United States Patent

[11] 3,549,779

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[21] Appl. No. **788,868**
[22] Filed **Jan. 3, 1969**
[45] Patented **Dec. 22, 1970**

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[54] **PLURAL SHORT SUSTAIN PERCUSSION GATES AND COMMON GATE ARRANGEMENT FOR ELECTRONIC MUSICAL INSTRUMENTS**
12 Claims, 7 Drawing Figs.

[52] **U.S. Cl.** **84/1.26,** 84/1.13
[51] **Int. Cl.** **G10h 1/02**
[50] **Field of Search** ..... 84/1.01, 1.03, 1.04, 1.11, 1.13, 1.19, 1.24, 1.26(B, O)

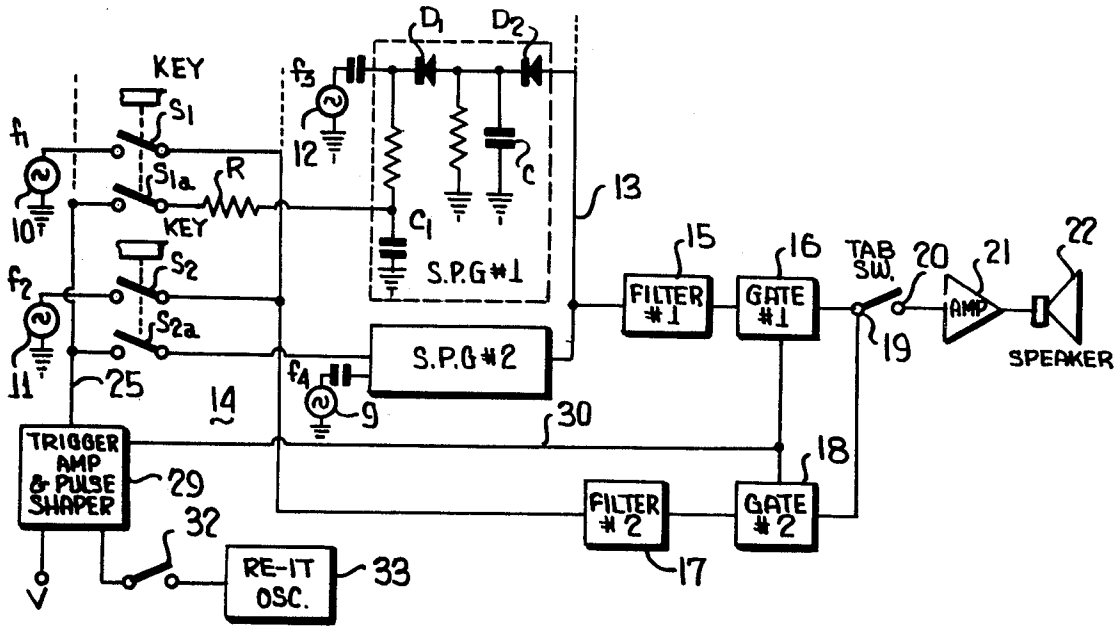
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ABSTRACT: Tone sources are connected via individual percussive short sustain gates to the input of a common gate, which transfers a long sustained tone signal each time it is subject to a control impulse. Each key, when actuated, supplies tone signal to a percussive gate and a control impulse to the common gate. In addition, actuation of each key supplies tone signal to a fast-rise, fast-decay common gate, the output of which is paralleled to the output of the long sustain common gate, to provide the effect of plucking a string. The individual short sustain gates simulate a damped percussive sound when a note is depressed and released immediately, and in that case the long sustain common gate will not affect the sound, although that gate will go through a cycle of operations. The fast-rise, fast-decay common gate will affect the sound regardless of whether a note is depressed and released or depressed and held down. If the key is depressed and held down, the individual short sustain gate will remain on, but the common gate will modify the signal to provide a long sustain note. The various percussive voices can be reiterated by applying reiteration pulses to the common gates.



