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[54] **TOUCH-RESPONSIVE TONE ENVELOPE CONTROL CIRCUIT FOR ELECTRONIC MUSICAL INSTRUMENTS**
10 Claims, 3 Drawing Figs.

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[51] **Int. Cl.** **G10h 1/00**
[50] **Field of Search** 84/1.01, 1.04, 1.11, 1.12, 1.13, 1.17, 1.19, 1.26, 1.27

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ABSTRACT: In a keying system for an electronic musical instrument in which an individual keyer is adapted to be 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, a common DC supply means with a voltage selector is provided to additively control the keyer irresponsive to the key depression intensity. The voltage selector determines which one of said two controls should prevail. The system is simple in construction and operation and inexpensive and easy to manufacture as well as provides a variety of excellent tonal effects.

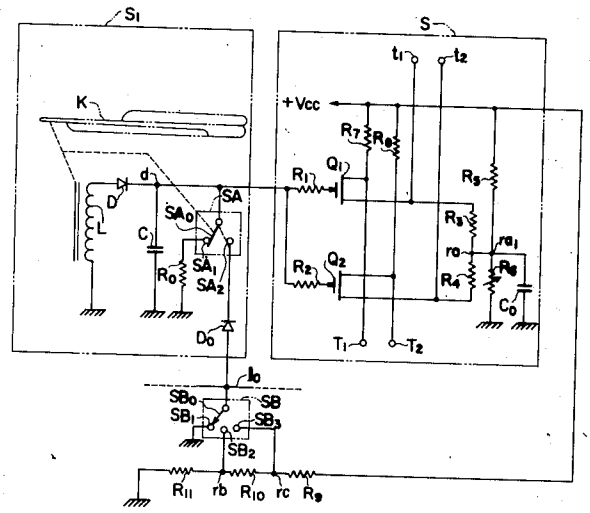


FIG. 1

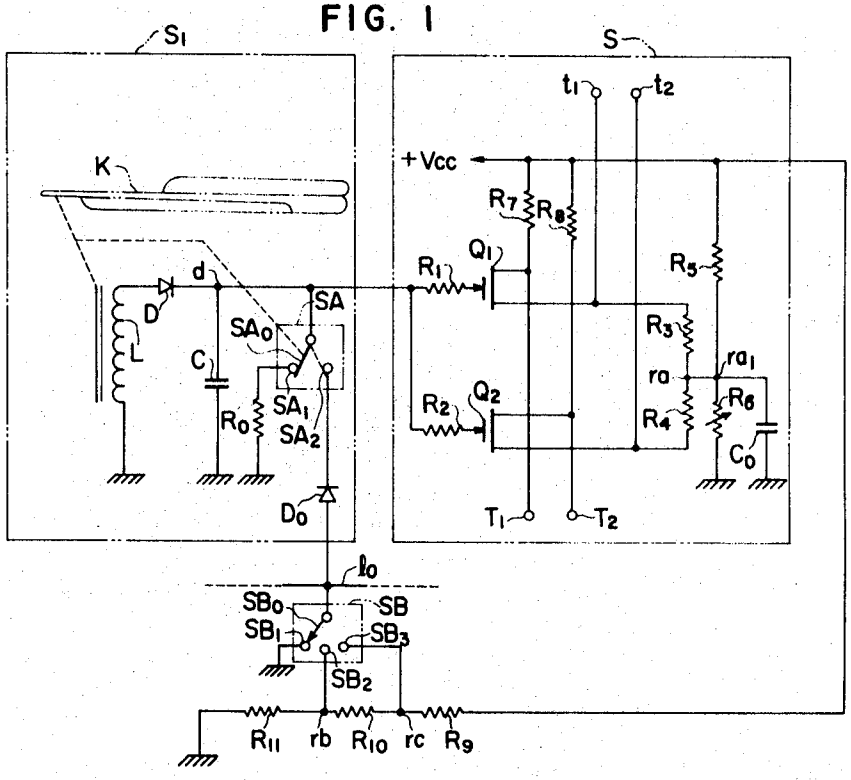


FIG. 2

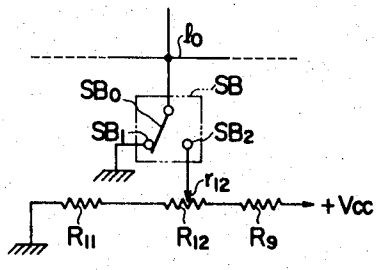
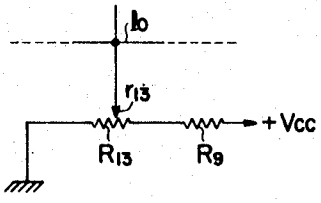


FIG. 3



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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.

It, therefore, is the principal object of the present invention to provide a tone envelope control circuit which is simple in construction, and easy and inexpensive to manufacture and which permits the electronic musical instrument incorporating the 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."

According to the present invention, there is provided a combination of a plurality of keyer circuits and a circuit connected through a manual changeover switch and allowing the keyer circuits to provide a loud tone signal having a predetermined large amplitude regardless of the intensity of key depression while providing a soft tone signal having a predetermined small amplitude when the intensity of the key depression is very low, so that the player can easily provide various kinds of keying effects at will.

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,

FIGS. 2 and 3 are partial circuit diagrams showing modifications of the essential portion of the embodiment of FIG. 1.

The same characters or references are hereafter used to indicate the same parts.

Reference is made in detail to a preferred embodiment of the present invention with reference to the accompanying drawings.

L designates a coil grounded at one end thereof and 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), the other end of which is grounded through a series circuit of a rectifying element D and a capacitor C. A junction *d* between the element D and the capacitor C is connected to a movable contact SA_o of a changeover switch SA of one-pole two-position type, 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 sources series connected resistors R_3 and R_4 are connected. The connection point r_a of the resistors connects with the juncture r_{a1} of bleeder resistance elements R_5 and R_6 connected in series between a DC voltage +Vcc of a power source and ground. The juncture r_{a1} is also grounded via a capacitor C_o.

