United States Patent

Adachi

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[54] **KEYING SYSTEM CAPABLE OF PRODUCING PIANO-TONE EFFECTS FOR USE IN ELECTRONIC MUSICAL INSTRUMENTS**

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[52] **U.S. Cl.** **84/1.13,** 84/1.26

[51] **Int. Cl.** **G10h 1/06**

[58] **Field of Search** ..... 84/1.01, 1.09, 1.1, 1.13, 1.26, 84/DIG. 7, DIG. 8, DIG. 23, 1.17, DIG. 22

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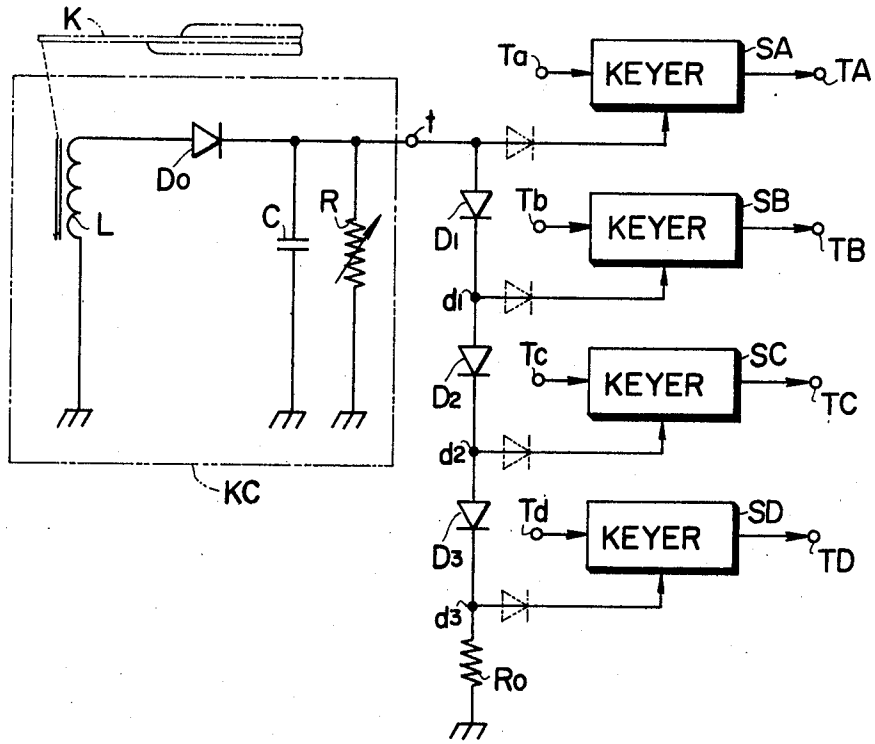
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Primary Examiner—Lewis H. Myers
Assistant Examiner—Stanley J. Witkowski
Attorney—Cushman, Darby & Cushman

[57] **ABSTRACT**

In a keyboard electronic musical instrument, a keying system is described which includes, per key and associated therewith, a percussive pulse generating circuit for generating a percussive pulse having a peak amplitude responsive to the key depressing speed, a divider circuit consisting of serially connected diodes or resistors which are supplied with the percussive pulse and in response thereto deliver percussive pulses of successively different amplitudes from a highest to a lowest. A plurality of tone keyers are also provided for respectively keying tone signals of different frequencies, which keyers are respectively controlled by the different amplitude percussive pulses delivered from the divider circuit, wherein the higher amplitude pulse controls the lower frequency keyer, etc. Thus, when a key is struck, a composite percussive sound is produced which includes a plurality of different frequency tones, wherein the higher frequency signals decays faster than the lower frequency signals. Thus the sounding effects of a piano are better simulated.

