Signal-Selecting System for an Electronic Musical Instrument

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ABSTRACT
A signal selecting system for an electronic musical instrument comprising tone generators, gating means, keyswitches and a transistor preference circuit. The transistor preference circuit comprises a plurality of bias resistors, a plurality of transistors and a plurality of base resistors for the respective transistors. The transistors are controlled by the keyswitches so as to produce control voltages at the collectors thereof, respectively, whereby when one or more keyswitches are simultaneously closed, only one transistor is conductive and so the corresponding gating means is actuated so as to select preferentially only one output tone signal.

4 Claims, 2 Drawing Figures
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ELECTRIC POWER SOURCE

GATING MEANS

TONES GENERATOR

MEMORY MEANS

MEMORY MEANS

MEMORY MEANS

MEMORY MEANS

KEYSWITCH

TRANSISTOR PREFERENCE CIRCUIT

FIG. 1

OUTPUT TERMINAL

DETECTING MEANS
SIGNAL-SELECTING SYSTEM FOR AN ELECTRONIC MUSICAL INSTRUMENT

FIELD OF THE INVENTION

This invention relates to an electronic musical instrument, and more particularly to a novel and improved signal-selecting system which is capable of selecting the tone signal having the highest or the lowest frequency from among tone signals produced by keyswitches which are closed simultaneously.

DESCRIPTION OF THE PRIOR ART

A conventional signal-selecting system for an electronic musical instrument uses a preference circuit comprising a plurality of transfer type keyswitches, each of which has a break-contact, a make-contact connected to an output terminal for providing a control signal thereto and a movable-contact, and which are connected in series in such a way that the movable-contact of one transfer type keyswitch is connected to the break-contact of a subsequent transfer type keyswitch. The movable-contact of said subsequent transfer type keyswitch is connected to the break-contact of a further subsequent transfer type keyswitch, and so on. Memory means or gating means of the signal-selecting system are controlled according to the output signals from the output terminals so as to provide the corresponding tone signals, respectively. However, such a conventional preference circuit fails to work reliably because there are many contacts of the transfer type keyswitches connected in series.

U.S. Pat. No. 3,585,892 of the present applicant has disclosed a reliable preference circuit which comprises normally conductive transistors which are arranged in a totem-pole connection with the base of each connected to a corresponding keyswitch, normally non-conductive transistors having bases and emitters which are coupled between collectors and bases of said normally conductive transistors, respectively, and bias resistors connected between bases and collectors of said normally conductive transistors, respectively. However, in such a conventional preference circuit, there are some disadvantages in that two transistors are required for each keyswitch, and in order to assure reliable operation, it is necessary for the transistors to have a low cut off current Icbo or ICEO, and further an additional biasing circuit is required so as to reduce the effects of cut off current Icbo or ICEO in order to assure more reliable operation. Consequently, the conventional preference circuit is apt to be complicated and expensive.

SUMMARY OF THE INVENTION

Therefore, an object of the present invention is to provide a novel and improved signal-selecting system for an electronic musical instrument.

Another object of the present invention is to provide a simple and reliable signal-selecting system comprising a preference circuit which comprises only one transistor for each keyswitch.

These objects are achieved by employing a signal-selecting system according to the present invention which comprises a plurality of tone generators generating tone signals having frequencies corresponding to the notes of the musical scale, respectively; a plurality of gating means capable of gating said tone signals, respectively; and a plurality of keyswitches corresponding to said tone generators and each having one end connected to one end of an electric power source through a common conductor; and a preference circuit which comprises a plurality of bias resistors which are connected in series and one end of said series connection is connected to the other end of said electric power source; a plurality of transistors; a plurality of base resistors connected between the bases and the collectors of said transistors, respectively; and a plurality of collector resistors connected to said collectors of said transistors, respectively, said emitters of said plurality of transistors being connected to the other ends of said keyswitches, respectively, said bases of said plurality of transistors being connected to the junction points of said plurality of bias resistors connected in series and the other end of said series connection of said bias resistors, respectively, and said collectors of said plurality of transistors, and being provided with a potential substantially equal to the potential of the other end of said electric power source through said collector resistors, respectively, said collectors being coupled to said gating means so as to control the gating operation of said gating means and to switch on and off the tone signals supplied thereto from said tone generators whereby when one or more keyswitches are simultaneously closed, only the transistor, the base of which is connected to the junction point closest to said other end of said electric power source among the transistors corresponding to the closed keyswitches, is made conductive and the corresponding gating means is actuated so as to select preferentially only one output tone signal.

