United States Patent

[11] 3,602,626

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[33] **Japan**
[31] **43/84108**

[54] **ELECTRONIC MUSIC KEYING CIRCUIT WITH DIODE AND CAPACITOR FOR REDUCING LEAKAGE CURRENT**
6 Claims, 8 Drawing Figs.

[52] **U.S. Cl.** **84/1.01,** 84/DIG. 7
[51] **Int. Cl.** **G01h 1/00**
[50] **Field of Search** 84/1.01, 1.13, 1.26; 307/253, 254; 330/28, 29

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Assistant Examiner—Stanley J. Witkowski
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ABSTRACT: An improved transistor keying circuit for use in electronic musical instruments to help minimize leakage of signals therethrough even when the circuit is in an off condition as is often caused by interelectrode transistor capacitances. The improved circuit utilizes a diode connected in series with a load resistor to a transistor collector or emitter electrode in a direction that permits collector-emitter current to flow normally in the forward direction thus permitting normal circuit operation when in an "on" condition. A capacitor is effectively shunt connected across the diode and load resistor with the output being taken from the junction of the load resistor and diode. Since the capacitor has a large capacitance as compared with the base-collector or base-emitter capacitance, leakage signals in the "off" state are effectively shunted to ground to greatly reduce the level of any leakage to the output terminal.