12 Claims, 14 Drawing Figures



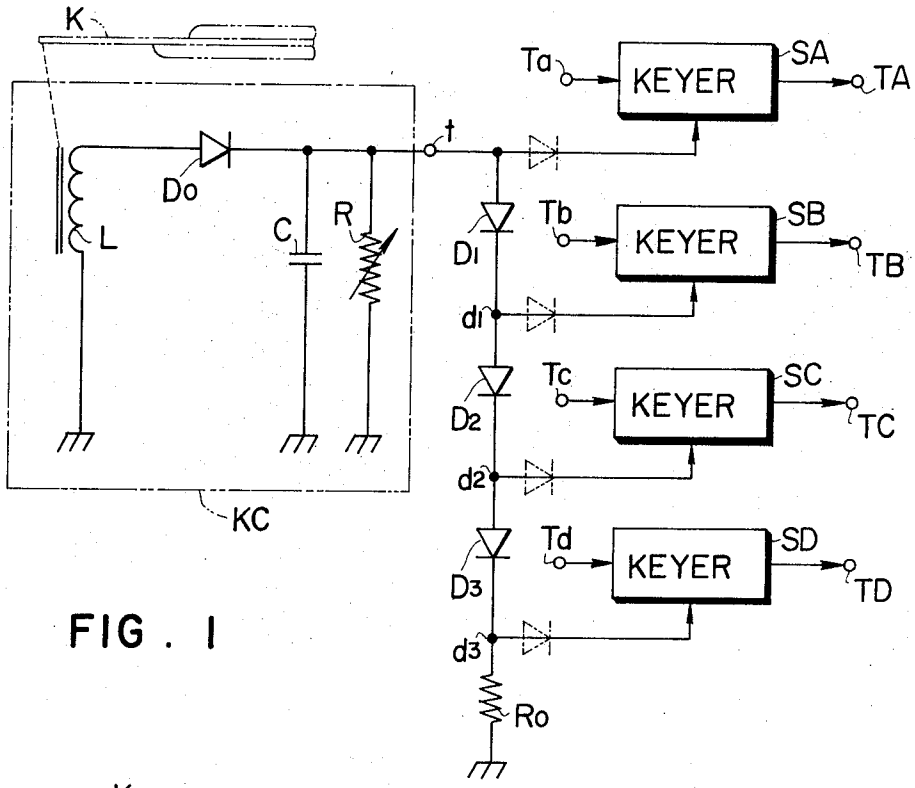

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FIG. 1

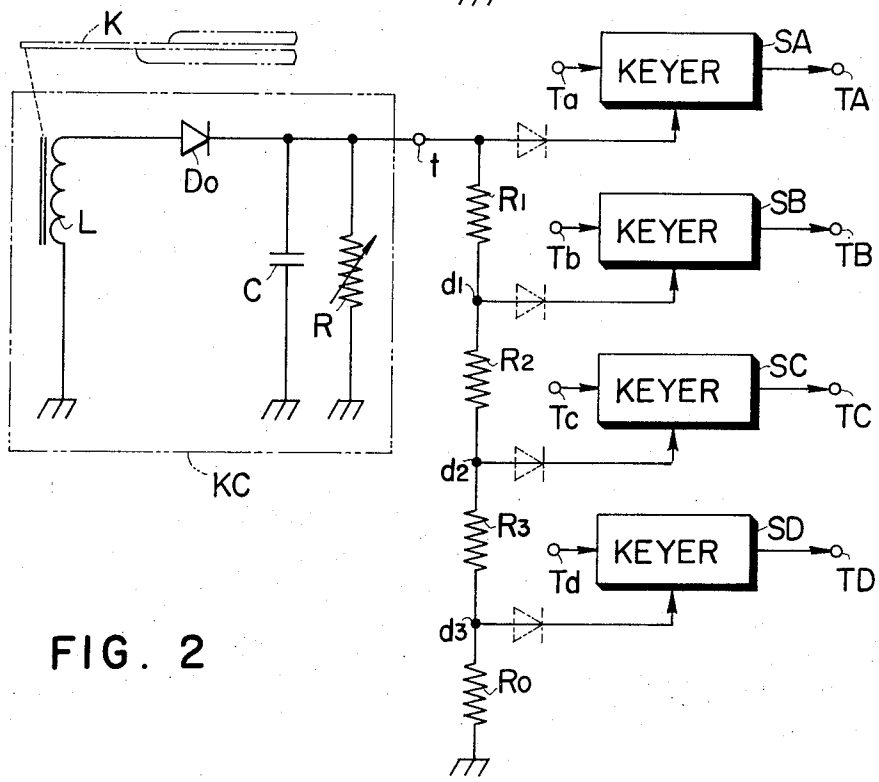

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FIG. 2

FIG. 3a

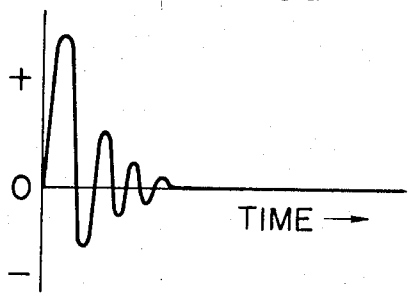


FIG. 3b

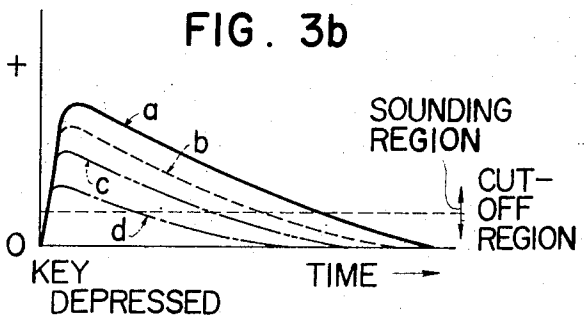


FIG. 3c

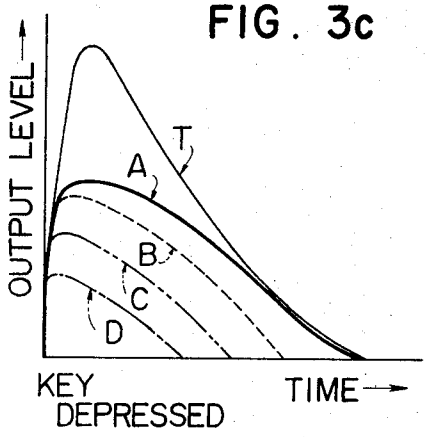


FIG. 3d

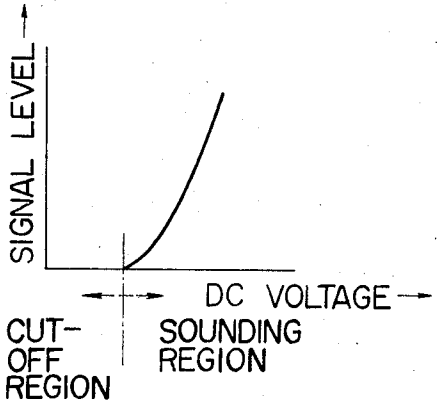


FIG. 4

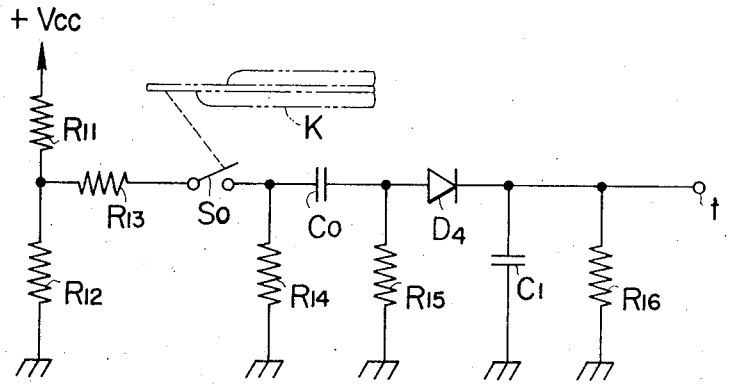


FIG. 5a

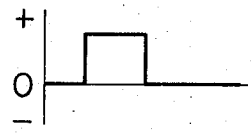


FIG. 5b

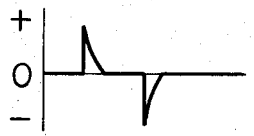


FIG. 5c

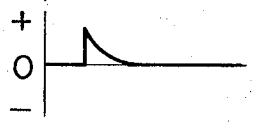


FIG. 6a

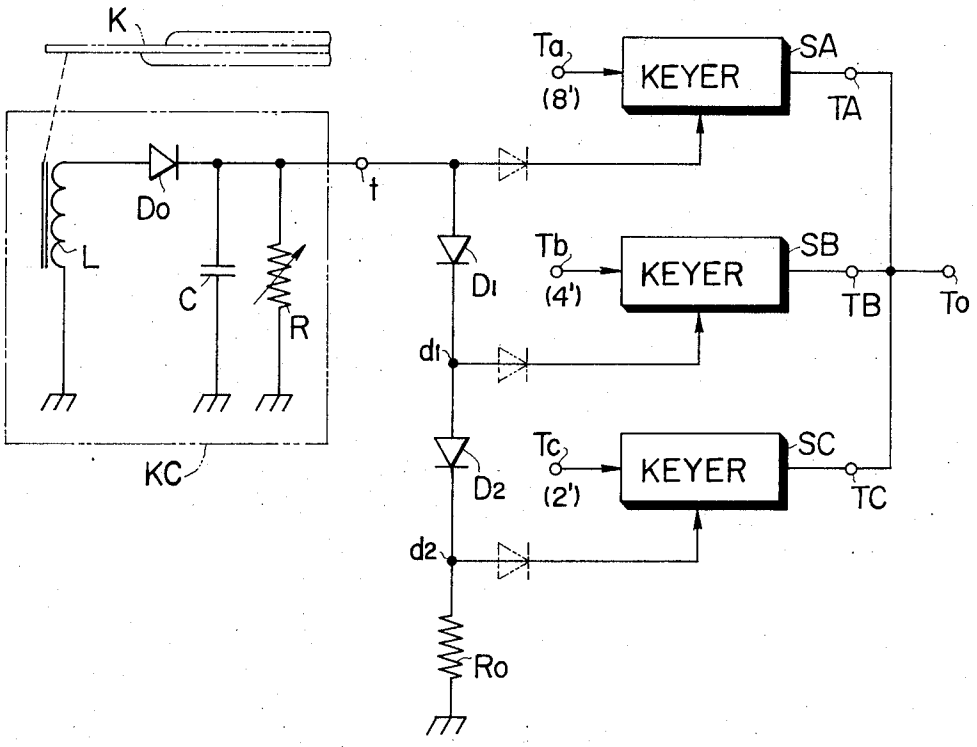


FIG. 6b

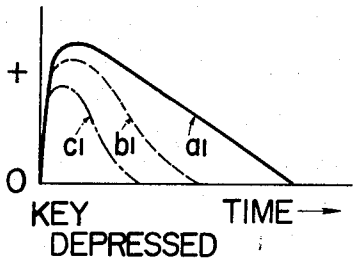


FIG. 6c

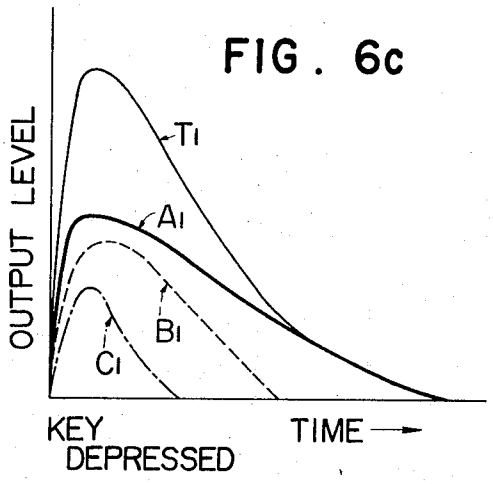
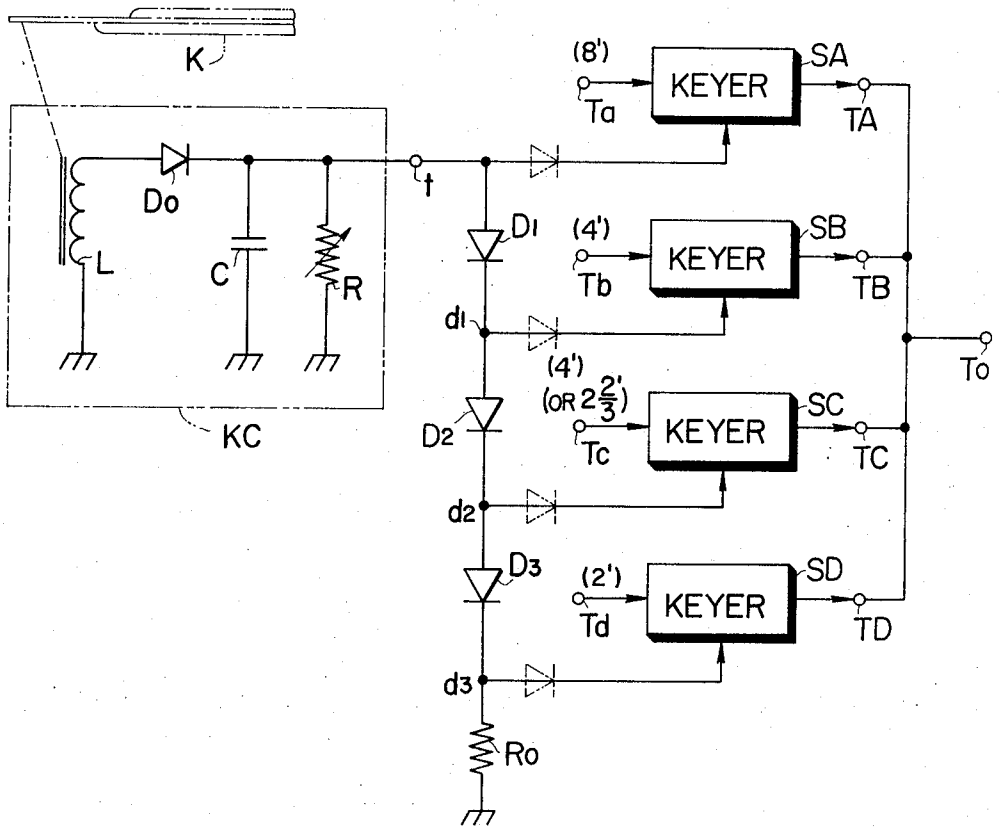


FIG. 7