BRIEF DESCRIPTION OF THE DRAWING

These objects and other features of the present invention will be made clear from the following detailed description of the invention considered together with accompanying drawings wherein:

FIG. 1 is a schematic circuit diagram of an embodiment of the signal-selecting system of the present invention.

FIG. 2 is a partial schematic circuit diagram showing a charge-discharge means which can be used in the signal-selecting system of the present invention.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

Referring to FIG. 1, a plurality of tone generators 11, 12, 13, 14 and 15 generate tone signals f1, f2, f3, f4 and f5 having frequencies corresponding to the notes of the musical scale, respectively.

A plurality of gating means 21, 22, 23, 24 and 25 are capable of gating said tone signals f1, f2, f3, f4 and f5, respectively.

A plurality of keyswitches K1, K2, K3, K4 and K5 correspond to said tone generators 11, 12, 13, 14 and 15, and each one of said keyswitches K1, K2, K3, K4 and K5 is connected to one end 2 of an electric power source 3 through a common conductor or bus-bar 1.

A transistor preference circuit 4 comprises a plurality of bias resistors R1, R2, R3, R4 and R5 which are connected in series and one end 5 of the series connection is connected to the other end 6 of said electric power source 3. The emitters of a plurality of transistors T1,
$T_1, T_2, T_3,$ and $T_4$ are connected to the other ends of said keyswitches $K_1, K_2, K_3,$ and $K_4$, respectively. The bases of said transistors $T_1, T_2, T_3,$ and $T_4$ are connected to the junction points $31, 32, 33$ and $34$ and the other end $35$ of the series connection of said bias resistors $R_{11}, R_{12}, R_{13},$ and $R_{14}$, respectively. The collectors of said transistors $T_1, T_2, T_3,$ and $T_4$ are provided, through respective collector resistors $R_{15}, R_{16}, R_{17},$ and $R_{18}$, with a potential substantially equal to the potential of the other end of said electric power source $3$. A plurality of base resistors $r_1, r_2, r_3,$ and $r_4$ are connected between said bases and said collectors of said transistors $T_1, T_2, T_3,$ and $T_4$, respectively. Said collectors of the transistors $T_1, T_2, T_3,$ and $T_4$ are coupled to said gating means $21, 22, 23, 24$ and $25$ so as to switch on and off the tone signals $f_1, f_2, f_3, f_4,$ and $f_5$ supplied to said gating means from said generators, respectively.

The gating means $21, 22, 23, 24$ and $25$ comprise the memory means $41, 42, 43, 44$ and $45$ and signal-switching means $51, 52, 53, 54$ and $55$. Each of said memory means $41, 42, 43, 44$ and $45$ is composed of a conventional flip-flop circuit. A flip-flop circuit for the memory means $41$ for example, comprises a first transistor $T_{31}$, a second transistor $T_{32}$, a first feed back resistor $R_{36}$ connected between the collector of said first transistor $T_{31}$ and the base of said second transistor $T_{32}$, a second feed back resistor $R_{38}$ connected between the collector of said second transistor $T_{32}$ and the base of said first transistor $T_{31}$, and a first collector resistor $R_{33}$ connected to the collector of said first transistor $T_{31}$ and another electric power source $9$, a second collector resistor $R_{34}$ connected between the collector of said second transistor $T_{32}$ and another electric power source, a set resistor $R_{32}$ connected between a set terminal $S_1$ and the base of said second transistor $T_{32}$, and a reset resistor $R_{35}$ connected between a reset terminal $R_1$ and the base of said first transistor $T_{31}$.

When a positive voltage is applied to the set terminal $S_1$, the second transistor $T_{32}$ saturates and the first transistor $T_{31}$ is switched off, and then a positive voltage is produced at the output terminal $Q$ which is connected to the collector of said first transistor $T_{31}$. On the other hand, when a positive voltage is applied to the reset terminal $R_1$, the first transistor $T_{31}$ saturates and the second transistor $T_{32}$ is switched off, and then there is no produced a voltage produced at the output terminal $Q$. Flip-flop circuits of the memory means $42, 43, 44$ and $45$ are similar to that of the memory means $41$.

Each of said signal-switching means $51, 52, 53, 54$ or $55$ comprises a series connection of a capacitor C, a resistor $R_4$ and a diode $D$, connected between the corresponding tone generator $11, 12, 13, 14$ or $15$ and an output terminal $7$. The junction point between each diode $D$ and resistor $R_4$ is connected to the corresponding output terminal $Q$ of the memory means $41, 42, 43, 44$ and $45$ and acts as a control terminal for the corresponding signal-switching means $51, 52, 53, 54$ or $55$. The signal-switching means $51, 52, 53, 54$ and $55$ are switched on, when the output voltages of the corresponding memory means $41, 42, 43, 44$ and $45$ are positive, respectively.

