

[54] **TOUCH-RESPONSIVE TONE
ENVELOPE CONTROL CIRCUIT FOR
ELECTRONIC MUSICAL
INSTRUMENTS**

[72] Inventor: **Ryu Hiyama**, Hamamatsu, Japan

[73] Assignee: **Nippon Gakki Seizo Kabushiki Kaisha**,
Hamamatsu-shi, Japan

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[58] Field of Search **84/1.01, 1.04, 1.11, 1.12,
84/1.13, 1.17, 1.19, 1.26, 1.27**

[56]

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Primary Examiner—Lewis H. Myers

Assistant Examiner—U. Weldon

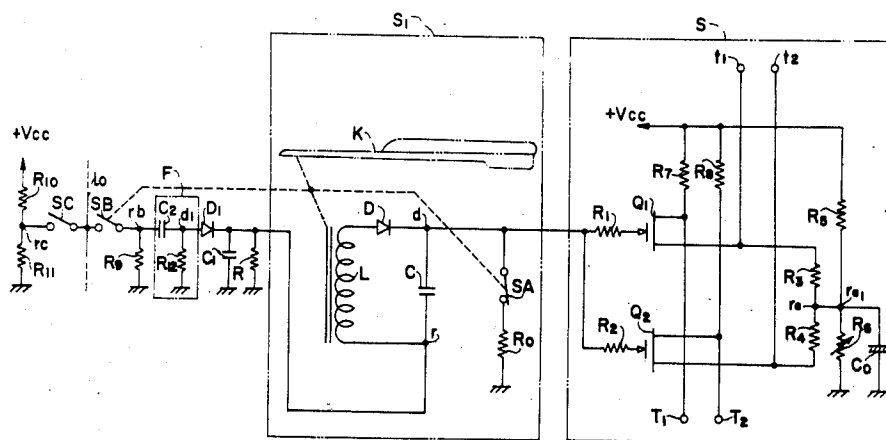
Attorney—Cushman, Darby & Cushman

[57]

ABSTRACT

In a keying system for an electronic musical instrument in which an individual keyer is controlled in response to the intensity of depression of a corresponding playing key so that a keyed tone signal has an amplitude in accordance with the key depression intensity, an impulse supply means associated with the operation of the key is provided to additively control the keyer individually. The impulse signal applied to the keyer determines the buildup envelope (amplitude) characteristic of the keyed tone signal. The system is simple in construction and easy to manufacture and provides a variety of excellent tonal effects.

7 Claims, 13 Drawing Figures



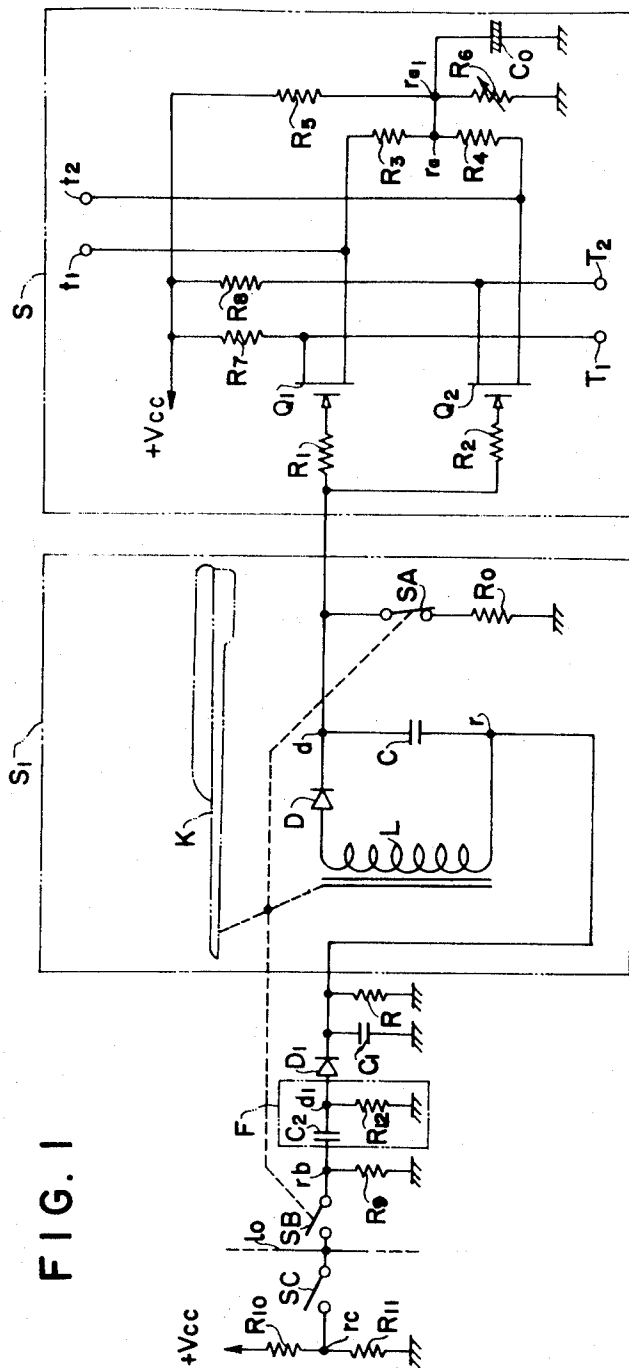


FIG. 1

INVENTOR.

