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[21] Appl. No. **775,320**  
[22] Filed **Nov. 13, 1968**  
[45] Patented **Jan. 26, 1971**  
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[54] **TOUCH PERCUSSION FOR ELECTRONIC ORGAN WITH BACK-TO-BACK DIODE GATES**  
5 Claims, 6 Drawing Figs.

[52] U.S. Cl. .... 84/1.26,  
307/246, 307/259

[51] Int. Cl. .... G10h 1/02

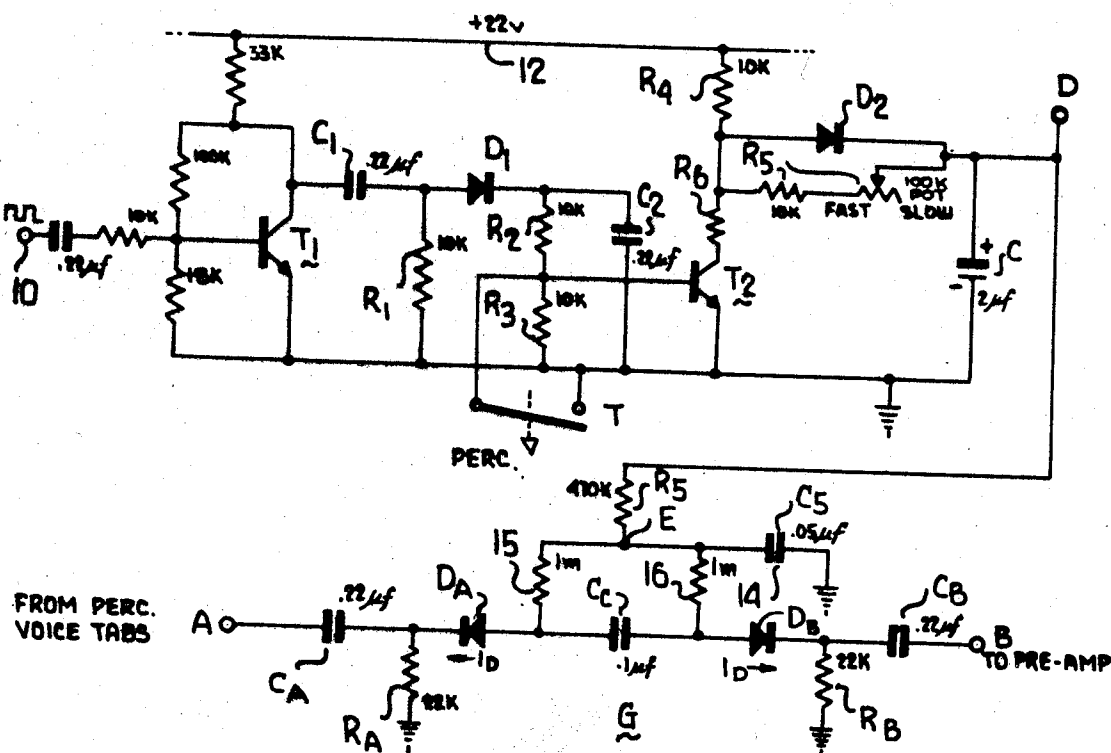
[50] Field of Search ..... 84/1.01,  
1.11, 1.13, 1.17, 1.19, 1.24, 1.26, (0); 307/256,  
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**ABSTRACT:** An electronic organ system in which tone signals deriving from percussive voice tabs are passed through a slow percussive linear diode gate to an amplifier and loudspeaker. The percussive voices are provided by either percussive gates or key switches individual to tone sources and have relatively fast decays following release of key switches. The individual percussive gates remain open while key switches are closed. The slow percussive gate is common to all the percussive voices and is either (1) normally open and gradually closed during any tone or (2) is normally closed and is rapidly opened and then gradually closed in response to onset of any tone regardless of whether other tones are then present, by means of a novel gating wave generator. The system utilizing percussive gates as tone generators is particularly useful in simulating piano tones since if a key is held down a long sustain results, which cuts off fairly rapidly if the key is released, but which is percussive, if a key is actuated staccato, with a short sustain.



