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ELECTRONIC LATCH AND WIPEOUT SYSTEM FOR MUSICAL INSTRUMENTS

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2 Sheets-Sheet 1

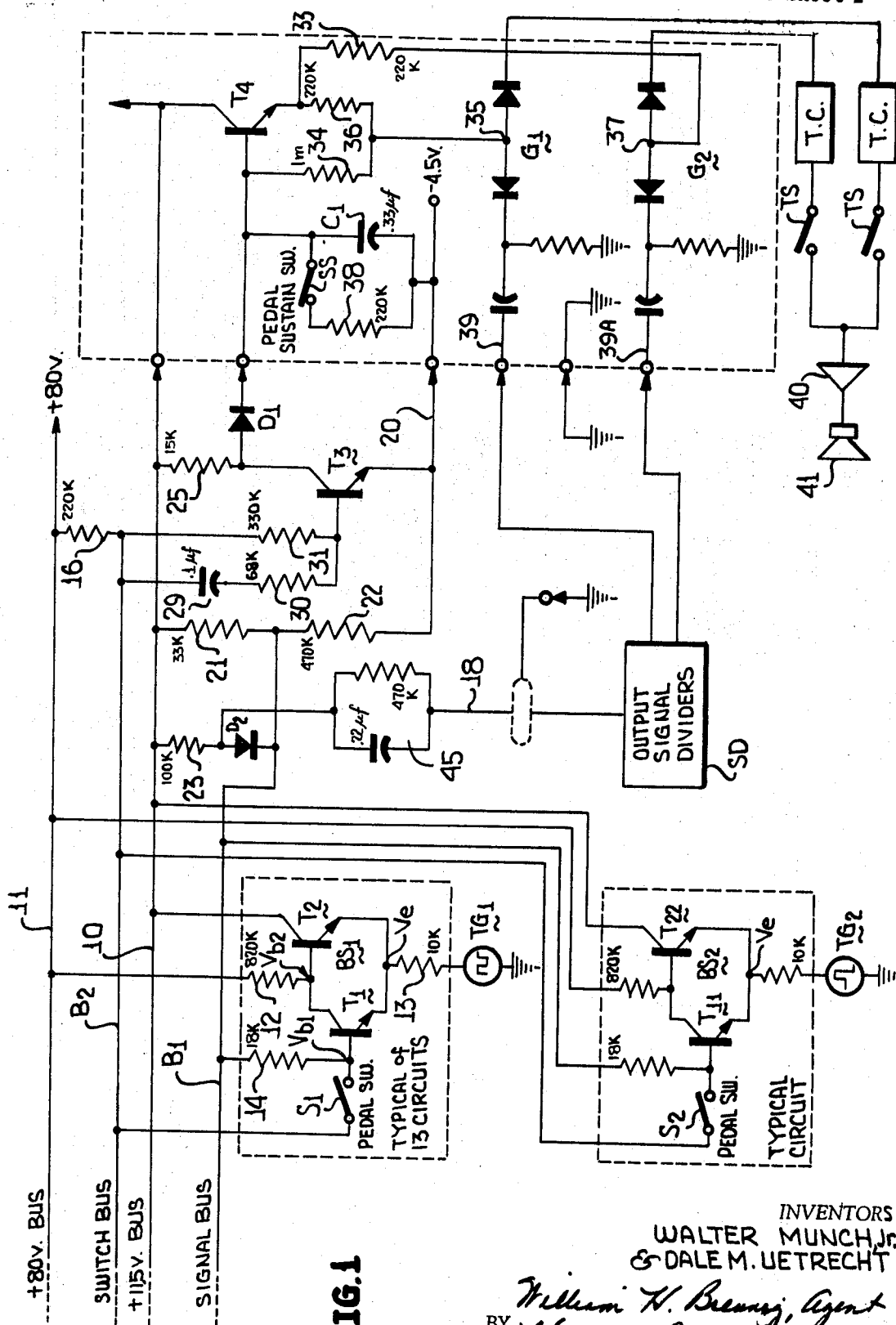


FIG. 1

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FIG.2

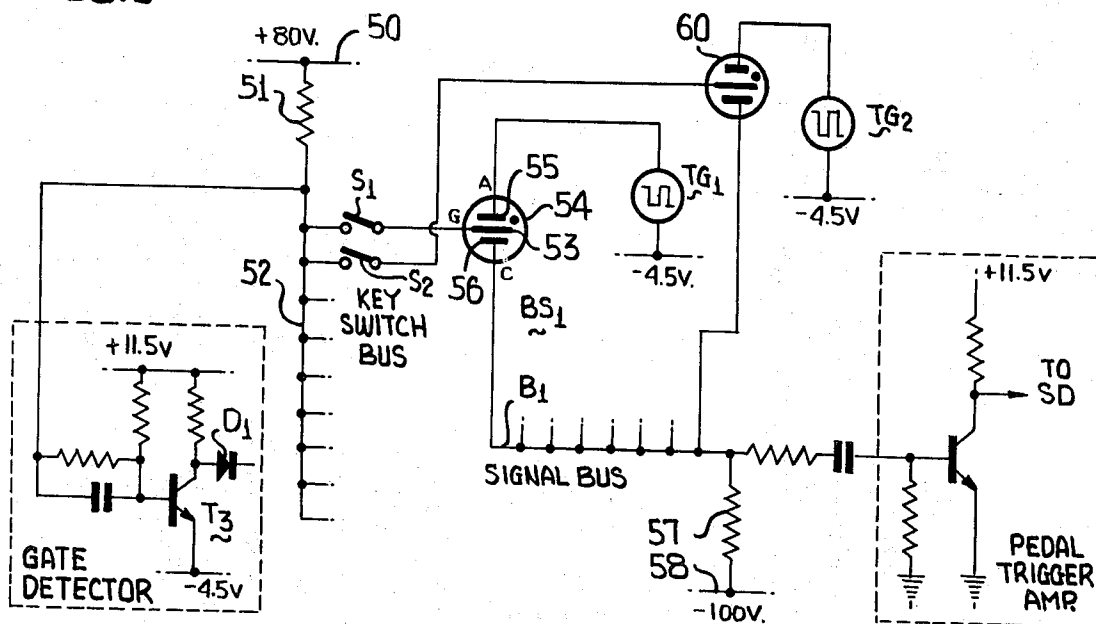
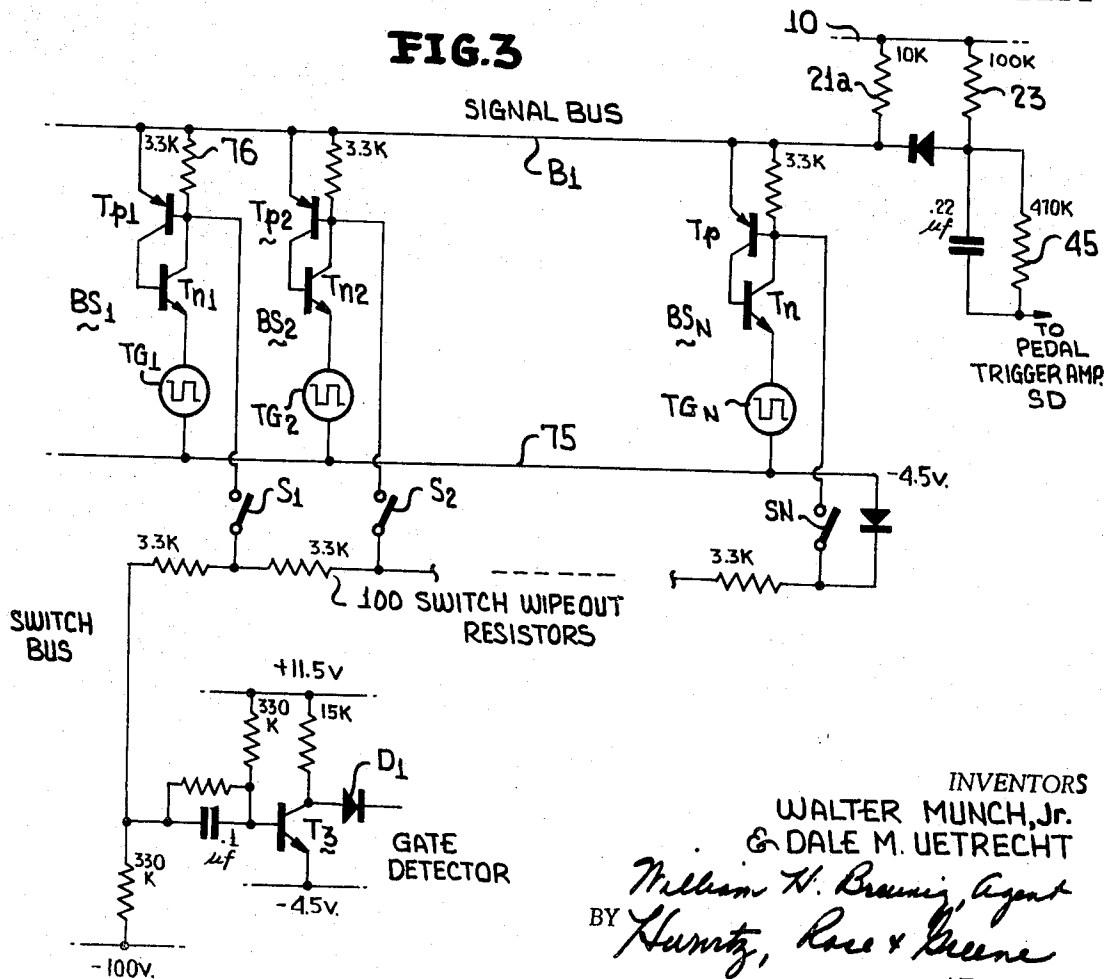