BY

Guy Miyama
Pushman, Parley & Lusk
 ATTORNEYS

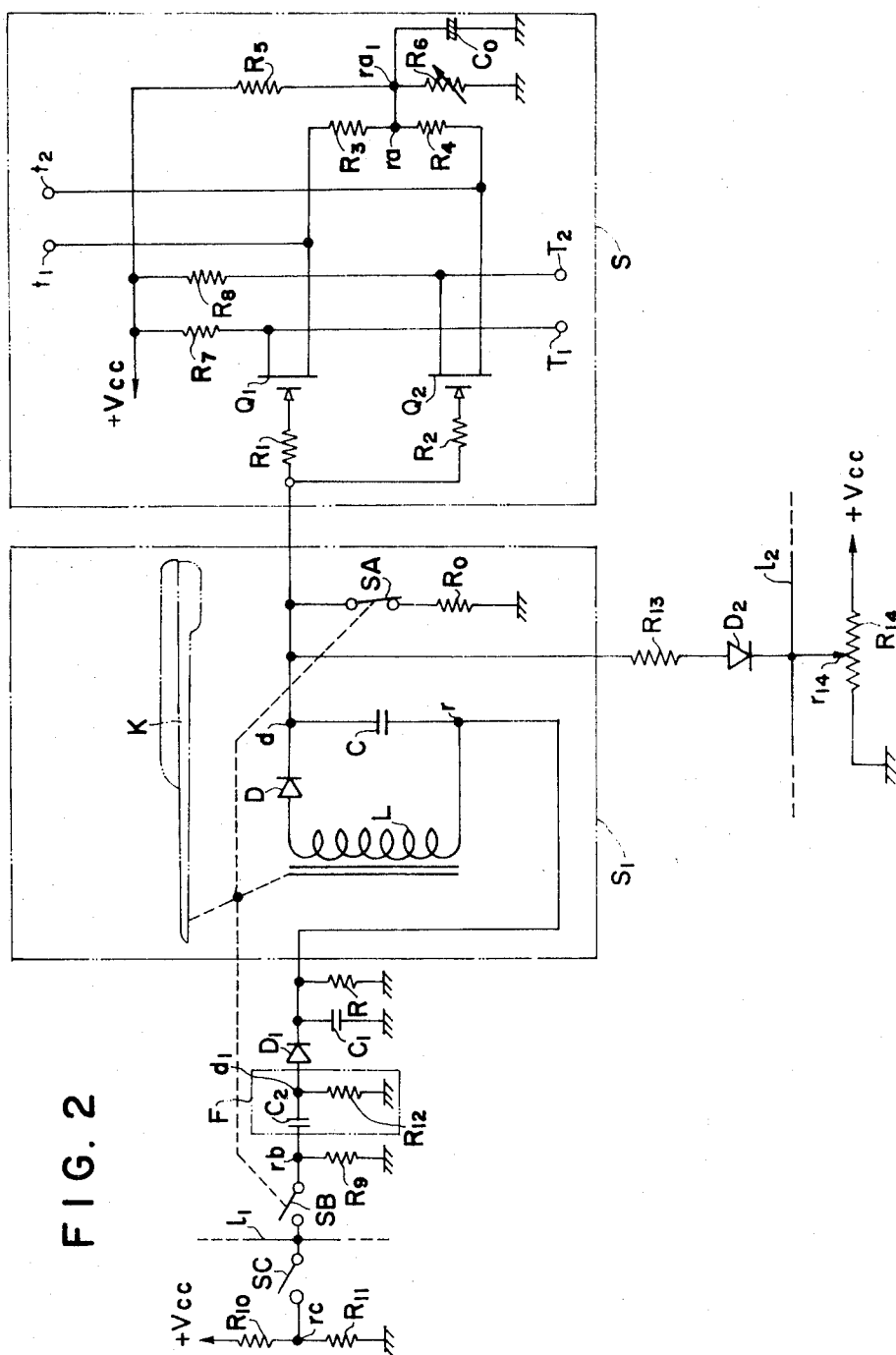


FIG. 2

INVENTOR.