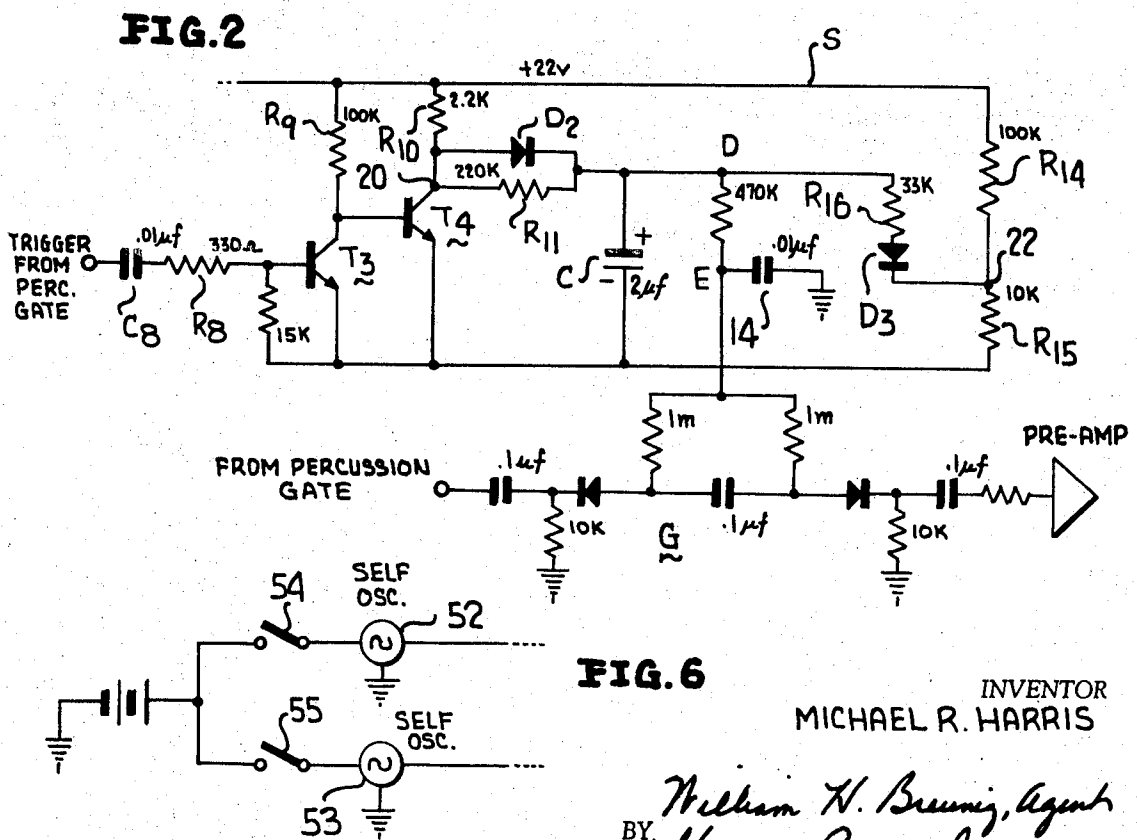
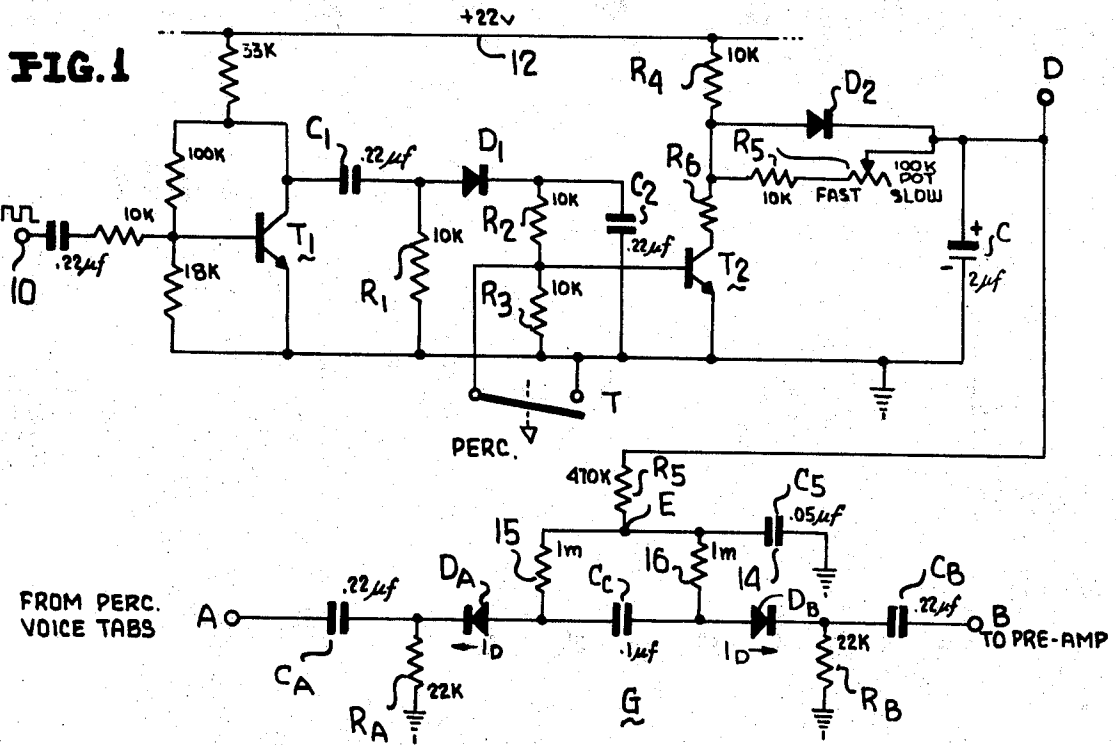