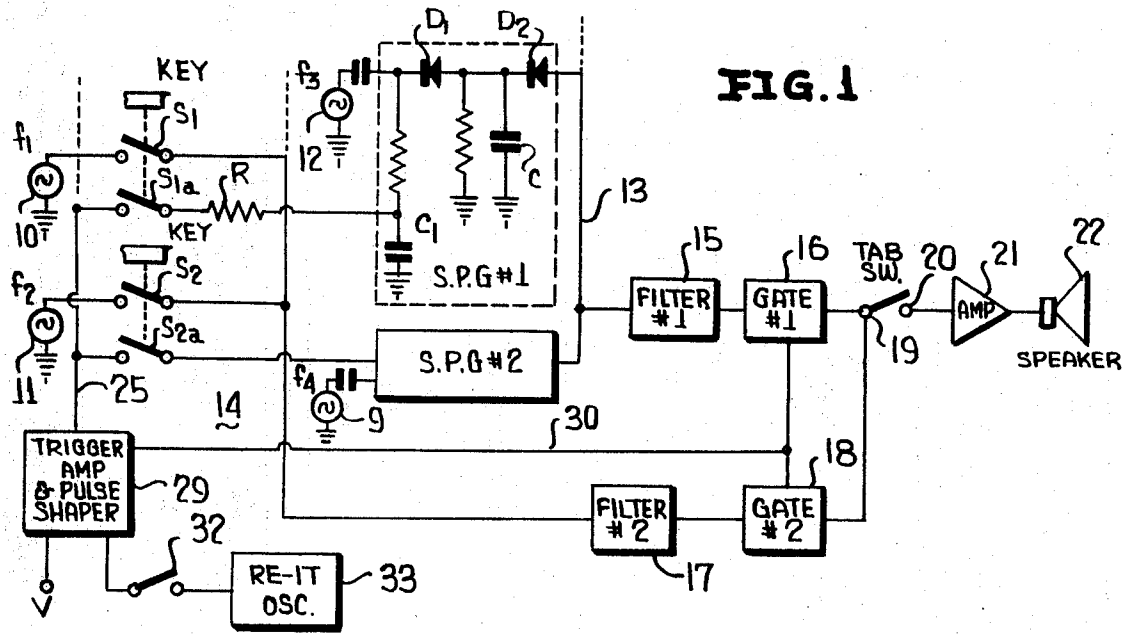


FIG. 1

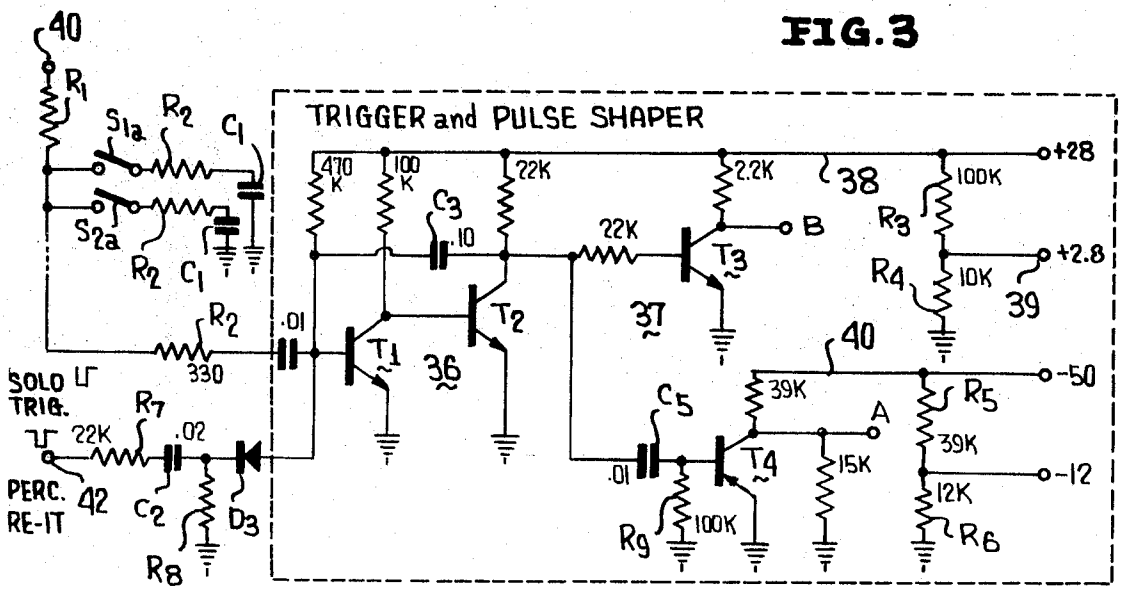