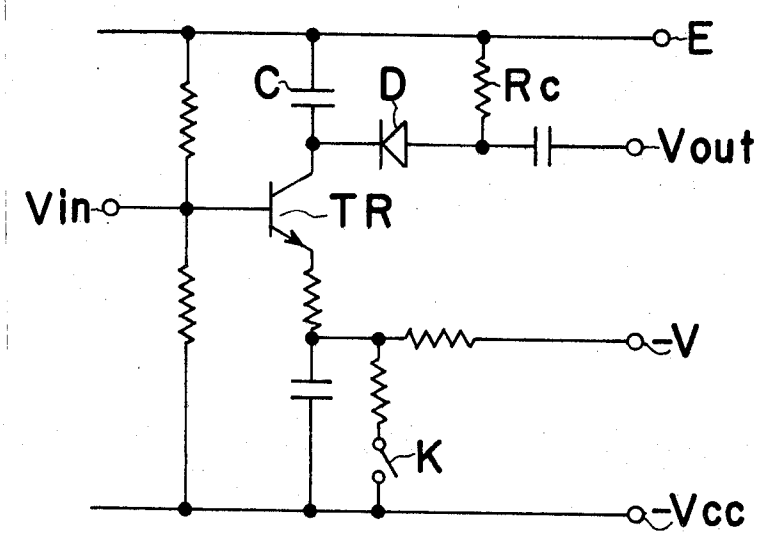

FIG. 1

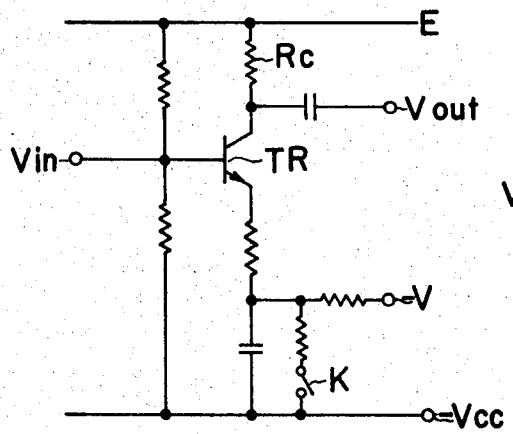

FIG. 2

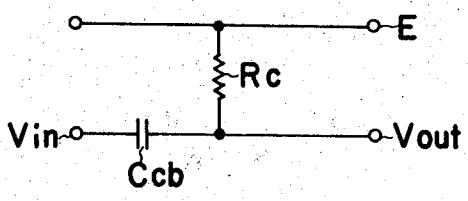

FIG. 3

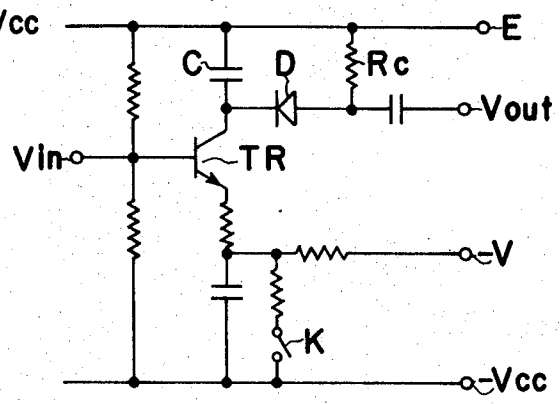

FIG. 4

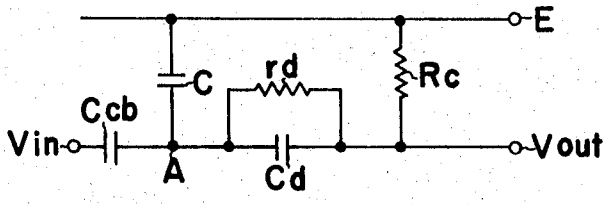

FIG. 5

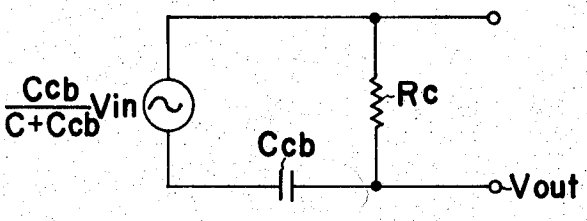

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FIG. 6

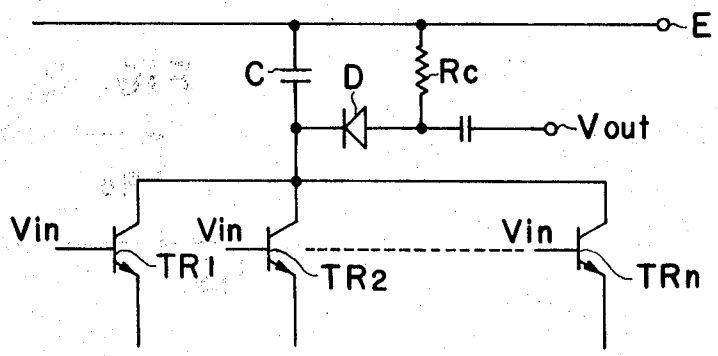


FIG. 7

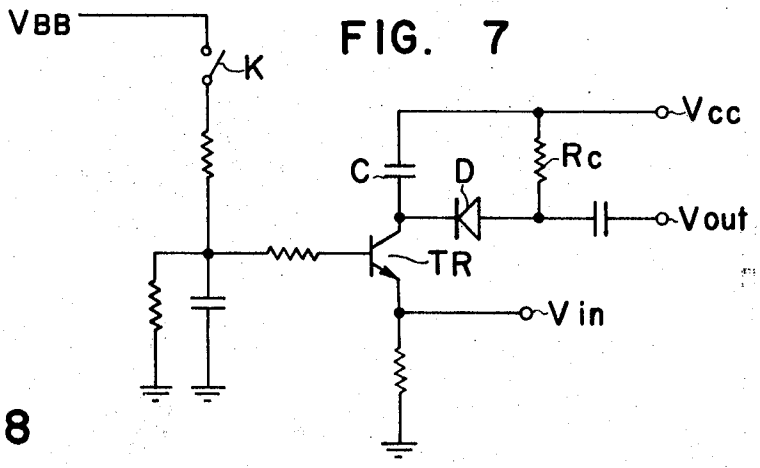
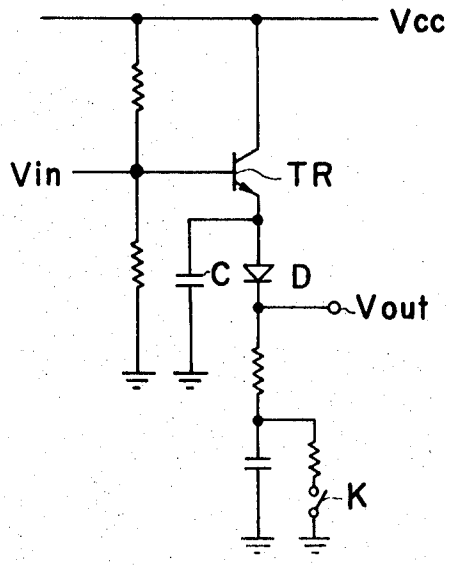


FIG. 8



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ELECTRONIC MUSIC KEYING CIRCUIT WITH DIODE AND CAPACITOR FOR REDUCING LEAKAGE CURRENT

The present invention is concerned with a keying circuit device for use in electronic musical instruments, and more particularly, it relates to an improved keying circuit which substantially reduces the signal leakage caused by the stray capacitance present between the collector and the base of a switching transistor of a keying circuit.