KEYING SYSTEM CAPABLE OF PRODUCING PIANO-TONE EFFECTS FOR USE IN ELECTRONIC MUSICAL INSTRUMENTS

BACKGROUND OF THE INVENTION

a. Field of the Invention

The present invention is concerned with a keying system for an electronic musical instrument, and more particularly, it relates to a specific keying system of the instrument, which is capable of producing the effects of a piano in association with the operation of a corresponding key.

b. Description of the Prior Art

Heretofore, there has been known an electronic musical instrument of the type in which a single tone signal is controlled in its output envelope and the decay time thereof through a corresponding keyer in association with the manipulation of a playing key. However, no inexpensive and simple system for producing such sounding effects as the tones of a piano has ever been made or proposed, which system should be capable of producing also variations in tone color with respect to time in response to the operation of a playing key. That is to say, the system of this type which is capable of producing a tone signal having rich high harmonics components of a short decay time and relatively low harmonics and a fundamental components of a long decay time was very complicated in structure and very expensive, and therefore, it was not suitable for practical use.

SUMMARY OF THE INVENTION

It is, therefore, an object of the present invention to provide a simplified and inexpensive keying system for producing piano-tone effects for an electronic musical instrument, which permits generation of a composite tone signal having rich high frequency partials of an abrupt decaying envelope at the initial stage of its sounding.

Another object of the present invention is to provide an electronic musical instrument keying system having a number of grouped keyers, each group being controlled in association with an individual key-actuated pulse voltage generating circuit.

A further object of the present invention is to provide an electronic musical instrument keying system, in which a group of keyers - each having a different input tone signal - are controlled in amplitudes and decay time of the respective input tones simultaneously in response to the operation of a corresponding key, resulting in a composite tone output signal.

Another object of the present invention is to provide the keying system of the type described previously, in which each group of keyers has a corresponding divider circuit including voltage dropping elements such as resistors and diodes for dividing a pulse voltage generated by the actuation of the playing key into similar pulses of different amplitudes and thereby controlling said keyers individually to produce different decay times.