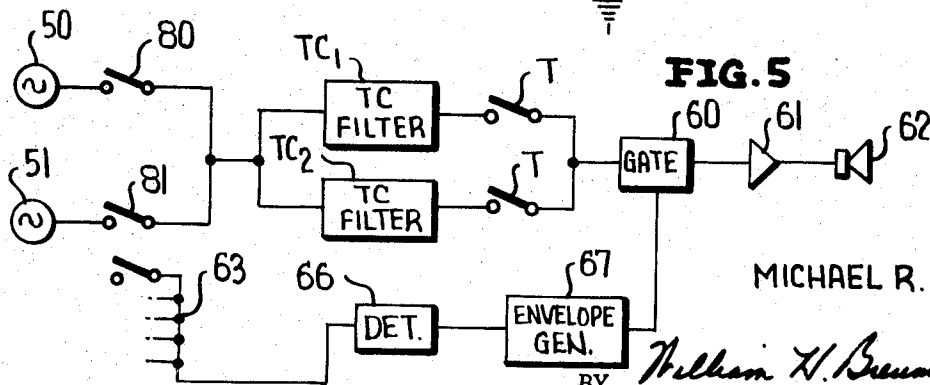
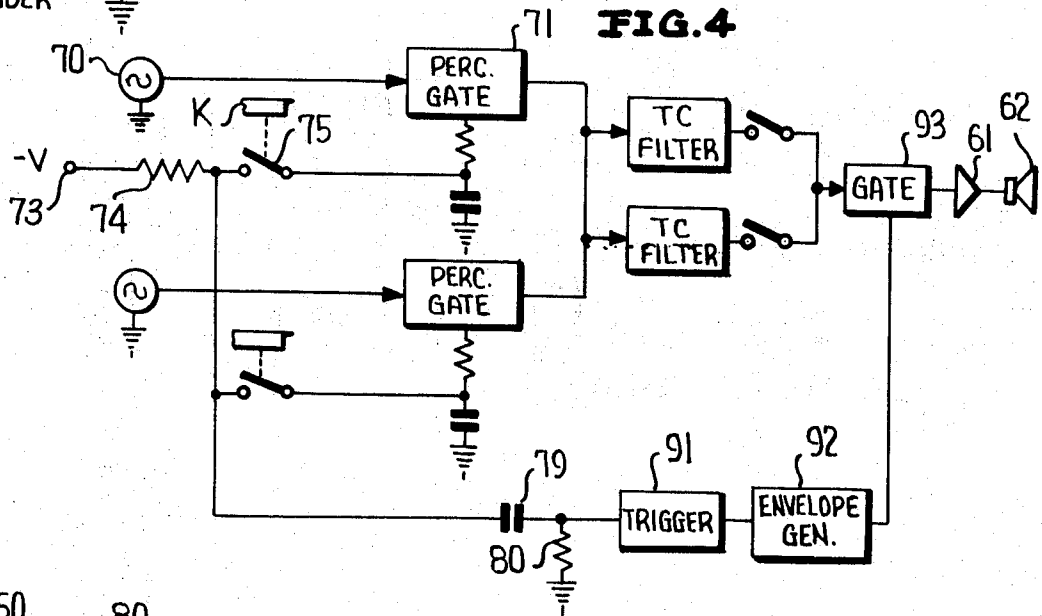
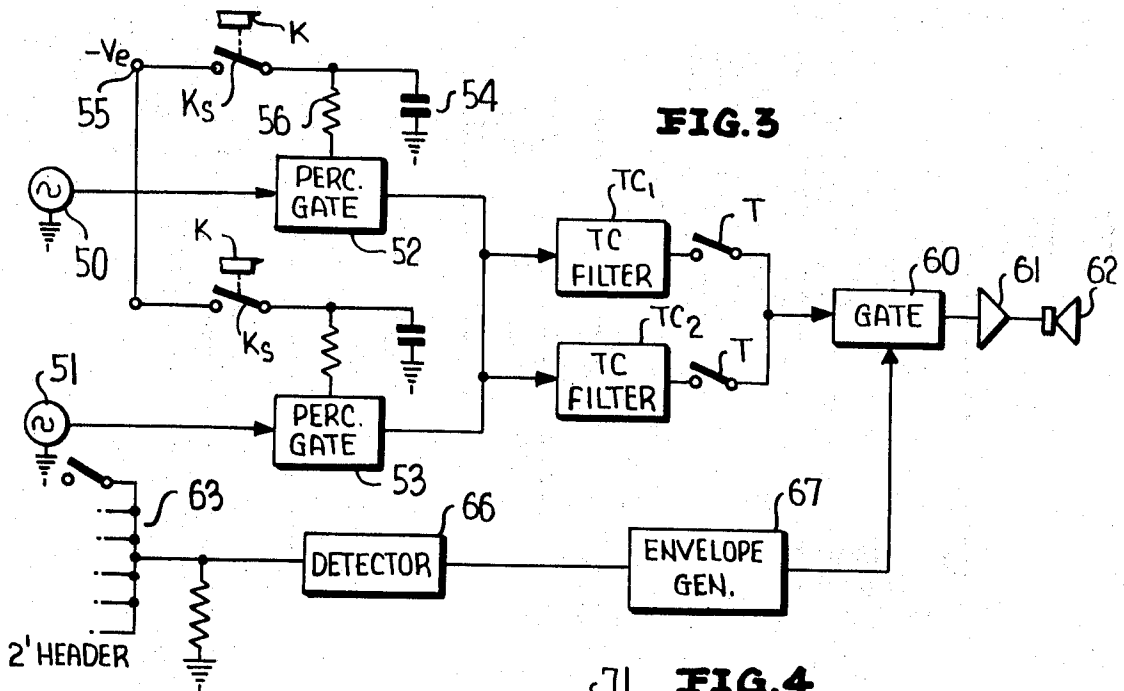