BY *Shun Okuyama*
Pushman, Dandley & Lushon
 ATTORNEYS

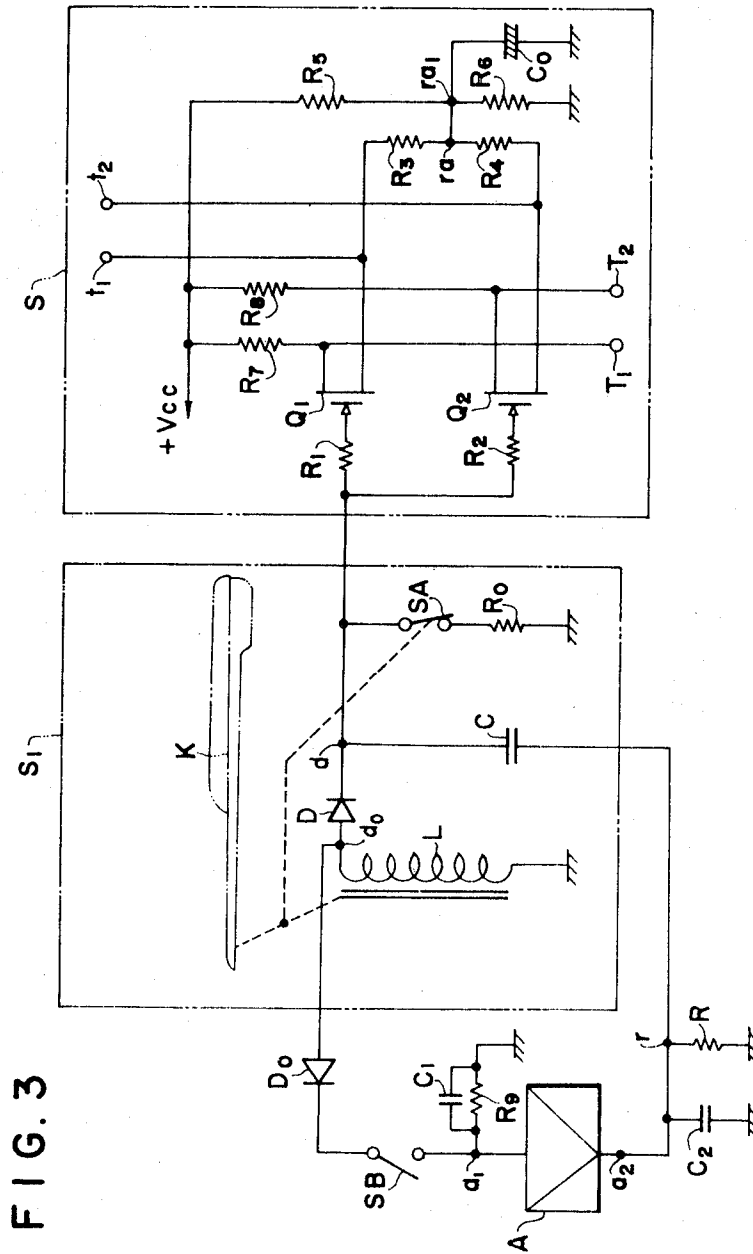
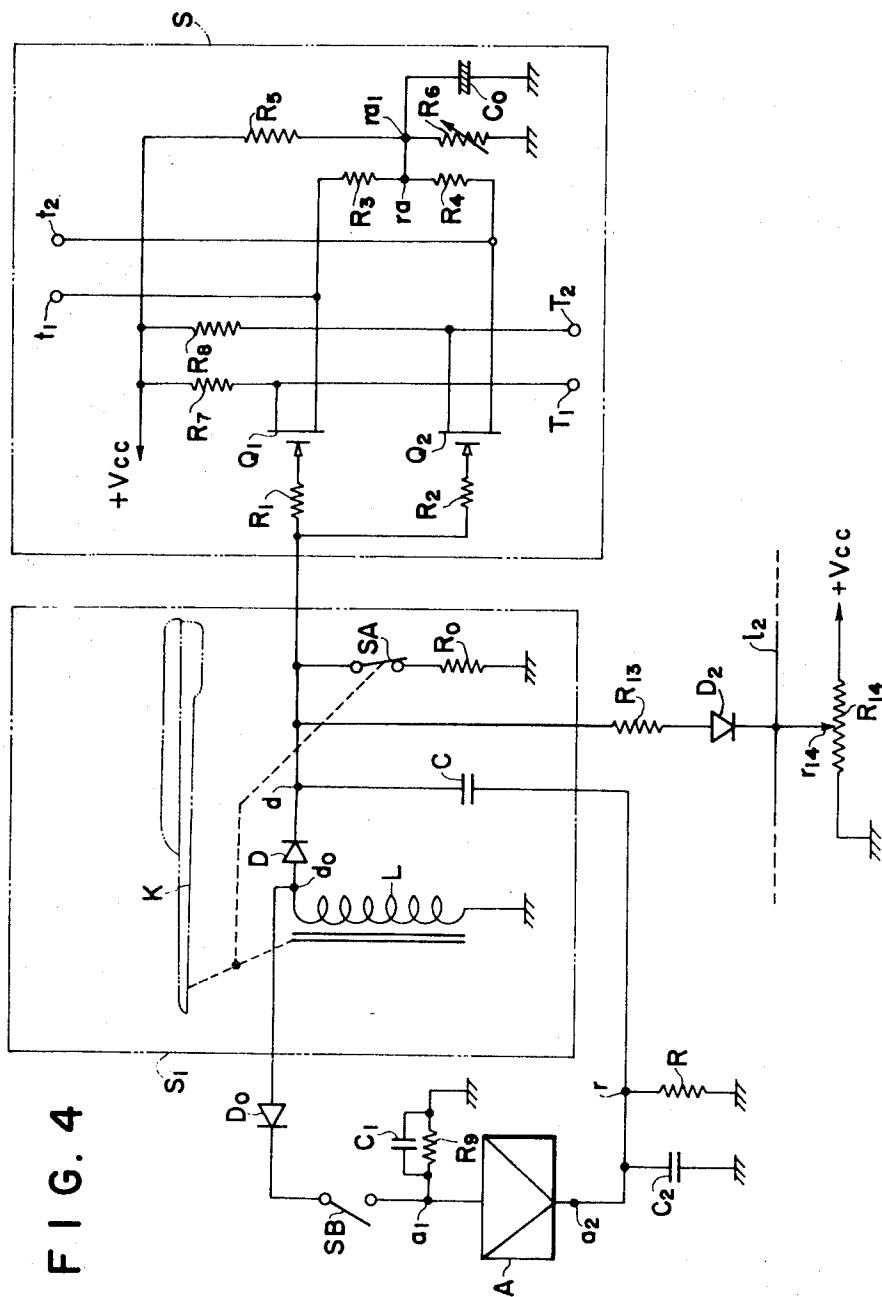