Other object, features, and advantages of the present invention will become apparent from the following detailed description with respect to some preferred embodiments of the invention when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic circuit diagram showing an electronic musical instrument keying system embodying the present invention;

FIG. 2 is a diagram showing a keying system of another embodiment using therein a divider circuit including a plurality of resistors in place of diodes of FIG. 1;

FIGS. 3*a* to 3*d* are diagrams for explaining the operation of the circuit systems shown in FIGS. 1 and 2;

FIG. 4 is a view showing another embodiment of a key-operated pulse voltage generating circuit of the keying system;

FIGS. 5*a* to 5*c* are diagrams showing pulse waveforms in the circuit of FIG. 4;

FIG. 6*a* is a view showing a keying system of another embodiment of the present invention, and a FIGS. 6*b* and 6*c* are diagrams for explaining the operation of the system of FIG. 6*a*; and

FIG. 7 is a view showing a keying system of a further embodiment of the present invention, similarly to FIG. 1.

It should be understood that like symbols and references indicate like parts hereunder.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1, there is shown an embodiment of the present invention, in which L indicates a coil grounded at one end thereof and adapted to vary the interlinking fluxes in association with the depression of a playing key K arranged on a keyboard of an electronic musical instrument (e.g. the key may carry a magnet thereunder), the other end of which is grounded through a series circuit of a rectifying element D_o and a capacitor C. A junction terminal *t* between the element D_o and the capacitor C is grounded through a variable resistor R, and thus, the block KC constitutes a percussive pulse generating circuit. This circuit KC delivers a pulse having an abrupt rise-up and a subsequent decay and having a peak amplitude responsive to the depression speed of the associated key.

The terminal *t* of the circuit KC is further grounded through a plurality of series-connected diodes D_1, D_2, D_3 and a resistor R_o. The terminal *t* and connection points d_1, d_2 and d_3 between the diodes D_1 to D_3 and the resistor R_o are connected to control terminals of tone keyers SA, SB, SC and SD which are available, and to their input terminals T_a, T_b, T_c and T_d, tone source signals of different footages, e.g., 8 feet, 4 feet, 2⅔ feet and 2 feet, are applied. On the other hand, at tone signal output terminals TA, TB, TC and TD of said keyers SA to SD, their output tone signals are derived individually or in combination (if mixed).

The keyers SA to SD are made non-conducting when the potentials at the control terminals (i.e. control electrodes of gating elements such as FET's or diodes used therein) are zero, whereby no tone output signal may appear at the output terminals TA to TD.

The number of the percussive pulse generating circuits KC which are installed in the console of the instrument corresponds in number to the number of individual playing keys, respectively, for example, 61.

Also, the number of the grouped keyers SA to SD may be arranged to correspond in number to the playing keys, for example, the number of all the keys multiplied by four times (e.g. 244) in the embodiment of FIG. 1. In case tone source circuits of the same pitches are used in common, for example, when the tone source signals are of 8 feet, 4 feet, 2⅔ feet and 2 feet in footage, the number of the keyers may be the number of all the keys plus 2 × 12 (e.g. 85). In this latter case, a diode should be provided between each of the connection points d_1 to d_3 and the corresponding each keyer to prevent the interlinking of unnecessary keyers.

Reference is now made to the operation of the above-mentioned circuit with reference to FIGS. 3*a* to 3*d*.

At first, when any one key K provided in the instrument is depressed, a magnetic member — which may be either magnetized or not magnetized and which may be attached to the key — moves toward or away from the fixed coil L, thereby generating a damped pulse voltage — whose peak amplitude is approximately proportional to the intensity or the speed of depression of the playing key — due to variation in interlinking fluxes established around the coil, as shown by a waveform in FIG. 3*a* (alternating due to bounding of the element). The induced alternating voltage is rectified through the diode D_o and as a result, positive DC components developed at the diode D_o are stored on the capacitor C. Then, since the charges stored on the capacitor C are discharged through the relatively high resistance resistor R, the variation in the potential at the terminal *t* becomes slowed down (percussive form) as shown by curve *a* in FIG. 3*b* and thus, the envelope of a tone source signal e.g. 8 feet obtained at the output terminal TA of the keyer SA is obtained in such a form as indicated by curve A in FIG. 3*c* and will have a relatively prolonged period of decay time.