FIG. 3

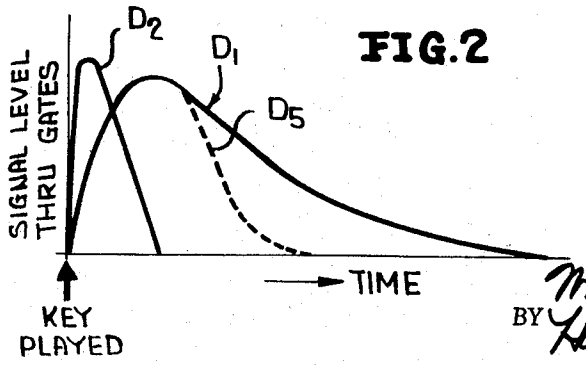
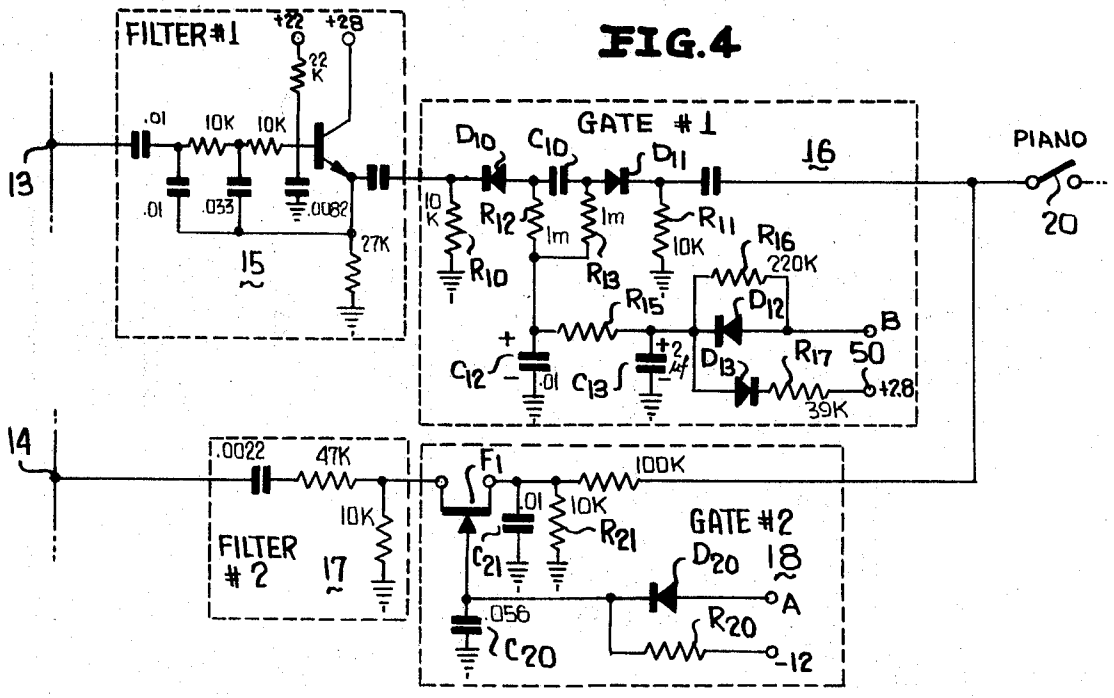