**FIG. 6**

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## TOUCH PERCUSSION FOR ELECTRONIC ORGAN WITH BACK-TO-BACK DIODE GATES

### BACKGROUND OF THE INVENTION

Touch percussion is the name given to an organ tone control system wherein the outputs of selected tone color filters employing percussive tones are passed through a percussive linear gate common to all the tones. It is known to connect key switches of an organ all to a common percussive gate, which turns rapidly on and then slowly off, in response to actuation of any key regardless of the condition of the remaining keys. It is also old to provide a sustaining gate in common for all the tone signal outputs of an organ. The novelty of the present system resides in the provision of a long sustain percussion gate for a large group of tones which are themselves of short sustain character, by providing a short sustain percussive gate in cascade with each tone source, and a long sustain percussive gate in cascade with those tone color tabs of the system which provide percussive tone, so that the long sustain percussive gate passes formed signal spectra rather than the square waves. A novel diode gate is provided which operates linearly in response to the signal spectra, i.e., without introducing intermodulation products.

The system may operate in either of two modes. In one, presence of any signal on a given output header is detected and utilized to gradually turn off a normally-on linear diode gate. This system has a disadvantage that if any key is held down, the organ will not operate in response to actuation of other keys. In a second mode of operation, transient trigger pulses are generated on actuation of a key. These are used to control a normally-off linear diode gate to turn it rapidly on and then to gradually turn it off. Thereby, actuation of a key results in sounding of notes corresponding with then actuated keys together with sounding of the note corresponding with the newly actuated key.

The crucial feature of the invention apart from use of a novel linear diode gate, is the provision of short sustain percussive gates individual to each key, in conjunction with a long sustain percussive gate common to all the short sustain percussive gates. The short sustain gates are of the type which remain on if the key is held down, and the long sustain gate is of the type which initially is, or becomes, conductive and thereafter becomes gradually nonconductive. It follows that in response to a staccato playing only the short sustain gates come into play, while on sustained playing, the notes die slowly away even while keys are held down, but decay rapidly when keys are released. The system has particular application to simulating the piano, wherein continued depression of a key does not result in a sustained tone, but rather results in a slowly decaying tone, release of the key causing a rapid decay of the tone. The possibility of linearly gating tones is advantageous in that the slow gate may be connected to follow stop tabs and therefore does not interfere with or modify the normal operation or location of the tone color filters of existing organ designs.

### SUMMARY OF THE INVENTION

A percussive linear diode gate, utilizing back-to-back diodes separated by a capacitor, turned on by current in the microampere range, is driven by complex AC signal at low level. The gate is common to the percussive voices of an electronic organ and has a much longer sustain time than do the percussive voices themselves. Piano tones can be simulated. A novel gating wave generator for the gate is utilized.

### BRIEF DESCRIPTION OF THE DRAWINGS

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

FIG. 2 is a schematic circuit diagram of a second embodiment of the invention;

FIG. 3 is a block diagram of a first organ system employing the invention of FIG. 1;

FIG. 4 is a block diagram of a second organ system employing the invention of FIG. 2;

FIG. 5 is a block diagram of an organ system representing still another embodiment of the invention, and specially one in which short time constant percussive gates are not employed.

FIG. 6 is a block diagram of still a further embodiment of the invention, in which the concepts of the invention are applied to self-oscillators which are turned on by keying.

### DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1 of the accompanying drawings, 10 is a header of an electronic organ, and therefore has the tone signal thereon when, and only when, a key is in actuated condition. The tone signal is normally square wave in nature.  $T_1$  operates as an amplifier and isolation circuit and transfers the tone signal to capacitor  $C_1$  and resistance  $R_1$  connected in series from the collector of  $T_1$  to ground. The tone signal is half wave rectified by diode  $D_1$  and causes capacitor  $C_2$  to be charged. Resistances  $R_2$ ,  $R_3$  are connected in shunt of  $C_2$ , providing a time constant sufficiently long to sustain the charge on  $C_2$  between pulses.  $T_1$ ,  $D_1$  and associated circuits act as a detector of tone signal, providing steady DC so long as tone signal is present on header 10.  $R_2$ ,  $R_3$  is composed of a 10.K ( $R_2$ ) and a 100.K ( $R_3$ ) resistor. Across the latter is connected the base-emitter circuit of  $T_2$ , which is normally off. A switch  $T$  is connected between base and emitter of  $T_2$  to maintain  $T_2$  off, but with switch  $T$  open, presence of tone signal will turn  $T_2$  on. In absence of tone signal,  $T_2$  is off and the anode of diode  $D_2$  at supply voltage of 22.V, its anode being connected to supply lead 12 via a small resistance  $R_4$ . The cathode of  $D_2$  is connected to a plate of a capacitor  $C$ , the other plate of which is connected to ground. On receipt of a signal,  $C$  discharges through  $R_5$  (a variable resistance) and  $T_2$ . By adjusting  $R_5$  the decay time of  $C$  can be adjusted. Charge of  $C$ , which occurs when a signal ceases to be present, is quite rapid, the time constant being determined by  $R_4$ . Discharge occurs via  $R_5$ ,  $R_6$  and is quite slow, and, moreover, adjustable.

Signal from percussive tabs are applied at terminal A. This implies that key switch-controlled percussive gates, or key switch contacts followed by percussive tone color filters, transfer signal selectively from a gamut of tone signal sources, which may be a frequency divider chain providing tone signal for tone of each nomenclature.

The signal input to terminal A is a complex signal, derived from square waves, but at this point already tone colored. If a single key is depressed, a frequency spectrum and wave envelope is produced which depends on the character of a percussive gate or the original waveform and of a following tone color filter. If several keys are simultaneously depressed, or depressed in rapid succession, the frequency spectrum will be more complex. In any event, the spectrum does not consist of level-amplitude square waves, but of tone colored percussive signals.

The gate  $G$  has the function of linearly modulating the input wave passed by the gate to an output terminal, that is without introducing harmonic or intermodulation distortion. The gate  $G$ , to this end, operates with very slight bias current and low signal level. For example, the input signal may be at 10 mv. maximum, and gating current may be a few microamperes.

The gate  $G$  includes diodes  $D_A$  AND  $D_B$  having their anodes back-to-back and separated by a relatively large coupling capacitor  $C_C$ . The cathodes of  $D_A$ ,  $D_B$  are connected to ground by resistances  $R_A$ ,  $R_B$ , and are AC coupled to terminals A and B by large capacitors  $C_A$  and  $C_B$ , circuit values being provided in the drawings. From control point D to terminal E is connected a large resistance  $R_5$ , and point E is connected to ground by a capacitor 14, which operates as a transient filter. Point E is connected to the anodes of  $D_A$ ,  $D_B$  by 1.M resistors 15 and 16, respectively. The gate  $G$  is normally on, being maintained on by currents to diodes  $D_A$  and  $D_B$ , which flow in response to voltage at point D. The presence of  $C_C$  between the diodes isolates these from each other for DC so that each is independently biased, and they need not be matched. Were  $C_C$  absent, and the diodes  $D_A$ ,  $D_B$  mismatched for voltage

drop, bias current would divide unevenly and all the bias current would tend to flow in one only of the diodes, which would render the gate inoperative for its intended purpose.