Due to the voltage-current characteristic (especially the forward non-conducting region) of the employed diodes D_1 to D_3 as shown in FIG. 3*d*,a voltage appearing at the terminal *t* is divided and appears at the connection points d_1, d_2 and d_3 at reduced levels. For example, a silicon diode has a forward voltage drop of about 0.6 volt and, if such diodes are employed as the series-connected diodes D_1 to D_3, voltage drops of 0.6 volt occur across D_1 and D_3, respectively. Accordingly, it will be understood that the voltage *a* applied to the terminal *t* becomes as shown by curves *b*, *c* and *d* in FIG. 3*b* at points d_1, d_2 and d_3, respectively, thus providing reduced decay times by deriving the applied voltage at the points d_1, d_2 and d_3. As a result, at the output terminals T_B, T_C and T_D of the associated keyers, the envelopes of different footage signals (e.g. 4 feet, 2⅔ feet and 2 feet respectively) become as shown by curves B, C and D in FIG. 3*c*, respectively, which successively are rendered leveled down and are shortened in time. Therefore, if output tone signals of such characteristics are mixed (electrically or acoustically) and derived, a composite signal thus derived becomes as shown by curve T of FIG. 3*c*, which has a rapidly decaying higher harmonics components and relatively more slowly decaying lower harmonics components; thus presenting a tone signal having variations in tone color with respect to time. Such a signal makes a sound effect quite similar to the effects obtained from a piano. In this case, the tone signals gang-keyed by the manipulation of a key should preferably be of 8-foot, 4-foot, 2⅔-foot and 2-foot register signals, wherein the slight (2 cents) deviation of the 2⅔-foot signal from the exact integer relation with other footage signals brings forth a beat effect, thus increasing the similarity to the piano sound. Or otherwise, the tone signals may be of 8-foot, 4-foot and 2-foot register signal from a common divider chain and of 4-foot register signal from another divider chain, wherein the slight difference in the signal frequencies between 4-foot register signals of the different divider chains brings forth a beat effect, thus increasing the similarity to the piano sound.

As the voltage induced across the coil L (in FIG. 3*a*) corresponds to the depressing speed or depressing intensity of the key K at the time this key is depressed, the level of said each tone source signal can be varied overall in response to the key depressing speed. Accordingly, when the key is depressed quickly, the keyed tone signals of different footages not only are all totally increased in their levels but also in the decay times or sustain times thereof as well, while when the key is slowly depressed, the keyed tone signals are all totally decreased in level as well as decay time.

In the above embodiment, the percussive pulse generating circuit KC used is of the type which provides a sawtooth pulse whose level is varied in response to the depressing speed of the key K thereby providing a so-called touch-responsive effect to the keyed output. However, the circuit KC may be of the type providing an approximate sawtooth wave signal independently of the depressing speed or depressing intensity of the key as shown in FIG. 4.

In this Figure, when a key-actuated normally open switch S_o is closed and then opened upon the operation of the key K, a positive voltage at a power source +Vcc is divided by resistors R_{11} and R_{12}, and resistors R_{13} and R_{14}, respectively, to produce a rectangular wave voltage of FIG. 5a across a resistor R_{14}. This rectangular wave voltage is differentiated by a differentiator consisting of a capacitor C_o and a resistor R_{15}, to develop a voltage waveform of FIG. 5*b*. This waveform is rectified by a rectifier D_4 to provide only its positive components. The positive-going differentiated pulse is subjected to waveform shaping through a capacitor C_1 and a resistor R_{16} into an approximate sawtooth waveform DC voltage (percussive pulse) as shown in FIG. 5c. Such a voltage may be used as the keying signals to the keyers SA to SD through the divider circuit made of series-connected voltage dropping elements.

FIG. 2 shows a modification of FIG. 1 in which only series-connected diodes D_1 to D_3 are substituted by resistors R_1 to R_3. The functions and effects of this embodiment are substantially the same as the embodiment of FIG. 1.

