscillation frequency at the respective pitches of the notes in the chromatic musical scale. The variations of the resistor R_1 also affects the absolute frequency and the variation of the resistor R_7 also affects the control rate, but the repeated adjustment as mentioned above finally brings the device into a correct or substantially correct condition. In an actual instrument, the switch SW constitutes key switches in a playing keyboard. The player has only to manipulate the playing keys during music performance. The resistors R_1 and R_7 have no longer to be adjusted after the device comes out of the factory, except when the device is subjected to reparation such as replacement of the transistor. The diodes D_1, D_2, D_3 and D_4 is for the temperature compensation together with the resistors R_6 and R_8

FIG. **3** shows one embodiment of the invention having the basic construction of FIG. **1**, with the detailed circuit diagrams, employing the variable frequency oscillators shown in FIG. **2** and other circuits of conventional constructions, so that the realizability and the operation of this invention can be better understood. In this figure, a capacitor C_4 is provided to obtain a sustain effect. This capacitor C_4 keeps the control voltage for a while even after the keyboard **1** is released, which permits the oscillators **4**, **5**, and **6** to maintain their oscillations of the same frequencies, and the sustain effect in the output sounds can be obtained through an operation of the switching circuits **9**, **10**, and **11**.

As is apparent from the above description, the fundamental and the harmonic frequencies are not maintained in an exact integer relationship, whereby an advantageous effect simulating natural auditory sensation of the sounds is imparted to the output sounds. Furthermore, since the plurality of variable frequency oscillators is controlled by a single control voltage, a coupler system of a simple and economical construction can be obtained. When this device is assembled into an electronic musical instrument, output sounds of excellent quality similar to natural sounds can be obtained when pedals or a solo device of the musical instrument is operated.

I claim:

1. A device for generating a plurality of harmonically related sounds in an electronic musical instrument having keys; which device comprises a control voltage generator associated with said keys and generating, when a key is depressed, a DC control voltage representing a tone name of said key being depressed; a plurality of variable frequency oscillators connected to said control voltage generator, each oscillating a tone signal having a frequency determined by said control voltage and substantially harmonically related to each other upon receipt thereof, and each except one including a control rate adjuster for varying the changing rate of the oscillation frequency in response to the change of said control voltage; switching circuits connected to said oscillators and associated with the keys for receiving and keying output signals from said oscillators upon depression of said key; a tone color circuit connected to said switching circuits for receiving the tone coloring output signals from said switching circuits; and an amplifier and a loudspeaker for converting output signals from said tone color circuit into sounds.

2. A device as defined in claim **1**, wherein said control voltage generator includes means providing a tone sustain effect, said means comprising a storage capacitor coupled across said voltage generator for maintaining said DC control voltage for a period of time after release of said keys.

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