FIG.3



1

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ELECTRONIC LATCH AND WIPEOUT SYSTEM FOR MUSICAL INSTRUMENTS

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22 Claims

ABSTRACT OF THE DISCLOSURE

A series of bistable devices are connected in parallel between tone oscillators and a signal bus. Each bistable device serves as a gate between its tone oscillator and the signal bus. A switch bus is connected to control elements of the bistable devices, via a switch for each bistable device. The switches are operable by pedal keys of an electric organ. With all switches open the switch bus has a relatively high voltage, and all the bistable devices are in a first state. On closure of one of the switches the associated bistable device changes state and gates tone signal through to the signal bus, but concurrently changes DC voltages of the system. Simultaneous closure of any other switch cannot then change the existing state of any of the bistable devices, by virtue of the changed DC voltages and this condition obtains until one of the switches is opened, and another switch subsequently closed. In the latter event, the bistable device associated with the another switch changes state and the first mentioned bistable device reverts to its first state. If two pedal switches are closed simultaneously, one of these at random will seize control and the other have no effect, or a preference network may be included in the system to prefer one bistable device to another.

BACKGROUND OF THE INVENTION

Pedal latch systems are available in the prior art and have long been employed in electronic organs.

Certain latch systems are mechanical in nature, i.e., depression of any pedal latches that pedal in switch closed condition, and concurrently wipes out any previously depressed pedal. Other systems are electrical in nature, employing time constant circuits to hold a signal source latched to a load for a predetermined time following pedal actuation, and still other electrical latches are of unlimited duration, i.e., the latches hold until electrically released. The general function of a latch is to hold a single connection between a tone source and a load, such as a loudspeaker. The function of pedal wipe out systems is to wipe out all previously called for signals when a new signal is called for, so that only one note is played at a time, and still another is to prevent calling forth of two notes when two pedal keys are actuated. The latter function may be performed by preference circuitry, where preference is shown always for the higher (or in the alternative the lower) of two notes called for simultaneously, or by a random selection device in which no preference exists for higher or lower notes.

A representative U.S. patent showing a mechanical latch is: Hammond et al., 2,480,132, issued Aug. 30, 1949.

2

A representative U.S. patent teaching electronic latching is: Anderson, 3,190,951, issued June 22, 1965.

It is characteristic of the present system to utilize a single device to obtain both latching and wipeout. In general, when a number of these devices are connected to a common bus one will be in a first stable state and the remainder will be in a second stable state. If one of the devices is connected to a second common bus it will transfer to the first stable state and the device previously in the first stable state will transfer to the second stable state. If a second device is then connected to the second common bus it will, nevertheless, not transfer to the first stable state until the first connected device is disconnected. This requires a device which has two stable states. Further, the device, when connected to the common bus, controls the common bus in such manner that no other device can be in the same stable state as the first device. Further still, it must be possible to switch the desired stable state to a second device and to maintain this state whether or not a permanent connection is made.