The set terminals $S_1$ of the memory means $41, 42, 43, 44$ and $45$ are connected to the collectors of the transistors $T_1, T_2, T_3,$ and $T_4$, respectively. A detecting means $8$ is coupled between output terminals of the signal-selecting means and the reset terminals $R_1$ of the memory means $41, 42, 43, 44$ and $45$. The detecting means comprises transistors $T_1$ and $T_2$. The collector of said transistor $T_1$ is connected to the electric power source $9$ through a collector resistor $R_{41}$ and is provided with a positive voltage $\pm E$ Therefore, the emitter of the transistor $T_2$ is connected to ground and to the voltage source $9$ through resistors $R_{12}$ and $R_{13}$, respectively, and the base of the transistor $T_{11}$ is connected to the output terminals of the signal-switching means $51, 52, 53, 54$ and $55$. The emitter of said transistor $T_{12}$ is connected to the electric power source $9$, the base of the transistor $T_{13}$ is connected to the collector of said transistor $T_{11}$, and the collector of the transistor $T_{13}$ is connected to ground through another collector resistor $R_{14}$ and to the reset terminals $R_1$ of said memory means $41, 42, 43, 44$ and $45$.

The detecting means $8$ detects the state when two or more memory means are set simultaneously. When two or more memory means are set, the base voltage of the transistor $T_{11}$ exceeds a threshold voltage and so the transistor $T_{11}$ is saturated. The voltage at the collector of the transistor $T_{11}$ is inverted by the transistor $T_{12}$, and there is produced an output voltage $E'$ at the collector of the transistor $T_{12}$. This output voltage $E'$ resets immediately said two memory means which were set previously. On the other hand, when no memory means or only one memory means is set, the base voltage of the transistor $T_{11}$ is less than the threshold voltage. Therefore, the detecting means $8$ does not produce an output voltage, and so no memory means is reset.

Hereinafter is a description of the operation of the signal selecting system of the present invention. Now, it is assumed that each of the base resistors $r_1, r_2, r_3, r_4,$ and $r_5$ has resistance $r$ and each of the bias resistors $R_1, R_2, R_3,$ and $R_4$ has resistance $R$. These resistors are such that the value $R$ is higher than the value $r$.

When the keyswitches, for example, $K_1$ and $K_2$ are closed simultaneously, a current flows from one end $2$ of the electric power source $3$, through a path comprising the common conductor $1$, the keyswitch $K_1$, a parallel circuit of the base resistors $r_1$ and the emitter-base junction of the transistor $T_1$ and the bias resistor $R_4$, to the other end $6$ of said electric power source $3$. The transistor $T_1$, therefore, saturates and then the gating means $21$ is provided, at the control terminal thereof, with a voltage approximately equal to the voltage $E'$, the output voltage of the electric power source $3$. That is, the positive output voltage at the collector of the transistor $T_1$ is applied to the set terminal $S_1$ of the memory means $41$, i.e., the flip-flop, so as to set the memory means $41$. Then, said memory means $41$ produces a positive voltage at the output terminal $Q$ so as to switch on the corresponding signal-switching means $51$. Consequently, the gating means $21$ is switched on, and so an output tone signal $f_1$ corresponding to the keyswitch $K_1$, is provided and maintained at the output terminal $7$.

In this case, a voltage equal to the base-emitter forward voltage drop $V_{BE}$ (which is usually 0.6 to 0.8 volt for a silicon transistor) is produced between the common conductor $1$ and the base of the transistor $T_1$. On the other hand, a voltage produced by said base-emitter forward voltage drop $V_{BE}$ of the transistor $T_1$ is divided by a voltage divider formed by the bias resistor $R_4$ and the base resistor $r_2$, and there is produced a voltage of $V_{BE} \times r/(R+r)$ across the base and the emitter of the transistors $T_4$. In this case, however, the voltage $V_{BE} \times n$
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r/(R+r) is less than a half of \( V_{\text{ges}} \), because the resistance value \( R \) is larger than the resistance \( r \), as described hereinbefore. Therefore, the transistor \( T_3 \) is nonconductive, because the voltage \( V_{\text{ges}} \times r/(R+r) \) is less than the voltage \( V_{\text{ges(ON)}} \) which is the threshold voltage of the transistors \( T_1, T_2, T_3, T_4 \) or \( T_5 \). The other transistors \( T_5, T_6 \) and \( T_7 \) are also nonconductive, because the voltages across respective base and emitter of said other transistors \( T_5, T_6 \) and \( T_7 \) are much less than that across the base and emitter of the transistor \( T_2 \). Consequently, only the transistor \( T_1 \) saturates and actuates the corresponding gating means \( 21 \) so as to produce at the output terminal \( 7 \) preferentially only one output tone signal \( f_1 \) which is applied from the tone generator \( 11 \) corresponding to the keyswitch \( K_1 \). The operation of the preference circuit \( 4 \) becomes more reliable the less the value of the resistance \( r \). Therefore, it is desirable to reduce the value of the resistance \( r \). But in this case a high voltage is required for the electric power source \( 3 \) so as to ensure the operation of the preference circuit \( 4 \). When the electric power source \( 3 \) has a voltage which is normally used in a conventional transistor circuit design, it is sufficient that the resistance \( r \) be smaller than the resistance \( R \).