FIG. 2

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FIG.4



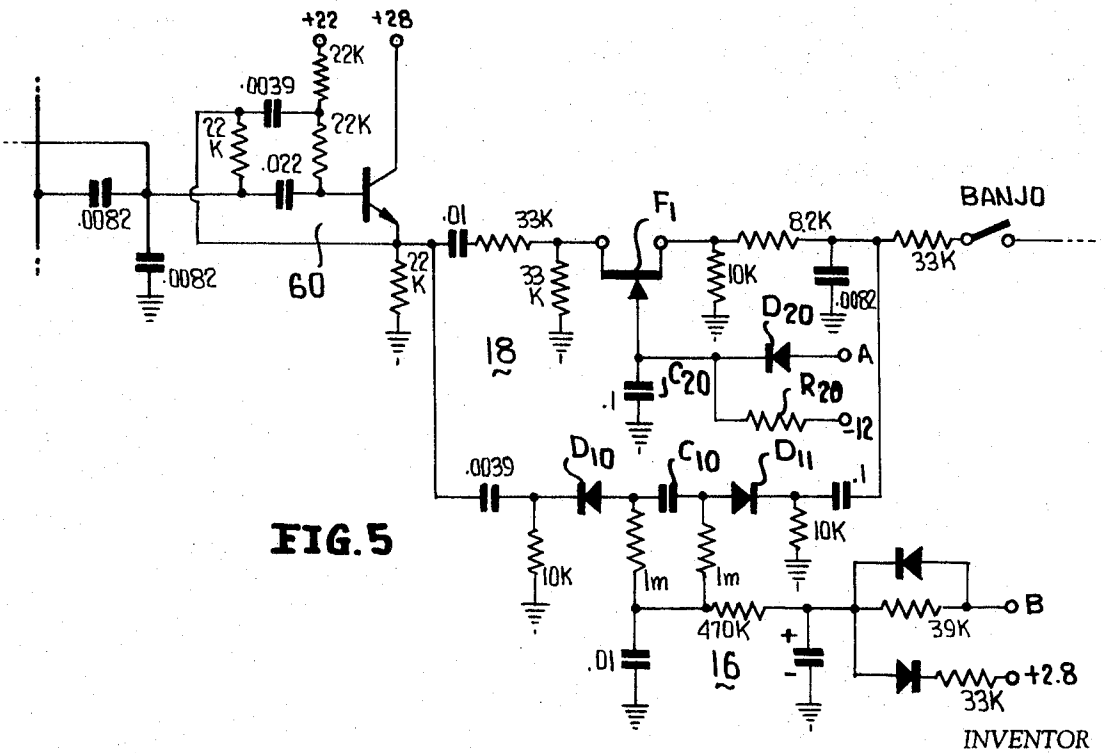


FIG.5

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FIG.6

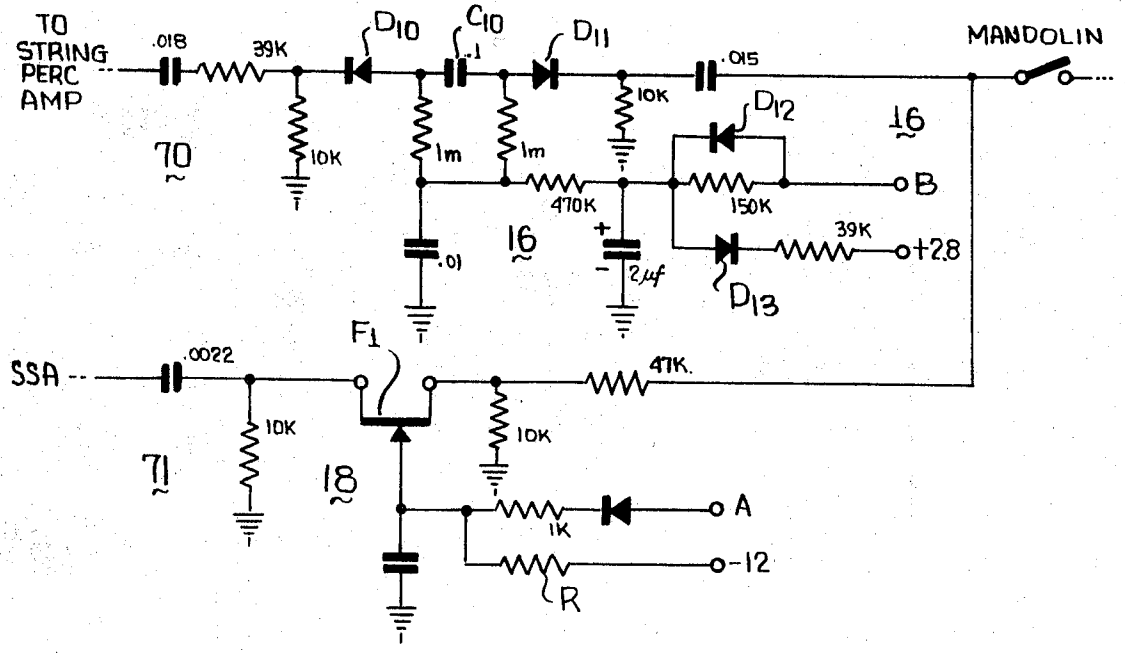
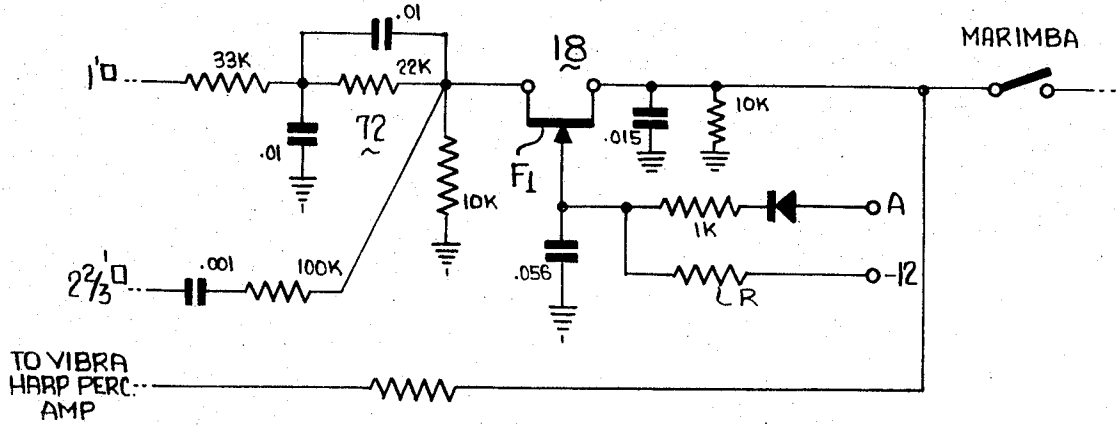