FIG. 3

INVENTOR.

BY

Cher E. Egan
Tushman, Darby & Cushman
 ATTORNEYS



INVENTOR.

BY *Paul Higama*
Customs, W. Dwyer & Co.
ATTORNEY

FIG. 5

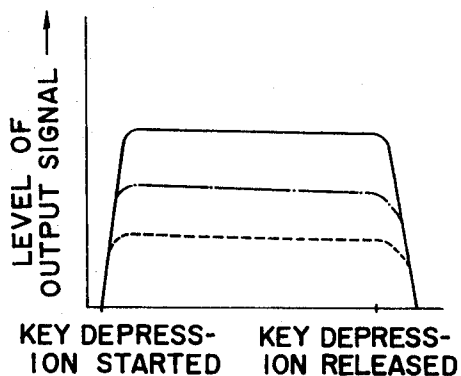


FIG. 6

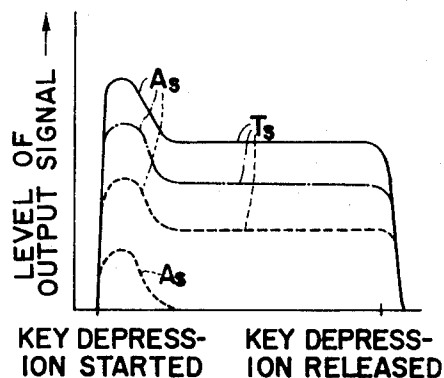


FIG. 7

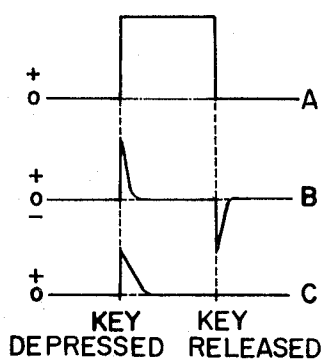
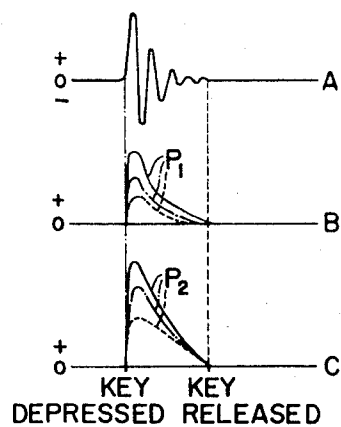


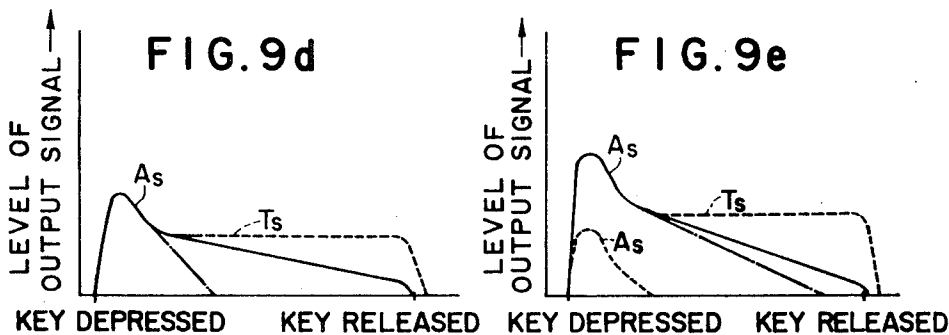
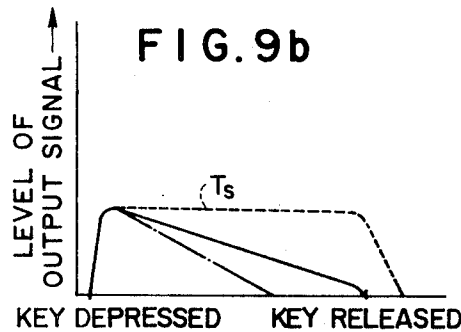
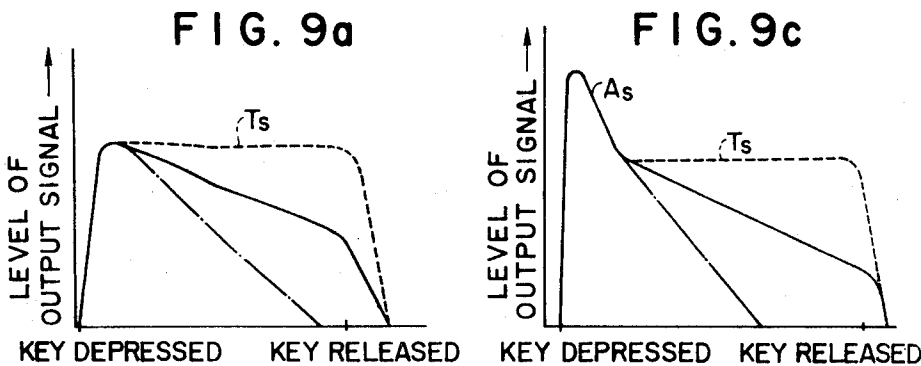
FIG. 8