After the keyswitches \( K_2 \) and \( K_2 \) are opened, only the memory means \( 41 \) remains in the set state. Therefore, said selected one tone signal \( f_1 \) continues to be supplied to the output terminal \( 7 \).

After the above mentioned operation, when one any or more keyswitches other than the keyswitch \( K_1 \), for example \( K_3 \) is closed, two memory means \( 41 \) and \( 43 \) are now set. The detecting means \( 8 \) detects this state when two or more memory means, for example, \( 41 \) and \( 43 \) are set, and produces an output voltage which is approximately \( E^* \) volts so as to reset instantaneously the memory means which have been set, as described hereinbefore.

When the keyswitch \( K_3 \) is still closed after the reset operation, the memory means \( 43 \) is actuated by the output voltage of the collector of the transistor \( T_3 \) and so only one output tone signal \( f_3 \) is provided at the output terminal \( 7 \). With respect to the case when any two or more keyswitches, for example two keyswitches \( K_2 \) and \( K_3 \), or \( K_2 \) and \( K_3 \), or three keyswitches \( K_2, K_3 \) and \( K_2 \), are closed simultaneously, the operation is the same as that described above with respect to the case when the keyswitches \( K_1 \) and \( K_2 \) are closed.

That is, when one or more keyswitches are simultaneously closed, only the transistor, the base of which is connected to the junction point closest to the other end \( 6 \) of the electric power source \( 3 \) among the transistors corresponding to the closed keyswitches, is made conductive and that transistor actuates the corresponding gating means so as to select preferentially only one output tone signal. Therefore, the signal-selecting system of the present invention is capable of selecting preferentially the tone signal having either the highest or the lowest frequency from among tone signals produced by keyswitches which are closed simultaneously, in accordance with arrangements of the keyswitches \( K_1, K_2, K_3, K_4, K_5 \) and \( K_6 \) and of the tone generators \( 11, 12, 13, 14 \) and \( 15 \).

Each of the memory means \( 41, 42, 43, 44 \) and \( 45 \) may be replaced by a charge-discharge means, as shown in FIG. 2. In this case, the detecting means \( 8 \) of FIG. 1 is unnecessary. Each of the charge-discharge means comprises a diode \( D' \) connected between the set terminal \( S \) and the output terminal \( Q \), a sustain capacitor \( C_1 \) connected between the output terminal \( Q \) and ground, a discharging resistor \( R_9 \) connected in parallel with said sustain capacitor \( C_1 \), and a reset transistor \( T_{15} \).

The collector and the emitter of said transistor \( T_{15} \) are connected in parallel with said sustain capacitor \( C_1 \) and the base thereof is connected to ground through a resistor \( R_9 \) and also to the reset terminal \( R \). The reset terminal \( R \) is connected to the keyswitches \( K_5, K_6, K_7, K_8, K_9, K_{10} \) through respective differentiating capacitors \( C_2 \).

When any one of the keyswitches is closed, a positive voltage at the collector of the transistor \( T_1, T_2, T_3, T_4 \) or \( T_5 \) is supplied to the sustain capacitor \( C_1 \) through the diode \( D_1 \). After any one of the keyswitches is opened, the voltage across the sustain capacitor \( C_1 \) is gradually discharged through the discharging resistor \( R_9 \), and then the output tone signal at the output terminal \( 7 \) gradually decays producing a sustain effect. When any one of the keyswitches is closed during the decay operation, a reset pulse is applied to the base of the reset transistor \( T_{15} \) through the differentiating capacitor \( C_2 \). Then, the reset transistor \( T_{15} \) saturates and the voltage is instantaneously discharged across the sustain capacitor \( C_1 \). In the case when any of the other keyswitches is closed, the operation is performed in a similar manner to that described above. Therefore, only one tone signal is selected and switched to the output terminal \( 7 \).