SUMMARY OF THE INVENTION

The invention employs plural bistable circuits as latches, which act as gates to pass tone signals to a signal bus, when in a first state, for transfer to an electro-acoustic transducer. The bistable devices are all connected to a switch bus via mechanical switches. The switch bus changes its voltage from a high to a low voltage when any one of the switches is closed and thereby prevents all others of the bistable devices from achieving the first state while the one switch is closed. The bistable circuits themselves function not only as latches and gates, but to effect wipe out of all first states except the one called for by a closed switch, and to prevent achieving of the first state by more than one bistable circuit despite the fact that two switches are in closed condition simultaneously.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic circuit diagram of a preferred embodiment of the invention;

FIG. 2 is a schematic circuit diagram of a modification of the system of FIG. 1; and

FIG. 3 is a schematic circuit diagram of a further modification of the system of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Considering first the operation of a single bistable device BS1, transistor T1 has its collector directly connected to the base of transistor T2. The collector of T2 is directly connected to fixed positive supply bus 10 (11.5 v.). The collector of T1 is connected to fixed positive supply bus 11 (80 v.) via a resistive load 12 (820K). The emitters of T1 and T2 are connected together to point labeled Ve, and thence via a resistance 13 and tone generator TG1 to ground. The base of T1 proceeds from signal bus B1 via resistance 14 (18K). The DC voltage drop in proceeding to the base of T1 such that a small positive bias exists, say 3 v. DC positive with respect to the peak value of TG1, which provides positive and negative excursions with respect to ground, of values -4.5 v. to +5.5 v. Switch bus B2 can be connected to the base of T1 via pedal switch S1, which is at 48 v. with all switches S1 open. Bus B2 is connected back to +80 v. bus 11 via high resistance 16 (220K), so that when switch S1 is closed, bus B2 drops to

3

about 10 v. or less. T1, T2 are in a bistable configuration. Assume T1 is highly conductive. The bias for T2, i.e., the voltage between its base and emitter, is then sufficiently small that T2 will remain off. Assume T2 is highly conductive. The emitter of T2 will be negative with respect to the voltage on bus 10 by the collector-emitter saturation voltage of transistor T2. The emitter voltage of T1 will go positive with respect to the base of T1, and T1 will remain cut off. In alternative language, if T2 is highly conductive, the emitter of T1 goes so far positive that T1 is cut off, while if T1 is conductive the voltage across the base-to-emitter circuit of T2 is small and T2 remains non-conductive.

If the voltage of B1 goes negative with respect to V_e when T2 is conductive, the configuration is stable. If B1 is positive with respect to V_e when T1 is conductive, the configuration is stable. Both conditions can be satisfied with the same value of voltage at B1, as V_e varies, so that if multiple bistable circuits like BS1 are connected in circuits to the B1, B2 buses, one of these can be in one state and the remainder in the other, at the same time, and all will be in stable states.

With T1 highly conductive, signal from source TG1 can proceed via the emitter to base of T1 to signal bus B1 and thence to signal output lead 18. To render T1 highly conductive, S1 is closed.

In normal operation S1 would be closed by actuation of a pedal. So long as S1 is closed, it is desired that actuation of no other pedal can have effect, i.e., change state of a bistable circuit.

So long as S1 is closed, the voltage of bus B2 is reduced, because of the steady current which flows via T1, resistance 13, TG1 to ground, and the voltage drop which exists in resistance 16. With bus B2 at reduced voltage, T11 is reverse biased and cannot be rendered conductive even if S2 is closed. With S1 and S2 closed, only one circuit can be in the first stable state, i.e., conductive, at any one time for any appreciable time, i.e., one half cycle of TG1, TG2, etc. Assume that both BS1 and BS2 are in the first stable state and that both tone signals are then negative. Since the tone signals are not of the same frequency, one will go positive before the other. That signal will reverse bias T1 or T11, as the case may be, and switch it to the second stable state, leaving the other signal in control of its transistor, because B1 and B2 would then be of reduced voltage.