FIG.7



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PLURAL SHORT SUSTAIN PERCUSSION GATES AND COMMON GATE ARRANGEMENT FOR ELECTRONIC MUSICAL INSTRUMENTS

BACKGROUND OF THE INVENTION

It is known, in the electronic organ art, to utilize percussive gates for tone signals. These are essentially keyed on gates which have rather short sustain time, and they remain on so long as a key remains depressed. They provide percussive sounds if a key is hit and released at once.

Percussive gates are known to which tone signal is or may be continuously applied, and which in response to a short control pulse, provided on key actuation, provide a rapid buildup and long decay of conductivity. Such gates provide a long sustained note of predetermined duration, which terminates even if the key which provided the control pulse should be held down. However, the two types of gates have not heretofore been employed in cascade. When so employed, they provide excellent piano simulation in that hitting and releasing a key quickly, i.e., staccato playing, provides a short sustained note, but actuating a key and maintaining it actuated, provides a long sustained note of predetermined duration, regardless of duration of key actuation.

In addition to the above, actuation of each key provides signal to a percussive gate which forms a waveform simulating the plucking of a string, and which is exclusive of the common gate. The several gates may be respectively subjected to notes of different footages or frequencies, if desired, and reiteration can be accomplished by applying repetitive short pulses to the common gate, to simulate strumming. A variety of percussive voices can be simulated by means of the present gating system and appropriate tone color filters.

SUMMARY OF THE INVENTION

A percussive gating system employing two gates in series, one of which is responsive to key actuation, a separate gate being provided for each key, and is a diode gate having a short sustain, the other of which is a common gate, i.e., common to all the short sustain gates, and has a predetermined long duration conductivity. The latter comes into play only if a key is depressed for a sufficiently long time. In addition, a common gate can be connected directly between the tone sources and the output of the first mentioned common gate, which has a very short sustain and a fast rise, to simulate plucking of strings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of a system according to the invention;

FIG. 2 is a wave shape diagram indicating delay times through the several gates of FIG. 1;

FIG. 3 is a schematic circuit diagram of the trigger and pulse shaper, of FIG. 1;

FIG. 4 is a schematic circuit diagram of a portion of the system of FIG. 1, arranged to simulate the piano;

FIG. 5 is a schematic circuit diagram of a portion of the system of FIG. 1, arranged to simulate the banjo;

FIG. 6 is a schematic circuit diagram of a portion of the system of FIG. 1, arranged to simulate the mandolin; and

FIG. 7 is a schematic circuit diagram of a portion of the system of FIG. 1, arranged to simulate the marimba.

BRIEF DESCRIPTION OF THE PREFERRED EMBODIMENT

In FIG. 1, 10, 11, 12 and 9 are respectively tone sources of diverse frequencies f_1, f_2, f_3, and f_4, respectively. Connected in cascade with source 12 is a short sustain gate SPG_1. This gate is connected to a header 13. Tone source 9 is connected in cascade with gate SPG_2, which in turn is connected to header 13. Tone source 10 is connected via key switch S_1 to a header 14, as in source 11 by means of key switch S_2.