INVENTOR

BY

Edwin Higuma
Cushman, Darby & Cushman
ATTORNEY



INVENTOR.

BY

Ryu Higama
Cushman, Darby & Cushman
ATTORNEYS

TOUCH-RESPONSIVE TONE ENVELOPE CONTROL CIRCUIT FOR ELECTRONIC MUSICAL INSTRUMENTS

The present invention relates to a touch-responsive tone envelope control circuit for electronic musical instruments, and more particularly, to a specific tone envelope control circuit which can improve the tone envelope effects in a key-operated electronic musical instrument such as an electronic organ to provide excellent effects of music being played.

Recently, the same inventor has developed a tone envelope control circuit of a touch-responsive keying type which permits an electronic musical instrument using the control circuit to provide a variety of excellent tonal effects by making use of the effect that the tone envelope is subjected to the intensity of a playing key depression, called a "touch-responsive control effect."

In association with the art as mentioned above, many attempts have been made by the inventor for providing various kinds of keying effects affecting the mood of music being played.

It therefore, is the principal object of the present invention to provide a keying system with a tone envelope control function for an electronic musical instrument, in which the output of the system may attain a tone signal having a buildup portion in amplitude, which is so called "an attack signal," in addition to the "touch-responsive control effect."

Another object of the present invention is to provide a touch-responsive keying system including a plurality of circuits each capable of producing a signal of a predetermined buildup amplitude, so called an attack signal, irresponsive to the intensity of a key depression thereby to cause a change in the envelope (amplitude) of a keyed tone signal.

A further object of the present invention is to provide a touch-responsive keying system including a plurality of circuits each capable of producing a buildup signal or attack signal providing a change in a keyed tone signal in accordance with the key depression intensity.

A still further object of the present invention is to provide a touch-responsive keying circuit having a plurality of circuits each supplying a buildup amplitude signal to a keyer circuit producing the touch-responsive control effect and a percussion effect.

Other objects, features and advantages of the present invention will be apparent from the following detailed description taken in conjunction with the accompanying drawings in which,

FIG. 1 is a circuit diagram showing an embodiment of the present invention,

FIG. 2 is a circuit diagram showing a modification of the circuit shown in FIG. 1,

FIG. 3 is a circuit diagram showing another embodiment of the present invention,

FIG. 4 is a circuit diagram showing a modification of the circuit shown in FIG. 3, and

FIGS. 5 to 9a-9e are diagrams for explaining the operations or functions of the circuits shown in FIGS. 1 to 4, respectively.

Now, same characters or references indicate same parts hereunder.

Referring now to FIG. 1, there is shown a first preferred embodiment of the present invention.

L designates a coil adapted to vary the interlinking fluxes in association with depression of an operating key arranged on a keyboard of an electronic musical instrument (e.g., the key carries a magnet thereunder), one end of which is connected through a series circuit of a rectifying element D and a capacitor C to the other end. A junction *d* between the element D and the capacitor C is connected to a movable contact of an on-off switch SA whose stationary contact (normally closed) is grounded via a resistor *R*₀ and which is actuated in association with the operation of the key K. The connection point *d* is also connected respectively through resistors *R*₁ and *R*₂ to the gates of field effect transistors *Q*₁ and *Q*₂ (hereunder referred to as FET's) between whose source series connected resistors *R*₃ and *R*₄ are connected. The connection point *r*_a of the re-

sistors connects with the juncture *r*_{a1} of bleeder resistance elements *R*₅ and *R*₆ connected in series between a DC voltage +*V*_{cc} of a power source and ground. The juncture *r*_{a1} is also grounded via a capacitor *C*₀.

The sources of the FET's *Q*₁ and *Q*₂ are adapted to receive through terminals *t*₁ and *t*₂ individual tone signals each having a predetermined frequency of different footage, produced by conventional tone generators of the electronic musical instrument (not shown), respectively. At the drains of the FET's *Q*₁ and *Q*₂, load resistors *R*₇ and *R*₈ connected to the power voltage +*V*_{cc} at their one ends are connected at the other ends, respectively. At the connection points of the drains of the FET's *Q*₁ and *Q*₂ and the load resistors are provided respectively output terminals *T*₁ and *T*₂ which are adapted to develop the tone signals each having a required envelope (amplitude) and a different footage number applied to the input terminals *t*₁ and *t*₂ from the respective drains thereof by varying the gate potentials at the FET's *Q*₁ and *Q*₂ in association with the operation of the key. As a whole, the above-mentioned arrangements are shown as a key-depressing speed-detecting circuit *S*₁ and a keyer circuit *S* by two two-dot chain blocks in FIGS. 2 through 4 and FIG. 1.