On the other hand, if both signals were positive, when two pedals were actuated, the first one to go negative would control the voltage of B1 and B2 and reverse bias the other, switching it to the second stable state. Essentially, one of the tone generators may go positive, within a short time interval, while the other is negative, after which only one tone generator can have its output gated through, even if two pedal switches are actuated simultaneously. Once a tone oscillator has assumed control, it can only be displaced from control if its pedal switch is opened and the other pedal switch closed.

Connected between bus 10, maintained at +11.5 v., and a -4.5 v. bus 20, is a voltage divider composed of resistances 21 and 22 (33K and 470K). The resistance values of the voltage divider and the voltage values specified, determine the voltage of bus B1 at about 1 v. below that of bus 10. Connected between bus 10 and bus B1 is a relatively high resistance 23 (100K) and a diode D2, in series, and output signal lead 18 is connected to the junction of these. The signal path thus proceeds via diode D2. Resistance 23 is shunted by a lower resistance 21 (33K). The voltage of bus B2 with all pedal switches S1, S2, etc. open is +48 v., due to a voltage drop in proceeding from bus 11 at +80 v. to bus B2 via resistance 16. However, when a pedal switch is closed a new path for current appears, via resistance 16 to signal bus B1. The voltage of bus B2 then drops to about 10 v. or less.

Transistor amplifier T3 has its collector connected via a collector load resistance 25 to bus 10 and its emitter

4

directly connected to negative bus 20. The base of T3 is connected via resistance 31 to B2, so that the amplifier is normally conductive and maintains its collector at a low negative voltage. On actuation of a pedal switch, as S1 or S2, voltage on bus B2 decreases. This decrease in voltage is communicated to the base of T3 via capacitor-resistor 29, 30, and via resistance 31. Since resistance 30 is relatively low, a sharp pulse of current is applied to the base of T3 just as one of switches S1, S2 is closed. The collector of T3 rises in voltage in response to the pulse, providing a positive pulse, which proceeds via diode D1 to charge sustain capacitor C1. As long as S1 or S2 remains closed, the signal from TG1 or TG2 is communicated to the base of T3. Therefore, capacitor C1 is maintained at a positive voltage so long as S1 or S2 remains closed. Assume pedal sustain switch SS to be open. The charge on C1 cannot leak off via diode D1, which is back-biased after termination of the signal from TG1 or TG2. Therefore, the charge on capacitor C1 can only leak off via high resistance 34 to the control point 35 of gate G1, and via the base-to-emitter circuit of transistor T4 and via emitter resistance 36 when T4 is conductive to control point 35. The emitter of T4 is connected via resistance 33 to control point 37 of gate G2.

Normally the base of T4 is negative with respect to the emitter, and T3 is saturated. The emitter of T4 finds a ground point via gates G1 and G2, but the base is subject to -4.5 v. at bus 20, i.e., with sustain switch SS closed, there is a direct connection via resistance 38 from bus 20 to the base of T4, while with SS open, capacitor C1 charges to near -4.5 v. from signal input lead 39.

Gates G1 and G2 are therefore in non-conductive condition. When C1 is charged positive, T4 becomes conductive and the control points of gates G1 and G2 become positive, and the gates become conductive.

Signal from lead 18 is applied to divider stages, lead 18 itself providing a 4' note and the divider stage providing division by two for application of an 8' note to signal input lead 39 of gate G1, while division by four is accomplished before application of a 16' note to the signal input lead 39a of gate G2.

Gates G1 and G2 are per se conventional and are therefore not described in detail. The signal output leads of these gates lead to tone color filters TC, tone selection switches TS and an audio amplifier 40 and loudspeaker 41.

Reviewing now the operation of the system of FIG. 1, assume that all switches S1, S2, etc. are open. T1, T11, etc. are then non-conductive and T2, T22, etc. conductive. No signal paths then exist between generators TG1, TG2, etc. and output lead 18. Assume now that S1 is closed raising the voltage at the base of T1 to that of switch bus B2, and reducing the voltage of that bus from about 48 v. to about 10 v. or less. T1 becomes conductive and T2 non-conductive, and current now flows from TG1, to the emitter of T1, to the base of T1, and via resistance 14 to signal bus B1. From signal bus B1 the signal flows through diode D2 to output signal lead 18 to signal dividers SD. The dividers produce 8' and 16' notes corresponding with C, at the frequency of TG1. The reduction in voltage at switch bus B2, which occurred when S1 was closed, renders T3 transiently non-conductive, and a positive pulse is communicated to gate G1. After S1 is open, if SS is closed, the charge on C1 decays rapidly via resistance 38, but if SS is open, the decay is slow via resistance 34. T4 amplifies the current supplied from C1, providing gating current, sustained or short, as the case may be, to the control points 35, 37 of gates G1, G2.