As described hereinbefore, according to the present invention, the preference circuit \( 4 \) of the signal-selecting system can be composed of a small number of electronic components. Accordingly there are provided many further advantages, i.e., simplicity of arrangement, reduction of manufacturing steps, inexpensiveness of the system, etc., are achieved.

While a particular embodiment of the invention is described hereinbefore, it will be apparent that various modifications can be made in the form and construction thereof without departing from the fundamental principles of the invention. It is, therefore, desired by the following claims, to include within the scope of the present invention all similar and modified forms of the apparatus disclosed and by which the results of the invention can be obtained.

What is claimed:

1. A transistor preference circuit comprising:
   a. an electric power source;
   b. a plurality of keyswitches, each having one end connected to one end of said electric power source;
   c. a plurality of bias resistors connected in series with each other, one end of said series connection of said bias resistors being connected to the other end of said electric power source;
   d. a plurality of collector resistors coupled to the other end of said electric power source;
   e. a plurality of transistors having the emitters thereof connected to the other ends of the respective keyswitches, the bases thereof connected to the junction points of the respective bias resistors and the other end of said series connection of said bias resistors, respectively, and the collectors thereof connected to the respective collector resistors and being provided with a potential substantially equal to the potential of the other end of said electric power source;
and a plurality of base resistors connected between
the bases and the collectors of the respective tran-
sistors;
whereby when one or more keyswitches are simulta-
neously closed, only the transistor, the base of
which is connected to the junction point closest to
the other end of said electric power source among
the transistors corresponding to the closed keys-
switches, is made conductive and produces an output
control voltage at the collector thereof.
2. A signal selecting system for an electric musical
instrument comprising:
  a plurality of tone generators generating tone signals
  having frequencies corresponding to the notes of
  the musical scale, respectively;
  a plurality of gating means coupled to the respective
tone generators for gating said tone signals;
a first electric power source;
a plurality of keyswitches corresponding to said tone
generators and each having one end connected to
one end of said electric power source; and
a preference circuit which comprises a plurality of
bias resistors connected in series and one end of
said series connection being connected to the other
end of said electric power source; a plurality of
transistors; a plurality of base resistors connected
between the bases and the collectors of the respec-
tive transistors; and a plurality of collector resistors
connected to said collectors of the respective tran-
sistors and being coupled to the other end of said
first electric power source, the emitters of said plu-
rality of transistors being connected to the other
ends of the respective keyswitches, the bases of
said plurality of transistors being connected to the
junction points of the respective bias resistors con-
ected in series and the other end of said series
connection of said bias resistors, respectively, and
said collectors of said plurality of transistors being
provided with a potential substantially equal to the
potential of the other end of said electric power
source through said collector resistors, said collec-
tors being coupled to said gating means for control-
ling the gating operation of said gating means and
the supply of tone signals thereto from said tone
generators;
whereby when one or more keyswitches are simulta-
neously closed, only the transistor, the base of
which is connected to the junction point closest to
said other end of said electric power source among
the transistors corresponding to the closed keys-
switches, is made conductive and the corresponding
gating means is actuated so as to select preferen-
tially only one output tone signal.
3. A signal selecting system for an electric musical
instrument as claimed in claim 2, wherein said plurality
of gating means each comprise memory means and sig-
na1-switching means, respectively, said memory means
being connected to the respective parts of the transistor
preference circuit for being set according to signals
provided from the collectors of the respective transis-
tors in said transistor preference circuit and memoriz-
ing the set state even after said signals from a collector
have been removed, and said signal-switching means
being connected to the memory means and being by
the output signals from said memory means for switching
the tone signals applied thereto on and off.
4. A signal-selecting system for an electric musical
instrument as claimed in claim 3, wherein said signal-
selecting system further comprises a detecting means
having an input terminal connected to all of the output
terminals of said plurality of memory means, said de-
tecting means being for detecting a state when two or
more memory means are set simultaneously and reset-
ting said two or more memory means so that only one
memory means corresponding to a keyswitch still
closed after the reset operation is set.
UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION


Inventor(s) TAKATSUGU NAKAJIMA

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 2, line 10, "collectors" should be --emitters--.
Column 3, line 12, "collectors" should be --emitters--.
Claim 1, column 7, line 2, "collectors" should be --emitters--.
Claim 2, column 7, line 27, "collectors" should be --emitters--.

Signed and sealed this 8th day of October 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR. C. MARSHALL DANN
Attesting Officer Commissioner of Patents
UNITED STATES PATENT OFFICE
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