Further, the juncture *r* between the capacitor *C* and the coil *L* in the detecting circuit *S*₁ is grounded through a parallel circuit of a resistor *R* having a low resistance and a capacitor *C*₁, and is further grounded via in turn a rectifying element *D*₁, capacitor *C*₂ and resistor *R*₉ connected in series. The connection point *r*₀ of the capacitor *C*₂ and resistor *R*₉ is connected to a movable contact (normally open) of an on-off switch SB, which is actuated to close upon depression of the key *K* and whose stationary contact is connected to a common DC supply line *I*₀. The line *I*₀ is connected through another manually actuated switch SC to the connection point *r*_c between bleeder resistors *R*₁₀ and *R*₁₁ disposed between the power source +*V*_{cc} and ground. The connection point *d*₁ between capacitor *C*₂ and rectifying element *D*₁ is grounded via a resistor *R*₁₂. The capacitor *C*₂ and the resistor *R*₁₂ constitute a differentiation circuit *F*.

The common line *I*₀ is used in common to the whole keying circuit in the electronic musical instrument, particularly to the whole detecting circuit *S*₁ at their predetermined positions.

The keyer circuit *S* is so constructed that the gate-to-source potential of each FET's *Q*₁ and *Q*₂ is set through the resistors *R*₅ and *R*₆ at such a required value that when each of the gate potentials is at an earth potential, i.e., zero volts, each of the FET's is caused to be nonconducting so that the drain-source impedance is rendered extremely high. The movable contacts of the on-off switch SA provided in the detecting circuit *S*₁ and switch SB are arranged to make them respectively open and closed only when the key is depressed. The number of the detecting circuits *S*₁ and the keyer circuits *S* which are installed in the console of the electronic musical instrument corresponds in number to the playing keys, for example, 61.

Now, description will be made on the operation of the above-mentioned circuit arrangement.

At first, under a condition that the switch SC is held open, when any one key *K* provided in the electronic musical instrument is depressed, a magnetic member (magnetized) attached to the key moves close to or away from a fixed coil *L*, thereby resulting in a damped pulse voltage approximately proportional to the intensity or speed of depression of a playing key due to a variation in interlinking fluxes established round the coil. The induced alternative voltage (shown FIG. 8A) is rectified through the element *D* and as a result, a positive DC voltage developed at the element *D* is stored in the capacitor *C*. As soon as the charge stored on the capacitor *C* is applied respectively through the resistors *R*₁ and *R*₂ to the gates of the FET's *Q*₁ and *Q*₂, the respective drain-source impedances are caused to be reduced in response to the gate input levels of the FET's, so that the individual tone signals applied to the sources of the FET's may be derived at the output terminals *T*₁ and *T*₂ provided at the drain side thereof.

At this time, since the movable contact of the switch SA is actuated in interlocked relation with the operation of the key K, namely, since the contact is made open to the stationary contact only during depression of the key as shown by a dotted line in FIG. 1, the positive charge stored on the capacitor C is blocked by a reversely connected diode D to flow toward the coil thus, no discharge is caused, and hence, the charge is applied through resistors R_1 and R_2 to the gates of the FET's Q_1 and Q_2 , resulting in reduction of the source-drain impedance of each of the FET's in response to the intensity of key depression as mentioned above. As a result, the tone input signals separately applied to the respective sources of the FET's may be derived at the output terminals T_1 and T_2 which are on the drain side of the FET's separately. The envelope (amplitude) of the output tone signal varies in response to the intensity or speed of the key depression as shown in FIG. 5. That is, upon quick depression of key, the charge stored on the capacitor C provides a high potential, causing an output tone signal of a high level as indicated by solid line in FIG. 5, while with slow depression of key, the output tone signal may be obtained at a low level as indicated by a dotted line in FIG. 5. Thus, the present arrangement permits a tone envelope control which provides a so-called touch-responsive effect in an electronic musical instrument and which provides said effect resembling that of a piano.

In the case described above, if the playing key K is kept depressed, no further alternating voltage is induced in the coil L. However, since the input gate impedance of each of the FET's Q_1 and Q_2 is greatly high (for example, 10^9 ohms) the charge stored on the capacitor C immediately after depression of the key has no discharging path, and accordingly, it does not discharge for a long period of time, so that the FET's Q_1 and Q_2 are held in their conducting states during the depression of the key, at each of terminals T_1 and T_2 , continuously providing the output tone signal having a level responsive to the intensity of the key depression.