8' and 16' notes are then applied to tone color filters TC, and one of these may be selected by tab switches TS, for application to amplifier 40 and loudspeaker 41.

So long as S1 is closed, bus B2 is of reduced voltage and therefore closure of any other switch, as S2, cannot affect the associated bistable device, as TG2.

5

The voltage of B1 must be selected to be negative with respect to V_e when T2 is on, but positive with respect to V_e when T1 is on. When T2 is on, V_e is equal to 11.5 v., i.e., the voltage of bus 10, while bus B1 is about 10.5 v. However, when T1 is on, the voltage of V_e varies between 4.5 v. and 9.5 v. because of the 18K resistance in its circuit, and B1 is positive with respect to V_e . If T1 is in the first stable state and all other bistable devices are in the second stable state, only TG1 is latched to bus B1. For the values stated, excursions of TG2, from -4.5 to +5.5 v., cannot change the state of T22.

The voltage V_{b1} at the base of T1 follows the voltage V_e when S1 is closed and T1 conducting, but when T2 is conducting follows the voltage on signal bus B1. V_{b1} is intermediate between the signal bus and the signal source TG1 when T1 is on and switch S1 is open. The emitter voltages V_e of T1 and T2 are about $\frac{1}{2}$ v. negative with respect to V_{b1} when T1 is conducting but is between 11 and 11.5 v. when T2 is conducting. The voltage at the base of T2, V_{b2} , is about equal to V_e when T1 is conducting but rises by $\frac{1}{2}$ v. when T2 is conducting.

The anode of D2 is 9.5 v. when neither T1 nor T11 is conducting, but when either of T1, T11 is conducting attains negative excursions with respect to 11 v. as a reference of the negative excursions of the signal bus B1 + $\frac{1}{2}$ v. The time constant circuit 45 provides coupling of the audio signal from B1 to lead 18. The B1 signal bus is at +10.5 v., if T1 and T11 are not conducting.

In FIG. 2, voltage bus 50 (+80 v.) is connected via a voltage dropping resistance 51 to a switch bus 52. The latter is connected commonly to multiple key switches S1, S2 Taking switch S1 as exemplary, it is connected to the grid 53 of a neon tube triode 54 having an anode 55 and a cathode 56. The anode 55 is connected in series with a tone generator TG1, referenced back to -4.5 v. The cathode 56 of the triode 54 is connected to a signal bus B1, which is referenced via voltage dropping resistance 57 to negative bus 58 (-100 v.). A second neon cell 60 is similarly connected. On closure of S1, triode 54 becomes conductive, and current flows in resistance 57 raising cathode voltage at both triode 54 and triode 60 and dropping voltage at switch bus 52. Since firing voltage is greater than holding voltage, triode 54 can remain fired whether switch S1 remains closed or is opened. However, the DC voltage on the signal bus has now risen so far that closure of switch S2, with S1 closed, cannot fire triode 60. With S1 open, however, triode 60 can fire and in so doing extinguishes triode 54. Low voltage at bus 52 occurs while a key switch is closed, which provides signal to gate detector transistor T3 to render a gate conductive, while tone proceeds to pedal trigger amplifier SD.

The overall system of FIG. 2 parallels, in its organization, that of FIG. 1, and only sufficient circuitry is provided in FIG. 2 to demonstrate how FIG. 1 can be modified to employ bistable neon tube gates in place of transistor gates. Similarly, the overall system of FIG. 3 parallels the overall system of FIG. 1, the distinctions deriving from (1) the character of the bistable system employed, and (2) utilization of a resistive preference network consisting of equal resistances. Identical parts in the several drawings are similarly identified.