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 +Vcc 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 FIG. 1.

In the detecting circuit S_1, one stationary contact SA_1 (normally closed) of the circuit changeover switch SA is grounded via a resistor R_o, and the other stationary contact SA_2 (normally open) is connected through a unidirectional conducting element D_o such as a diode to a movable contact SB_o of one-pole three-position type changeover switch SB, which may be manually operated and is used in common to the whole keying circuit in the electronic musical instruments. One stationary contact SB_1 of the switch SB is grounded, while other stationary contacts SB_2 and SB_3 respectively are connected to r_b and r_c which are connection points between series-connected bleeder resistors R_9, R_{10} and R_{11} connected between the power voltage +Vcc and ground. The movable contact SB_o is connected to a common line l_o, to which the indicated D_o and all the other D_o's in other detecting circuits (not shown) are connected.

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., 0 volts, each of the FET's is caused to be nonconducting so that the drain-source impedance is rendered extremely high. The movable contact SA_o of the changeover switch SA provided in the detecting circuit S_1 is arranged to contact the stationary contact SA_2 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, it is to be noted that the changeover switch SB may be of one-pole two-position type in case either of SB_2 contact and SB_3 contact is not required in design.

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

At first, under a condition that the movable contact SB_o of the circuit changeover switch SB is contacted by the contact SB_1, when any one key K provided in the electronic musical instrument is depressed, a magnetic member 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 of speed of depression of a playing key due to a variation in interlinking fluxes established round the coil. The induced alternative voltage 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 SA_o is actuated in interlocked relation with the operation of the key K, namely, since the contact SA_o is made in contact with the stationary contact SA_2 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_o to flow in the common line l_o, 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. 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, while with slow depression of key, the output tone signal may be obtained at a low level. 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 very 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 SA_o of the changeover switch SA is also returned to be in contact with the contact SA_1 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_o 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., 0 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.