Header 13 is connected via filter 15 to a common gate 16; header 14 is connected via filter 17 to common gate 18. Common gates 16 and 18 issue to a common collection point 19, which can be connected by a tab switch 20 to an amplifier 21 and loudspeaker 22.

Associated with each of key switches S_1 and S_2, is another key switch S_{1a}, S_{2a}, respectively. The latter are ganged with switches S_1 and S_2, respectively. Switches S_{1a} and S_{2a} are connected to a DC voltage line 25, which provides gating voltage to gates SPG_1 and SPS_2. The latter are typical short sustain gates, employing two series diodes D_1, D_2 per gate, which are normally nonconductive of the tone supplied by sources 9 and 12, but which are rendered conductive, on closure of a key switch as S_{1a}, by the consequent application of gating voltage. The gate remains conductive as long as gating voltage is applied. Since the gating voltage is applied across capacitor C_1, this capacitor is charged, and on opening the key switch, discharges through the gate, sustaining conductivity for a sensible time. An appropriate decay curve is illustrated at D_s, FIG. 2. Resistance R controls the rise of conductivity, of the SPG gate. If a key is depressed and rapidly released, the SPG gate will provide an output signal which rises and then falls according to the curve D_s. If desired, the resistance R may be deleted and slowing of rise time eliminated.

Whenever a key is depressed, and whether or not some other key is concurrently depressed, a voltage pulse is sensed by trigger and pulse shaper 29, which is applied to gates 16 and 18, via line 30. These gates are normally nonconductive, but in response to application of a control pulse proceed through a predetermined cycle of conductivity, typically that of D_1 of FIG. 2, for gate 16, and D_2 of FIG. 2 for gate 18. Tone signal is applied to gate 18 as soon as a key is depressed. To gate 16 is applied the output of one or more percussive gates SPG.

It is within the scope of the invention to employ source 10 in place of source 12, if desired, or source 12 may be one or more octaves above or below source 10, in frequency, i.e., the tones may be of different footages, or other frequency relations may appeal musically to the designer.

Gates 16 and 18 are normally nonconductive, and are turned on concurrently by pulses applied over line 30. Gate 18 produces a pulse of tone which rises very rapidly and decays very rapidly, regardless of whether the calling key is held down, per curve D_2. The SPG gate produces a pulse of tone, per curve D_s, if a key is depressed and rapidly released, or it produces a steady tone if the key is held down. Gate 16 produces a pulse per curve D_1, which can only occur if a key is held down, since otherwise the pulse of tone supplied to the input of gate 16 is so short that the gate has no audible effect, despite the fact that it proceeds through its normal cycle.

Reiteration pulses can be supplied to trigger and pulse shaper 29, via switch 32 from multivibrator oscillator 33. This has the effect of repeating the called-for tone or chord, so long as the appropriate key or keys are depressed.

In FIG. 3 are illustrated key switches S_{1a}, S_{2a}..., one for each key of the organ, or for those keys to which the system is to apply. A voltage terminal 40 supplies voltage via a resistance R_1 to the switches in parallel. The switches then proceed via resistances R_2 to capacitors C_1, which provide a transient pulse whenever a key switch is closed, because this action changes the voltage drop in resistance R_1. This voltage pulse actuates a monostable flip-flop 36, comprising transistors T_1 and T_2, to produce a pulse of predetermined amplitude and duration. This pulse is inverted by amplifier 37, employing transistor T_3, and applied to terminal B. A voltage divider R_3, R_4, connected to the supply lead 38 for T_1, T_2, T_3, all NPN transistors, provides 2.8 at terminal 39, the utility of which will be described hereinafter.

The output of flip-flop 36 is also coupled to the input of PNP transistor T_4, supplied from negative supply line 40, and a control pulse provided by T_4 is applied to terminal A. A DC voltage of −12 is also provided by voltage divider R_5, R_6. Reiteration voltage is supplied to the base of T_1 from terminal

42, via series RC circuit R_7, C_2 and diode D_3. Resistance R_8 provides charging path for capacitor C_2.