In FIG. 3, signal bus B1 is connected to bistable electronic switches BS1, BS2 . . . BS_n. Considering BS1, for example, it consists of a PNP transistor Tp1 and an NPN transistor Tn1, each having a base, emitter and collector. The collector of Tp1 is directly connected to the base of Tn1, and the collector of Tn1 to the base of Tp1. The emitter of Tp1 is connected to signal bus B1 and the emitter of Tn1 in series with a signal source TG1 to a -4.5 v. bus 75, common to all the bistable switches. The base of Tp1 is connected to key switch S1 and via voltage dropping resistance 76 to signal bus B1.

The bistable devices BS1 etc. are per se conventional. When all of these are in their first states, the Tp1 transistors are non-conductive, and negligible current flows

6

from TG1, TG2, etc. When S1 is closed, the base of Tp1 goes highly negative, and current flows from TG1 to bus B1, resistance 21a being the emitter load resistance for Tp1. Bus B1 then follows voltage variations of TG1, and the voltage at the base of T3 moves sufficiently in a positive sense that T3 becomes conductive and transfers gating voltage, as in FIG. 1. Signal on bus B1 is transferred to frequency dividers, via network 45, as in FIG. 1. Should S2 be closed while S1 is closed, it is ineffective to change the state of BS2, because it is supplied with bias from resistance string 100 at $\frac{1}{2}$ that available to Tp1. Similarly, if S1 and S2 are simultaneously closed, S1 will override S2. If S2 is closed first and while closed, S1 is closed, S1 will override S2, for the same reason. The systems of FIGS. 1 and 2 operate on a time preference system, i.e., if two key switches are simultaneously closed, either may override the other at random, depending on instantaneous values of tone signal. The system of FIG. 3, on the other hand, is position sensitive, the key switch of lowest identifying subscript controlling, when two or more key switches are actuated simultaneously.

What is claimed is:

1. In an electrical musical instrument, a plurality of tone generators; a load; bistable electronic switches each connected between one of said tone generators and said load; said bistable electronic switches having each a first stable state presenting a conductive circuit and a second stable state presenting a non-conductive circuit between one of said tone generators and said load;
2. a plurality of key switches operatively associated one for one with said tone generators and one for one with said bistable electronic switches;
3. a source of operating voltage for said bistable electronic switches;
4. control means responsive to simultaneous closure of one or more of said key switches for maintaining only one associated bistable electronic switch into its first stable state and for thereby producing a modification of said operating voltage such that the remaining ones of said bistable electronic switches are constrained to remain in said second stable state.
5. The combination according to claim 1, wherein said bistable electronic switches are each a bistable transistor pair configuration.
6. The combination according to claim 2 wherein said transistors are of the same conductivity type and each includes a base, an emitter and a collector; and wherein said emitters are directly connected together; and wherein the collector of one of said transistors is directly connected to the base of the other of said transistors.
7. The combination according to claim 1 wherein said bistable electronic switches include gas tube switching elements.
8. The combination according to claim 1 wherein each of said bistable electronic switches is a gas tube having an anode, a cathode and a control electrode.
9. The combination according to claim 2 wherein each bistable transistor pair configuration includes two interconnected transistors of opposite conductivity types having the collector of each directly connected to the base of the other.
10. The combination according to claim 1 wherein is provided a gate having an input circuit and an output circuit; means connecting said load to said output circuit; connection means connecting said bistable electronic switches in parallel to said input circuit; said gate being control voltage responsive into conductive condition and normally non-conductive; and means responsive to said modification of said operating

voltage for applying said control voltage to said gate.

8. The combination according to claim 7 wherein is further provided

a voltage divider included in said connection means.

9. The combination according to claim 1, wherein said control means includes

a fixed voltage terminal;

a bus;

voltage dropping resistance connected between said fixed voltage terminal and said bus;

said bistable switches being connected in parallel to said bus so as to produce current flow in said voltage dropping resistance and thereby a reduced voltage on said bus only while one of said bistable electronic switches is in said first stable state;

said bistable switches being arranged and adapted to refuse change of state to said first stable state while said bus has said reduced voltage.

10. The combination according to claim 1, wherein said control means is responsive to opening of the last one of said key switches to be opened to leave the one of the bistable electronic switches associated with said last one of said key switches to be opened in its first stable state until further actuation of one of said key switches.

11. The combination according to claim 10, wherein said control means is responsive only to closure of another one of said one or more of said key switches for maintaining said only one associated bistable electronic switch into its second stable state.