Now, considering the case where the playing key K is quite slowly depressed, voltage induced in the coil L is too small, and as a result, there will occur the case where the gate of each of the FET's Q_1 and Q_2 cannot be at a positive voltage sufficient to be conductive between the source and the drain. Further, there is a possibility of producing no output even though the key is depressed depending upon the intensity of key depression, and hence, the player is required to be skillful in playing the instrument in order to produce desired soft tones without fail, resulting in nervous strain.

On the contrary, when the electronic musical instrument is played at a loud tone level the key K is always required to be quickly and strongly depressed, and a long play under such a condition results in the fatigue of the player. In the present invention, various attempts have been made to obviate these conventional defects. The bleeder resistors R_9, R_{10} and R_{11} are arranged to divide the power voltage +Vcc at a predetermined ratio, and a positive voltage V_1 appearing at the connection point r_b is set at substantially the same as the charged voltage across the capacitor C when the intensity of key depression is weak. That is, in case any one key is too slowly depressed under the state in which the movable contact SB_o is in contact with the stationary contact SB_2, the induced voltage in the coil L will be too small and the voltage V_1 will prevail to be applied to the capacitor C for charging it via the unidirectional conducting element D_o and the movable contact SA_o being in contact with the contact SA_2 by key depression. The voltage V_1 is also applied respectively through the resistors R_1 and R_2 to the respective gates of the FET's Q_1 and Q_2. As a result, the source-drain impedance of each FET is lowered to some limited extent, so that input tone signals of different footage number which are separately applied to the respective sources thereof can surely be derived separately at the terminals T_1 and T_2 on the drain side thereof as output tone signals with low levels. That is, since the voltage V_1 at the connection point r_b is set substantially the same as the storage voltage of the capacitor C upon weak key depression, even an extremely slow key depression permits soft tone to be produced with the help of the voltage V_1. Therefore, the above arrangement facilitates the soft tone producing play as well as a long playing, and the nerve strain of the player is greatly reduced. In this case, release of the depressed key allows both the key and the changeover switch SA to return to their initial state, and allows the charge stored on the charged capacitor C to be discharged in a short period of time via the resistor R_o, so that each FET is turned to its nonconducting state to shut off any output signals.

The bleeder resistors R_9, R_{10} and R_{11} serve to divide the power voltage +Vcc at a predetermined ratio to provide a positive voltage V_2 at the connection point r_c. The voltage V_2 is determined to be substantially the same as the charged voltage across the capacitor C upon key depression with a high intensity. Therefore, in case key depression is effected under the condition in which the movable contact SB_o of the changeover switch SB is in contact with the stationary contact SB_3, the voltage V_2 is always greater than the induced voltage in the coil L and is applied—via the unidirectional conducting element D_o and the movable contact SA_o which, by key depression, is brought into contact with the contact SA_2—to the capacitor C for charging it, and is also applied respectively via resistors R_1 and R_2 to the gates of the FET's Q_1 and Q_2, so that the source-drain impedances thereof are extremely reduced to allow the output terminals T_1 and T_2 separately to derive desired output tone signals irrespective of the intensity of key depression.

This can be explained as follows. That is, since the voltage V_2 at the point r_c is substantially the same as the charged voltage across the capacitor C when the intensity of key depression is high, loud tone-producing play on the electronic musical instruments can be performed independently of the intensity of key depression. For example, even if the player slowly depresses the key K, such loud tone-producing play becomes possible. The operational manner in the circuit upon release of the depressed key is the same as described above. This will be convenient, when the player wants to play the entire music loudly.

Further, as the manual changeover switch SB, a one-pole two-position type switch may be employed. Another embodiment using a switch of this type is shown in FIG. 2, in which a series circuit of a bleeder resistor R_9, a potentiometer R_{12} and a resistor R_{11} is connected between the power voltage +Vcc and ground, the stationary contact SB_2 is connected to a movable contact r_{12} of the potentiometer R_{12} whereby the whole tone envelopes in soft or loud tone generating play by key depressing operation can be varied by changing the dividing voltage ratio by adjustment of the slidable contact r_{12}. Further, if there is provided an arrangement that the common line l_o is connected directly to a slidable contact r_{13} of a potentiometer R_{13} as shown in FIG. 3, the above-mentioned actions such as variations in tone levels or envelopes, etc. can be performed without using the changeover switch SB.