FIG. 6a shows an example of the keying system in which three keyers, each having an individual tone signal of a different footage (e.g. 8 feet, 4 feet and 2 feet) at its input terminal, are controlled simultaneously by an associated key and the respective keyed outputs are combined in a common terminal T_o. The keying signals supplied to the keyers SA, SB and SC exhibit voltage forms *a*1, *b*1 and *c*1 as shown in FIG. 6*b*, respectively. And as a result, the envelopes of the

respective keyed tone signals of different foot registers (i.e. 8 feet, 4 feet and 2 feet) exhibit curves A_1, B_1 and C_1 as shown in FIG. 6c, respectively, the mixed tone signal output at the terminal T_o having an envelope of a curve T_1 as shown in FIG. 6c.

FIG. 7 shows a modification of FIG. 1 in which the outputs of the four keyers SA to SD are combined at a common output terminal T_o, the keyers keying the tone signals of 8 feet, 4 feet, another 4 feet and 2 feet registers or the tone signals of 8 feet, 4 feet, 2⅔ feet and 2 feet registers.

I claim:

1. A keying system for an electronic musical instrument having a number of playing keys, comprising, per key:

a percussive pulse generating circuit associated with each individual key for generating a percussive electrical pulse in response to the operation of its respectively associated key;

a voltage divider circuit including serially connected voltage dropping elements connected to each of said percussive pulse generating circuits for delivering a plurality of electrical percussive pulses of respectively different amplitudes; and

a plurality of tone keyers for respectively keying tone signals of different frequencies, which keyers are respectively connected to said voltage dropping elements to effect correspondingly respective control by the respective percussive pulses of different amplitude delivered from said voltage divider circuit, the higher amplitude pulses controlling the keyers for the lower frequency tone signals.

2. A keying system according to claim 1, in which said voltage dropping elements comprise at least one resistor and a plurality of diodes.

3. A keying system according to claim 1, in which said voltage dropping elements comprise all resistors.

4. A keying system according to claim 1, in which said percussive pulse generating circuit includes means for generating said percussive electrical pulse having a peak amplitude responsive to the depressing speed of said associated key.

5. A keying system according to claim 1, in which said percussive pulse generating circuit includes means for generating said percussive electrical pulse as a constant pulse waveform regardless of the depressing speed of said playing key.

6. A keying system according to claim 1, in which said tone keyers associated with a key are four in number and which include means for producing an 8-foot, a 4-foot, a 2⅔-foot and a 2-foot register tone signal, respectively.

7. A keying system according to claim 1, in which said tone keyers associated with a key are four in number and which include means for producing an 8-foot, a first 4-foot and a 2-foot register tone signal and a second 4-foot register tone signal which is derived from other tone generator than said first 4-foot register tone signal, respectively.

8. In a keying system for an electronic musical instrument having a number of playing keys and a percussive signal generator, an improvement for more accurately generating percussion tonal effects with tone color approximating that of a true percussion instrument, said improvement comprising:

a voltage divider means having an input connected to said percussive signal generator to receive a percussive electrical pulse shaped to approximate the general amplitude rise-time and decay-time characteristics of percussion generated sounds in response to the actuation of a playing key,

said voltage divider means having plural outputs for providing a plurality of control pulses corresponding in shape to said percussive electrical pulse, but with each succeeding control pulse being successively reduced in amplitude from the preceding one,

a corresponding plurality of tone keyer means, each connected to key tone signals of predetermined frequencies in response to a corresponding one of said control pulses which are respectively connected thereto for causing the lower frequency tone signals to be keyed by the higher amplitude control pulses whereby the higher frequency keyed tones decay more quickly than the lower frequency keyed tones thereby more closely approximating the tone color characteristics of a true percussion instrument.

9. An improvement as in claim 8 wherein said voltage divider means includes both resistive and diode elements.

10. An improvement as in claim 8 wherein said voltage divider means comprises all resistive elements.

11. An improvement as in claim 8 wherein outputs of a plurality of tone keyer means are electrically connected in common for mixing the keyed tone signals.

12. An improvement as in claim 8 wherein at least one voltage divider means output is connected by diodes to control more than one tone keyer means.

* * * * *