12. The combination according to claim 1 wherein said control means includes means responsive to the signal levels of the tone generators operatively associated with two or more simultaneously closed key switches for selecting said only one associated bistable electronic switch to be maintained in its first stable state.

13. The combination according to claim 1 wherein said control means includes means responsive to one of said key switches being closed and its associated bistable electronic switch in its first stable state for preventing all of the remaining bistable electronic switches from being forced into their second stable states by closure of another key switch.

14. The combination according to claim 1 further comprising means for selectively rendering percussive all tone signals passed through said bistable electronic switches to said load, whereby closure of a key switch to force a conductive bistable switch from its first to its second stable state acts to abruptly terminate the percussive tone signal conducted to said load.

15. In an electronic musical instrument:

a plurality of tone generators, each providing a tone signal which alternates between first and second signal levels;

a load;

a plurality of bistable electronic switches, each connected between said load and a respective tone generator, said bistable electronic switches each having a first stable state in which a tone signal is conducted therethrough from said tone generator to said load, and a second stable state in which conduction of a tone signal therethrough is blocked;

a plurality of key switches, each operatively associated with a respective tone generator and bistable electronic switch; and

control means for maintaining only one of said bistable electronic switches in said first stable state and forcing all other bistable electronic switches into said second stable state, said control means including:

first means responsive to closure of each key switch in the absence of closure of a previously-closed key switch and in time-coincidence with provision of said first signal level by the tone generator associated with the closed key switch for forcing the bistable electronic switch associ-

ated with the closed key switch into its first stable state;

second means responsive to two or more of said bistable electronic switches in said second bistable state simultaneously for forcing into said second stable state all but the one of said two or more bistable electronic switches which is connected to the last tone generator to provide said second signal level.

16. The combination according to claim 15 wherein said bistable electronic switches each comprise a pair of transistors connected in bistable configuration.

17. The combination according to claim 16 wherein said transistors are of the same conductivity type and each includes a base, an emitter and a collector; wherein said emitters are directly connected together; wherein the collector of one of said transistors is directly connected to the base of the other of said transistors; and

wherein said tone generator is connected to said emitters.

18. The combination according to claim 16 wherein each pair of transistors includes two interconnected transistors of opposite conductivity types having the collector of each directly connected to the base of the other; and

wherein said tone generator is connected to the emitter of one of said pair of transistors.

19. The combination according to claim 15 wherein said bistable electronic switches include gas tube switching elements.

20. The combination according to claim 15 wherein each of said bistable electronic switches is a gas tube having an anode, a cathode and a control electrode; and

wherein each anode has a tone generator connected thereto.

21. The combination according to claim 15 further comprising means for selectively rendering percussive all tone signals passing through said bistable electronic switches to said load, whereby closure of a key switch to force a conductive bistable electronic switch from its first to its second stable state acts to abruptly terminate the percussive tone signal conducted to said load through that bistable electronic switch.

22. In an electronic musical instrument:

a plurality of tone generators, each providing a tone signal at a respective frequency which alternates between first and second signal levels;

a load;

a plurality of bistable electronic switches, each connected between a respective tone generator and said load, said bistable electronic switches each having a first stable state presenting a conductive circuit, and a second stable state presenting a non-conductive circuit between said tone generators and said load;

a plurality of key switches, each operatively associated with a respective tone generator and bistable electronic switch;

a source of operating voltage for said bistable electronic switches; and

control means responsive to simultaneous closure of one or more of said key switches for maintaining only one associated bistable electronic switch in said first stable state and for producing a modification of said operating voltage such that the remaining ones of said bistable electronic switches are constrained to remain in said second stable state until the key switch associated with said only one associated bistable switch is opened and another of said key switches is closed;

wherein said control means includes:

first means, responsive to whichever of the tone generators associated with said simultaneously

9

closed key switches first provides said first signal level after said simultaneous closure, for selecting the bistable electronic switch connected to that tone generator as said only one bistable electronic switch; and
 second means, responsive to time-coincidence of said simultaneous closure and the provision of said first signal level by two or more tone generators associated with said simultaneously closed key switches, for selecting as said only one of said bistable electronic switches that which is connected to the one of said two or more generators which provides said first signal

5

10

10

level for the longest period of time following said simultaneous closure.

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