Referring now to FIG. 2 of the accompanying drawings, the system is intended to operate in response to a pulse which occurs whenever a key is actuated, at the moment of actuation only. The pulse is applied by a DC isolating circuit composed of  $C_8$ ,  $R_8$  to the base of NPN transistor  $T_3$ , normally off, and turns  $T_3$  on transiently. An NPN transistor  $T_4$  has its base connected to the collector of  $T_3$ , the latter being collector loaded by resistance  $R_9$ .  $T_4$  is therefore normally on, but is turned off when  $T_3$  is turned on. The collector of  $T_4$  is collector loaded by small resistance  $R_{10}$  (2.2K) and has its emitter grounded, so that 20, the collector terminal goes to +22.v when  $T_4$  is off and to near zero v. when  $T_4$  is on. Terminal 20 is connected to large capacitor C ( $2\mu$ ) via diode  $D_2$ , which serves to rapidly charge C, when  $T_4$  is off via resistance  $R_{10}$ , and to slowly discharge C when point 20 goes to zero v. Charge time is thus about one-tenth of discharge time, and on receipt of a pulse, C rapidly charges and thereafter slowly discharges. Point D controls gate G as in the case of the circuit of FIG. 1.

Since the system of FIG. 2 is intended to provide piano tone simulation, a double decay rate is introduced into the gating voltage wave. To this end, a voltage divider composed of resistances  $R_4$ ,  $R_{15}$  (100.K and 10.K) is connected from supply lead S to ground. A resistance  $R_6$  (33K) and a diode  $D_3$  are connected between point D and the junction of  $R_4$ ,  $R_{15}$ . The diode  $D_3$  is biased on while the voltage of terminal D exceeds that of terminal 22, which occurs in the earlier portion of the decay of voltage across C. Therefore, C discharges through two parallel paths, one containing  $R_6$  and the other containing  $R_6$ ,  $R_{15}$  in series. When the voltage of terminal D has decreased to and below the voltage of terminal 22,  $D_3$  is biased off and one discharge path for B, i.e., that through  $D_3$ , is disabled, reducing the rate of decay. For other tones than piano tones, the circuit comprising  $D_3$  may not be required, and in general the decay rate of terminal D can be tailored to simulate that of the conventional instrument being simulated.

FIGS. 3-5 of the accompanying drawings represent typical organ systems employing the invention.

In FIG. 3 is illustrated an organ system having typical tone signal sources 50, 51, derived normally from a frequency divider chain. These tones may also be derived by turning on normally-off self-oscillators 52, 53, FIG. 6, as by closing key switches 54, 55 leading to a voltage source, and thus energizing the oscillators.

The outputs of oscillators 50, 51 are connected to typical percussive gates 52, 53, having short time constants of decay, but which remain on while keys K are depressed, and key switches KS are therefore closed. Each percussive gate is provided with a storage capacitor, as 54, which is charged from terminal 55 when key switch KS is closed, maintaining the gate conductive. The charge to capacitor 54 decays at a sensible rate through resistor 56 when key K is released, and the note being played decays with a short sustain.

The outputs of percussive gates 52, 53 are passed selectively through tone color filters  $TC_1$  and  $TC_2$  via tabs T to a long time constant percussive gate 60, and from that gate to an amplifier 61 and loudspeaker 62. 63 is a 2-foot header of the organ and therefore will have tone signal thereon whenever a key is actuated, and for as long as the key is actuated. For example, the key switches leading to this header may be closed by the keys K. The tone or tones on header 63 are detected in detector 66 to provide a DC control voltage, to envelope generator 67, which generates an appropriate gating wave. The latter is applied to long sustain gate 60, normally on, and turns the latter off with a long sustain. The system of FIG. 3 employs the gating wave generator and gate of FIG. 1 of the accompanying drawings, and FIG. 3 is intended to exemplify a complete system incorporating FIG. 1.