T_1 is normally conductive, since its base is connected to the positive supply. On application of a negative pulse via R_2, transistor T_1 becomes nonconductive. T_2 is normally nonconductive because its base is at 0 when T_1 is conductive. When T_1 becomes nonconductive, T_2 turns on, discharging C_3. C_3 then maintains T_1 nonconductive for a time after the control pulse disappears, and until its charge dissipates. T_3 is normally conductive, and on arrival of a negative pulse from T_2 becomes transiently nonconductive, providing a positive pulse at terminal B.

The output of T_2, which is a negative pulse, is differentiated in C_5, R_9 and turns on transistor T_4, at PNP transistor. Point A at the output of T_4 is normally at −15, since T_4 is normally nonconductive, its base being grounded for DC. When T_4 is rendered transiently conductive, point T_4 goes to 0, but this output pulse is extremely short due to the action of the differentiator.

Referring now to FIG. 4 of the accompanying drawings, tone signal from header 13 is applied via active filter 15, which is tailored to simulate the content of a piano tone. The output of active filter 15 is applied to a generally conventional diode gate 16. Gate 16 includes a grounding resistance R_{10} at its input, and another R_{11}, at its output. The gate itself involves back-to-back diodes D_{10} and D_{11}, having their anodes coupled via a capacitor C_{10}, which isolates the gates for DC, but permits AC signal to pass. Gating voltage is applied to the anodes of D_{10}, D_{11} via *lm* resistances R_{12}, R_{13}, so that gating current is measurable in microamperes.

Input current is constrained to have a low value. For these operating conditions, the gate is linear over its entire range of gated signal, producing no harmonic or intermodulation distortion, despite the fact that the input signal is complex and that the gating voltage proceeds through a wide range of values. The gate per se forms the subject matter of a copending application, filed on Nov. 13, 1968, in the name of Harris, entitled Touch Percussion for Electronic Organ, and assigned to the assignee of this present application.

Gating voltage is applied at terminal B, being taken from terminal B of FIG. 3. The gating voltage is applied via diode D_{12} to charge capacitor C_{12} and C_{13}. Resistance R_{15} provides a charging time constant for C_{12}. The charge is applied as a short pulse, and cannot leak off via D_{12}, but only slowly via resistance R_{16} and T_3. (FIG. 4). Diode D_{13} acts as a snubber, being conductive so long as the gating voltage sufficiently exceeds a 2.8 bias set in at terminal 50, and thereafter being nonconductive. A gating pulse applied to charge C_{12} and C_{13} then decays via three paths, i.e., R_{16}, R_{12} and R_{13} and via D_{13}, R_{17}, for a time. When the gating voltage has decayed to 2.8, the diode D_{13} shuts off, and decay continues only via R_{16}, R_{12}, R_{13}, and hence at a slower rate. This double rate of decay of gating voltage is desirable to simulate piano tones.

The gate 18 employs a FET, F_1. Tone signal is applied via passive high pass filter 17, to the source electrode and the drain electrode proceeds to one side of tab switch 20. The gate electrode is connected via resistance R_{20} to −12 and also to a point A via D_{20}. It will be recalled that point A is normally at −15 and proceeds to ground potential on receipt of a control pulse. The −15 is not applied because diode D_{20} is interposed, and the gate is held nonconductive by the −12 bias. Upon grounding of point A, the negative charge on C_{20} rapidly decays via D_{20}. Capacitor C_{21} and resistance R_{21} provide a click filter. The time constant of C_{20}, R_{20} now controls rise time, since T_4 is only momentarily conductive. The discharge of C_{20} takes place via D_{20}, T_4 and is very rapid; the recharge takes place through R_{20} and is slower, and the total wave shape is that of D_2, FIG. 2.

The system of FIG. 4 reproduces the sound of a piano hammer striking a string, followed by a rapid building of tone, followed by a slow decay, if the key is held down, and the double-rate decay requisite for true piano reproduction. If the key is struck and promptly released, gate 16 is ineffective because the SPG gate has a far more rapid decay time and about the same rise curve, as does gate 16. Gate 16 goes through its cycle of operations, for each depression of a key, regardless of how long the key is held depressed, but it produces no audible effect if the key is released with sufficient rapidity.