In electronic musical instruments, it has been the general practice to use, as the tone generators, square wave oscillators, since they contain a large amount of higher harmonic waves suitable for forming various tone colors. The square wave signals which are oscillated by these oscillators are supplied to either a filter, an amplifier or a musical effect impressing circuit of various types through keying circuits as they one shown in FIG. 1. In the keying circuit shown in FIG. 1, the equivalent circuit of the signal passage when the key switch K is in its "off" state is as shown in FIG. 2. It is noticed from the drawings that the capacitance *Ccb* which is the inter-collector-base capacitance of the transistor is connected in series between the input and the output side. This capacitance is normally negligibly small. However, in view of the fact that the input signals of the keying circuit are square waves which are rich in higher harmonic components, these components tend to appear, as the leakage signals passing through the capacitance *Ccb*, on the output side. Accordingly, even in case the key switch is in its "off" state, the electronic musical instrument equipped with such a conventional keying circuit has the drawback that said higher harmonic components come out in the form of background noise.

SUMMARY OF THE INVENTION

It is, therefore, the object of the present invention to eliminate the foregoing drawback encountered in the keying circuits of conventional electronic musical instruments and to provide a keying circuit device which can substantially reduce the signal leakage caused by the capacitance between the collector and the base of a transistor.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a circuit diagram of a typical conventional keying circuit device which has been used in electronic musical instruments;

FIG. 2 is an equivalent circuit diagram of the essential portion of the signal passage in FIG. 1 when the key switch is in its "off" state;

FIG. 3 is an embodiment of the keying circuit device of the present invention;

FIGS. 4 and 5 are equivalent circuit diagrams when the key switch in FIG. 3 is in its "off" state;

FIG. 6 is a brief diagram showing another embodiment in which the present invention is applied to a plurality of keying circuits; and

FIG. 7 and 8 are circuit diagrams showing still another and yet another embodiments of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention will hereunder be described in further detail in connection with preferred embodiments by referring to the accompanying drawings.

In the drawings, FIG. 3 shows an embodiment of the keying circuit device of the present invention. This keying circuit device is of the arrangement comprising a diode D connected in series between the collector of a switching transistor TR and a load resistor Rc in such a way that said diode permits the collector current to flow in its forward direction (from the resistor Rc to the collector, in this case), and a capacitor C connected between the collector and the earth E and having a relatively large capacitance as compared with the inter-collector-base capacitance *Ccb*.

FIGS. 4 and 5 show the equivalent circuits for an instance where the key switch K is in its "off" state in the circuit illustrated in FIG. 3. In FIG. 4, the symbol r_d represents the working resistance of the diode. *Cd* represents the junction capacitance of the diode. Since, in these circuits, the signal voltage which appears at point A in FIG. 4 represents a partial voltage resulting from the division of the input signal voltage Vin by the total of the capacitance C and the inter-collector-base capacitance *Ccb*, the signal voltage at point A will be: $(Ccb/C+Ccb)$ Vin.

Also, the working resistance r_d resulting from the forward bias current of the diode D (or, in other words, resulting from the collector current of the transistor TR) will have a value which is considerably large when the key switch is in its "off" state, since the collector current of the transistor TR when the key switch is in its "off" state is much smaller than the current when said key switch is in its "on" state. Besides, the working resistance in this instance will take a value which is relatively large as compared with the reactance value of the junction capacitance of the diode against the higher harmonic components of the square wave input signal, and therefore, said working resistance r_d may be ignored. In addition, the junction capacitance *Cd* of the diode is normally substantially equal to the inter-collector-base capacitance *Ccb* of the transistor. Accordingly, the equivalent circuit shown in FIG. 4 will become as that shown in FIG. 5. Thus, the keying circuit shown in FIG. 3 may, after all, be regarded as being equal to the equivalent circuit shown in FIG. 5 in which the input signal voltage takes a value of $Vin \times Ccb/C+Ccb$ when the key switch K is in its "off" state.

More specifically, the keying circuit device of the present invention is arranged so as to cause also the diode to effect a switching action (meaning an increase in the impedance when the key switch is in its "off" state) by utilizing the difference in the magnitude of the working resistance r_d resulting from the changes in the forward bias current of the diode (or, in other words, the changes in the collector current of the transistor) depending on the "on-off" state of the key switch K, and that, along with this, the leakage signal is effectively decreased to $Ccb/C+Ccb$ time, while the key switch K is in its "off" position (compare the equivalent circuits in FIGS. 2 and 5), by the voltage-dividing action of both the capacitance C and the inter-collector-base capacitance *Ccb*, whereby reducing the leakage of tone signals while the key switch is in its "off" state.