Upon release of the key being depressed, the key is made restored by its self-return action and simultaneously, the movable contact of the on-off switch SA is also returned to be in contact with the contact at the position as shown by a solid line in FIG. 1, so that the charge stored on the capacitor C discharges in a short period of time through the resistor R_0 having a relatively low resistance. Accordingly, the gate potential of each of the FET's Q_1 and Q_2 becomes the earth potential, i.e., zero volts to render the FET's Q_1 and Q_2 to be in their nonconducting states, so that no output signal is developed at both terminals T_1 and T_2 .

Then in a condition in which the manual switch SC is kept closed, upon depression of the key the switch SB associated with the operation of the key is made closed there appears across the resistor R_0 a rectangular wave signal having a given positive voltage amplitude, which is shown in FIG. 7A, and the voltage of which is such that a positive voltage of the power source +Vcc is divided by the bleeder resistors R_{10} and R_{11} . The signal is differentiated by the differentiation circuit F into positive-going and negative-going pulses as shown in FIG. 7B, and then the pulses are filtered by the rectifying element D₁ to derive only the positive-going pulse. The derived positive-going pulse is charged on the capacitor C₁, and raises instantaneously the potential at the juncture r, which is as shown in FIG. 7C. The change in the potential at the juncture r is applied through the capacitor C to the gates of FET's Q_1 and Q_2 of the keyer circuit, so that the FET's are made in their conducting states for a short period of time, for example, 0.1 to 0.5 seconds immediately upon the key depression, instantaneously providing at the respective output terminals T_1 and T_2 on their drain side tone signals of high levels, respectively. The signals of this type may be called attack sounds. At the same time, the charge stored on the capacitor C in accordance with the key depression intensity can maintain the conducting states of the FET's Q_1 and Q_2 . Therefore, at the outputs of the keyer circuit may be provided tone signals each in which an attack sound component is partially superimposed on touch-

responsive sound component T_s , as shown in FIG. 6. It will be noted from FIG. 6 that various levels of the outputs may be made in accordance with the intensity of depression of the key. For example, if the key is very slowly depressed or with a very weak key depression, the touch-responsive sound component T_s can not be perceived, and hence, only the attack sound component A_s can be derived at the terminals T_1 and T_2 .

Now, upon release of the depressed key, the key K, the switches SA and SB are restored, and the charge thus stored is thoroughly discharged, so that the FET's are made in their nonconducting states, no output signal being derived, the remaining charge stored on capacitors C₁ and C₂ are discharged respectively through resistors R and R_9 and R_{12} . Further, the levels of the attack sound can also be varied by changing the dividing ratio of the bleeder resistors R_{10} and R_{11} supplied with the voltage of power source +Vcc.

In the circuit arrangement, since the attack sound can be obtained irresponsive to the key depression intensity, the build-up envelope characteristic in the produced tone signal becomes much distinct to thereby permit a variety of excellent tonal effects.

Referring to FIG. 2, there is shown a modification of the embodiment of FIG. 1. The different portion of the modified system from the previous one is as follows. The connection point d in the key depression speed-detecting circuit S₁ is further connected through a series circuit of a resistor R_{13} and a unidirectional conducting element D₁ such as a diode to a common potential line l_2 , which is connected through a potentiometer R_{14} having a slidable contact r_{14} to the positive voltage of the power supply +Vcc, thus constituting a discharging path (circuit).

In operation, when the switch SC is made open, the connection point r is held at a zero potential and therefore, the charge stored on the capacitor C in accordance with a key depression intensity only permits control of the gates of the FET's Q_1 and Q_2 as it is gradually discharged through the discharging path. That is, the envelope (amplitude) characteristics in the output tone signal can be varied as shown in by solid curves and one-dot chain curves FIGS. 9a and 9b with respect to the key depression intensity, for example, by varying the potential of the common line l_2 through the potentiometer R_{14} to a low potential, thus obtaining touch-responsive sound T_2 having a percussion effect. The chain curves of FIGS. 9a and 9b show the amplitude characteristics of the output tone signal when the common line l_2 is substantially at a zero potential, which signal is abruptly attenuated and might extinguish before release of the key depression. Further, when the switch SC is closed the output envelope is such that an attack sound signal of a given amplitude irrespective to the key depression intensity is partially superimposed on the touch-responsive sound signal T_s depending upon the key depression intensity, as shown in FIGS. 9c and 9d. Accordingly, if the key is quite slowly depressed, no touch-responsive signal can be derived but an attack sound signal A_s is only obtained as shown by a dotted curve in FIG. 9e. However, it will be easily understood that no attenuation of the touch-responsive sound signal is caused without the function of the discharging path, for example when the potential of the common line l_2 is higher than that at the point d.

Now, reference will be made to another embodiment of the present invention with reference to FIGS. 3 and 4. The circuit arrangement of this embodiment differs from the circuit of the previous embodiment only in that the former employs an impulse-generating circuit adapted to be energized with an electromotive force generated in response to a key depression intensity, in place of using an external DC voltage in the pulse generator as in the circuit of FIG. 1. Therefore, a detailed description except for the difference will be omitted hereunder.