The system of FIG. 2 of the accompanying drawings is employed in the organ system illustrated in FIG. 4 of the accompanying drawings. Here transfer of tone from a tone signal

source 70 to the tone color filters is caused by transfer of a DC voltage from terminal 73, via resistance 74 to key switch 75 to the control point of the gate 71. The gate has a short sustain and remains on while the key is depressed, its conductivity decaying rapidly, but sensibly thereafter. The system as described to this point operates like the system of FIG. 3.

A small resistor (74) is connected between -V and the key switches. When any key is depressed, a positive voltage transient appears at the key switch end of 74 irrespective of the number of keys depressed. This is detected as a pulse by differentiator 79, 30, and applied to a trigger generator 91, which initiates a long gating wave in envelope generator 92. The latter is applied to gate 93, normally off, to turn it on rapidly and thereafter gradually and slowly off.

In the system of FIG. 3, if any key is actuated, gate 60 proceeds through its cycle. Actuation of another key while the first is operated does not restart gate 60, which sees no difference between one note and several notes, so long as they overlap in time. In the system of FIG. 4, on the other hand, actuation of any key initiates a cycle of operation of gate 93, whether or not other keys are then actuated.

The system of FIG. 5 represents a simplification of the system of FIG. 3, in which short percussive gates are dispensed with, the key switches 80, 81 operating as the gates. If the key switches 80, 81 are rapid on-off switches, short sustain time will be zero, but variable resistance switches can be employed, which effect a gradual decay as a key is raised. Since FIGS. 3 and 5 illustrate analogous systems and employ the same numerals of reference, further discussion of FIG. 5 is not required.

The diode gating current in the diode gates of FIGS. 1 and 2 is not more than  $50\mu a$  and decreases as a function of time to zero. The applied musical tones applied to terminal A of FIG. 1 and the corresponding terminal of FIG. 2 is less than 25ma.

I claim:

1. A percussion circuit, including:

an array of tone signal sources each connected to a bus via a separate percussive gate having a relatively rapid decay rate;

a load circuit;

a further percussive gate connected between said bus and said load circuit, said further percussive gate having a relatively slow decay rate, said further percussive gate including;

back-to-back diodes connected in series between said bus and said load circuit;

means DC isolating said diodes;

a coupling capacitor connected between said diodes for solely AC coupling said diodes;

means maintaining AC current flow from said bus into said further percussive gate below about 25 mv; and

means separately biasing said diodes in response to a gating current wave which decreases gradually as a function of time from not more than  $50\mu a$  to substantially 0.  $\mu a$ .

2. The combination according to claim 1, wherein: said further percussive gate is normally open; and means responsive to presence of signal on said bus for generating said gating current wave.

3. The combination according to claim 1, wherein: said further percussive gate is normally closed; and means responsive to each initiation of conductivity of any one of said separate percussive gates for generating said gating current wave.

4. Gating circuit for musical tone signals, comprising:

a first diode;

a second diode;

a coupling capacitor connecting said diodes in a series circuit;

means applying musical tone signals to said series circuit; means deriving musical tone signals from said series circuit; first resistive means DC isolating said diodes from each other and applying separate substantially identical gating waves to corresponding electrodes of both said diodes;

5

second resistive means connecting the remaining ones of said electrodes to ground; and  
said first resistance means being arranged to limit diode bias current to less than 50.  $\mu$ a peak, the applied musical tones having peak amplitudes of less than 25.ma.

5. A gating system, comprising:  
a transistor switch having a first terminal providing voltage at two discrete levels with respect to ground selectively;  
a timing capacitor having one terminal connected to ground and having a further terminal; and  
a diode and a timing resistance connected in parallel and both connected between said first terminal and said

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further terminal, said diode being poled to conduct current into said capacitor while said voltage is at the higher of said two discrete levels, a linear diode gate responsive to the voltage across that capacitor, said linear diode gate including back-to-back diodes separated by a coupling capacitor connected in series between a tone signal source and a load circuit, and separate current limiting resistances connected between said capacitor and said diodes, said resistances being selected to limit bias current in said diodes below 50.  $\mu$ a peak.

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