The system of the invention is commonly applicable to simulation of the tones of the piano, the banjo, and the mandolin, although filtering and time constants differ for the separate cases. Appropriate circuitry, with circuit values and input wave characteristics, are provided in FIGS. 4, 5, 6, 7, respectively. To simulate the marimba, the circuit of FIG. 7 is adequate, i.e., use of gate 18, alone.

For the case of the piano, signal input for gate 16 is derived from a string percussion filter amplifier, while the gate 18 is supplied with solo 8-foot square waves. For the case of the banjo, both gates are supplied via a common low-pass active filter 60, and the utilization of a separate tone source for gate 18 is dispensed with. The net response of the system is then the sum of curves D_2 and D_8, or D_2 and D_1, as in the case of the piano, but the summed tones are duplicate in the case of the banjo, but not in the case of the piano.

In the case of the mandolin, the input filters are high pass filters, for both gates 16 and 18. Gate 16 receives output from a percussive string filter amplifier, but gate 18 and filter 71, receive solo 8-foot triangular waves.

In the case of the marimba, the filter 16 is not employed, since the tones are short. The gate 18 alone suffices, with a low pass filter 72 at its input, to which is applied a 1-foot square wave, a 2⅔-foot square wave being applied through a high pass filter to the input FET, and the output of a vibra harp percussive amplifier to the output of the FET. In this case, the vibra harp component of the output is always of duration established by an SPG gate, which is provided.

I claim:

1. An organ system, comprising:
a plurality of tone signal sources;
plural relatively short percussive gates connected in cascade one for one with said tone signal sources;
key operated means for rendering said gates selectively conductive, each of said gates being arranged to remain conductive while one associated key is actuated and to become gradually nonconductive thereafter with a relatively short sustain; and
a long sustain gate connected commonly in cascade with all said short percussive gates, said long sustain gate being arranged to be responsive to actuation of one of said keys for initiating a gating cycle of predetermined duration regardless of the actuated condition of said associated key.

2. An organ system, comprising:
a plurality of tone signal sources;
a plurality of key switches;
means responsive to selective actuation of said key switches for selectively calling forth tone signals from said tone signal sources;
a long sustain common gate;
a load; and
means connecting said common gate to pass all said tone signals to said load, said common gate being arranged to be responsive to operation of any of said key switches for initiating an on-gating cycle of predetermined duration and wave shape regardless of the duration of actuation of said any of said key switches.

3. The combination according to claim 2, wherein said common gate is operative to initiate said gating cycle in response to triggering pulses, and wherein is provided means responsive to actuation of any of said key switches regardless of the then condition of the remaining key switches, actuated or unactuated, for generating one of said triggering pulses.

4. The combination according to claim 2, wherein the first mentioned means are short sustain gates individual to said tone signal sources.

5. The combination according to claim 4, wherein is further provided a further common gate having sustain time shorter

than the sustain times of said short sustain gates, means for connecting said further gate selectively between said tone signal sources and said load, said further common gate having a faster build up time than said short sustain gates have.

6. The combination according to claim 4, wherein said short sustain gates and said common gate have substantially the same buildups, but radically different decay characteristics.

7. The combination according to claim 6, wherein said common gate has a double-rate decay characteristic.

8. The combination according to claim 7, wherein is further provided a tone color filter connected antecedent to said common gate, and wherein said common gate is a linear gate.

9. The combination according to claim 5, wherein said common gate is a linear gate and wherein said further common gate is a FET gate, said tone signals being square wave signals, means directly applying said square wave signals for passage by said FET gate, and tone color filtering circuitry connected between said tone signal sources and said common gate.

10. The combination according to claim 2, wherein is further provided a reiteration signal source, and means applying said reiteration signals to initiate gating cycles of said common gate.

11. The combination according to claim 3, wherein is further provided a reiteration signal source, and means responsive to said reiteration signal source for supply said triggering pulses.

12. In a gating system for an electronic musical instrument:

a source of tone signal;

a normally open switch;

a load;

means responsive to closure of said switch for transferring tone signal from said source in a path toward said load for the duration of said closure;

a gate connected in the path of said tone signal antecedent to said load, said gate being responsive to a control signal to providing a predetermined conductivity pattern as a function of time; and

means responsive to each initiation of closure of said switch for initiating said pattern, whereby a sufficiently long duration closure of said switch produces a tone signal conforming to said pattern in toto, but a sufficiently short duration closure of said switch produces a correspondingly short tone signal conforming to said pattern only in part.