Referring to FIG. 3, L designates a coil grounded at one end thereof and adapted to vary the interlinking fluxes in association with depression of an operating key, the other end of

which is grounded through a series circuit of a rectifying element D and a capacitor C and a parallel circuit of a resistor R and a capacitor C₂ whose one ends are grounded. A juncture d₀ between the rectifying element D and the one end of the coil L is connected via another rectifying element D₀ and a manually operated switch SB with the input side a₁ of a source follower amplifier A. The input side a₁ is grounded by a parallel circuit of a capacitor C₁₁ and a resistor R₁₀, and the output side a₂ of the amplifier A is grounded through the capacitor C₂ and connected to the storage capacitor C at the connection point r. The above arrangement thus constitutes the above impulse generator. The remaining circuit arrangement of this embodiment is substantially the same as that shown in FIG. 1.

In the operations and functions of this embodiment, as described above, it will be seen that when the manual switch SB is opened, no impulse-generating function is caused, whereupon the keying circuit serves merely to provide touch-responsive sound effects as shown in FIG. 5.

When the manual switch is closed, part of a damped alternative voltage generated by the depression of the key K in the coil L is further rectified by the element D₀, which voltage is shown in FIG. 8A. When the rectified voltage across the element D₀ is applied to the parallel circuit of capacitor C₁ and resistor R₀, an approximately sawtooth pulse signal P₁ corresponding to the key depression intensity, as shown in FIG. 8B, is applied to the input side a₁ of the amplifier A and as a result, an approximately sawtooth pulse signal P₂ (shown in FIG. 8C) applied by the amplifier A is developed at the output side a₂. The output pulse signal P₂ is charged or stored on the capacitor C₂ and, accordingly, the potential at the junction r is raised instantaneously and applied through the capacitor C to the control terminals of the corresponding keyer circuit, thus providing an attack sound effect in addition to the touch-responsive sound effect as described above in the output tone signal of the instrument. This permits the provision of said effect resembling that of a piano.

Next, reference is made to a modification of the embodiment of FIG. 3 for providing a percussion effect in addition to the touch-responsive control effect as described above with reference to FIG. 4.

The modification is such that at the connection point d in the detecting circuit S₁ there is provided the same discharging path circuit as described in FIG. 2. That is, the circuit includes a series circuit of the resistor R₁₃ and the diode D₂ one end of which is connected to a common DC voltage line l₂ and the other is connected to the point d and the potentiometer R₁₄ connected to the power supply +V_{cc} whose slidable contact r₁₄ is connected to the line l₂. The functions and effects of providing the specific discharging circuit are entirely the same as in FIG. 2, and the detailed description thereof is here omitted.

As the key depression speed-detecting circuit S₁, magnetosensitive elements or pressure-sensitive elements may be employed as a substitution of the induction coil used here. Furthermore, the FET's used in the keyer circuit may be replaced by other switching elements such as transistors, diodes or vacuum tubes, etc.

I claim:

1. In an electronic musical instrument having playing keys, a touch-responsive keying system for each playing key, said system comprising:

means for generating an electrical signal voltage responsive

to a depression intensity of a respectively associated playing key,

a charge storage element connected to said means for storing said electrical signal voltage,

a keyer circuit connected to said charge storage element for keying a tone signal in accordance with a supplied control voltage, and

an impulse-developing circuit associated with said respectively associated playing key for generating an impulse voltage upon depression of said key,

said impulse-developing circuit being connected with said charge storage element to provide a combination of said electrical signal voltage and said impulse voltage as said control voltage to said keyer circuit whereby a relatively abrupt buildup envelope tone signal is provided at an output of said keyer circuit.

2. A touch-responsive keying system according to claim 1, in which said impulse-developing circuit includes a differentiating circuit and means for energizing the differentiating circuit with a DC voltage upon depression of the respectively associated key.

3. A touch-responsive keying system according to claim 1, in which said charge storage element is connected with a series circuit of a resistor and a unidirectional conducting element connected both in series with a common DC potential so that the stored charge on said storage element is gradually discharged with a predetermined decaying voltage characteristic.

4. A touch-responsive keying system according to claim 1, in which said impulse-developing circuit is energized with said electrical signal voltage generated upon depression of the respectively associated key whereby said impulse voltage is responsive to said electrical signal voltage.

5. A touch-responsive keying system according to claim 4, in which said charge storage element is connected to a series circuit of a resistor and a unidirectional conducting element, both connected in series with a common DC potential so that the stored charge on said charge storage element is gradually discharged with a predetermined decaying voltage characteristic.

6. A touch-sensitive keying system according to claim 1, in which said keyer circuit includes:

a pair of active elements, each active element having a control electrode, a first electrode and a second electrode,

a pair of input terminals and a pair of output terminals, and a sustain circuit including a capacitor and a resistor and

connected to said keyer circuit for providing a sustained and gradually decaying envelope to a keyed tone signal after the respectively associated playing key is released,

each of said control electrodes being connected via a separate resistor to a capacitor comprising said charge storage element,

each of said first electrodes being connected to a respectively corresponding one of said individual input terminals for receiving an input tone signal of different footage and also being connected to the sustain circuit, and

each of said second electrodes being connected to a respectively corresponding one of said individual output terminals to derive the output signal thereat through an individual load.

7. A touch-responsive keying system according to claim 6, in which said active elements are field effect transistors.

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