As the key depression speed detecting circuit S_1, magneto-sensitive elements or pressure-sensitive elements may be used in place of the induction coil used here. Furthermore, the FET's used in the keyer circuit may be substituted by other switching elements such as transistors, diodes or vacuum tubes etc.

I claim:

1. In an electronic musical instrument having a plurality of keys, a touch-responsive keying system comprising:
   - a plurality of touch-responsive means, each for generating a touch-responsive DC voltage that corresponds to an intensity of depression of a respectively associated one of said playing keys,
   - a plurality of charge storage elements, one being provided and connected to each of said touch-responsive means for storing said touch-responsive DC voltage,
   - a plurality of keyer circuits, each corresponding to one of said charge storage elements and having a control terminal connected thereto,
   - a plurality of diodes, one being provided for each of said means,
   - voltage supply means for providing a predetermined DC voltage, means for connecting said predetermined DC voltage to said plurality of diodes, and
   - connecting means at each keyer circuit responsive to the depression of an associated key for connecting said predetermined DC voltage through a corresponding one of said diodes to a respectively associated control terminal thereby permitting said predetermined DC voltage to be supplied to a control terminal when said predetermined voltage is greater than said touch-responsive DC voltage for a particular key.

2. A touch-responsive keying system according to claim 1, in which each of said charge storage elements is connected to

a discharge element when its associated key is not fully depressed.

3. A touch-responsive keying system according to claim 1, in which said predetermined DC voltage is substantially equal to the touch-responsive DC voltage generated and stored by a weak key depression intensity.

4. A touch-responsive keying system according to claim 1, in which said predetermined DC voltage is substantially equal to the touch-responsive DC voltage generated and stored by a strong key depression intensity.

5. A touch-responsive keying system according to claim 1, in which there are provided two voltage supply means, one of which provides a predetermined DC voltage substantially equal to the touch-responsive DC voltage generated and stored by a weak key depression intensity and the other of which provides a predetermined DC voltage substantially equal to the touch-responsive DC voltage generated and stored by a strong key depression intensity, and means for selecting either one of said two predetermined DC voltages for connection to a respectively corresponding control terminal.

6. A touch-sensitive keying system for an electronic musical instrument comprising a plurality of individual key actuated circuits, each having:

a coil adapted to generate an induced electromotive force responsive to the actuation speed of a playing key,

a capacitor effectively connected to said coil for storing the induced electromotive force,

a discharging resistor,

a key-actuated changeover switch, one fixed contact of the changeover switch being connected to said resistor for effecting an electrical connection of said resistor across said capacitor during release of an associated key and another fixed contact of the changeover switch being connected to a unidirectional conducting element,

a keyer circuit, having a control terminal connected to said capacitor, for controlling the output characteristics of the musical instrument in association with the intensity of depression of the individual playing key by applying an input to said control terminal of the keyer circuit with the charge stored on the capacitor, and

a supply means connected to the unidirectional conducting element for supplying a preselected DC voltage to the control terminal upon full depression of the key via said changeover switch whereby said preselected DC voltage is supplied to the control terminal if it is greater than the voltage stored in said capacitor.

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

a pair of active elements, each having a control electrode, a cathode electrode and an anode electrode,

a pair of input and output terminals,

each of said control electrodes being commonly connected via a separate resistor to the capacitor,

each of said cathode electrodes being connected to an individual input terminal for receiving an input tone signal of different footages, and

each of said anode electrodes being connected to an individual output terminal to derive the output signal thereat through an individual load.

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

9. A touch-responsive keying system according to claim 6, in which said voltage supply means includes a voltage divider and a voltage selecting switch combined therewith.

10. A touch-responsive keying system according to claim 6 in which said voltage supply means includes a potentiometer to permit continuous preselection of a DC voltage to said control terminal.

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