FIG. 6 shows another embodiment of the present invention in which the collectors (output terminals) of the transistors of a plurality of keying circuits are connected in common relative to each other so that the leakage signal is reduced in common also by a set of diode and capacitor. In this embodiment, the working resistance—when the key switch is in its "on" state, or, in other words, when there flows a large amount of forward current of the diode—is only ten ohms which is sufficiently small as compared with the output resistance of the collectors of the transistors which amounts to several hundred kiloohms. Therefore, even if the collectors are connected in common, there will arise no problem in actual operation. By arranging in this way, it becomes possible to substantially reduce, by a set of diode and capacitor, the noise which is produced from a plurality of keying circuits, and accordingly, this arrangement is advantageous in terms of cost.

FIG. 7 shows a still another embodiment of the circuit of the present invention in which the square input signal is applied to the emitter of the transistor TR so that the opening and closing of the key switch is adapted to be performed by the base circuit.

FIG. 8 is a yet another embodiment of the present invention in which the transistor is arranged to serve as an emitter follower.

In both of these two embodiments, the circuits operate in the similar way as does the keying circuit shown in FIG. 3.

I claim:

1. An improved transistor switching circuit for use in electrical musical instruments and which minimizes undesired

leakage of signals from an input terminal to an output terminal in an off state due to internal interelectrode capacitances of the switching transistor, said improved circuit comprising:

at least one switching transistor having an input electrode and an output electrode with interelectrode capacitance therebetween,

an input terminal for receiving input signals,

an output terminal for providing an output signal corresponding to said input signal when said circuit is switched on,

a diode connected to said output electrode with a forward diode current direction corresponding to forward collector-emitter current in said transistor to insure normal switching operation when the circuit is switched on for passing signals from said input terminal to the output terminal but which offers a relatively large impedance when the circuit is switched off,

a load resistor series connected with said diode at a junction point,

said output terminal being connected to said junction point, and

a capacitor having a large capacitance as compared to said interelectrode capacitance, said capacitor being effectively shunt connected across said series connected diode and resistor thereby effectively minimizing undesired leakage of signals to the output terminal in the off state of said circuit by shunting such signals away from the output terminal.

2. A keying circuit for use in electronic musical instruments, said circuit comprising:

an input terminal;

an output terminal;

a transistor and a load resistor constituting an amplifier circuit,

one electrode of said transistor effectively being an input electrode and another electrode of said transistor effectively being an output electrode,

a key switch connected in said amplifier circuit at a position where closing and opening of said key switch renders said amplifier operative and nonoperative,

a diode connected in series between said load resistor and said output electrode in such a direction as to permit the normal forward transistor current to also flow in the forward direction of said diode; and

a capacitor connected between said output electrode and a constant potential terminal, said capacitor having a substantially large capacitance than the internal capacitance between said input electrode and said output electrode of said transistor;

said input terminal being connected to said input electrode and said output terminal being connected to the juncture of said diode and load resistor.

3. A keying circuit according to claim 2 wherein:

said transistor comprises an emitter-grounded amplifier,

said input electrode is a base electrode of said transistor,

said output electrode is a collector electrode of said transistor, and

said key switch is connected in series in the emitter path of said transistor.

4. A keying circuit according to claim 2 wherein:

said transistor constitutes a base-grounded amplifier,

said input electrode is an emitter electrode of said transistor,

said output electrode is a collector electrode of said transistor, and

said key switch is connected in series in the base path of said transistor.

5. A keying circuit according to claim 2 wherein:

said transistor constitutes a collector-grounded amplifier,

said input electrode is a base electrode of said transistor,

said output electrode is an emitter electrode of said transistor, and

said key switch is connected in series in the emitter path of said transistor.

6. A keying circuit for use in electronic musical instruments, said circuit comprising:

a plurality of input terminals;

a common output terminal;

a plurality of transistors and a common load resistor comprising common load amplifiers,

one electrode of each of said transistors effectively being an output electrode,

a second electrode of each of said transistors effectively being an input electrode,

a plurality of key switches each being connected in each of said plurality of amplifier circuits at a position where closing and opening of said each key will render its associated amplifier operative and nonoperative,

a diode connected in series between said common load resistor and said output electrodes in such a direction as to permit normal forward transistor currents to also flow in the forward direction of said diode; and

a common capacitor connected between said output electrodes and a constant potential and having a substantially larger capacitance than the internal capacitance between said input electrode and said output electrode of one of said transistors;

said input terminals being connected to said input electrodes, and said common output terminal being connected to the juncture between said diode and said load resistor.