United States Patent [19]

Bunger

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[54] **ARPEGGIO SYSTEM**

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[52] **U.S. Cl.** **84/1.03,** 84/1.24

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

[58] **Field of Search** 84/1.01, 1.03, 1.24, 1.17, 84/DIG. 22

[56] **References Cited**

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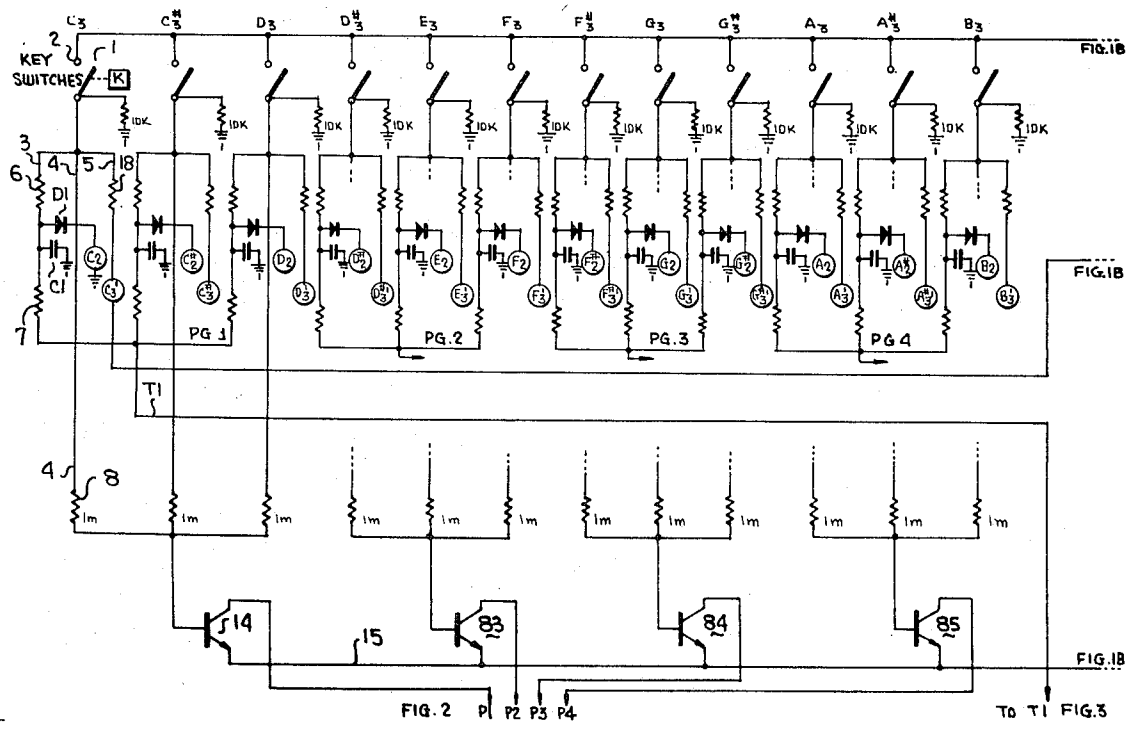
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Assistant Examiner—Stanley J. Witkowski
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[57] **ABSTRACT**

An electronic organ having provision for playing a played chord as guitar strum, including not only the notes of the played chord but also all notes an octave lower, including a sequence of key switch controlled gating circuits extending over two octaves, each key controlling two tone gates and actuation of any key starting a ramp type pulse sequencer, which turns on in sequence pulse gates of the system which correspond with the actuated keys. The system is arranged to operate with 12 pulse readouts in the sequencer and twelve pulse gates controlled by the sequencer, since although 24 key switches are included, each sounds two notes an octave apart. Eight key gates control the sequencer, since each key gate is responsive to the key switches of three adjacent half tones, and the eight key gates select all the required steps of the sequencer for operation to turn on the pulse gates in correct sequence.

23 Claims, 4 Drawing Figures



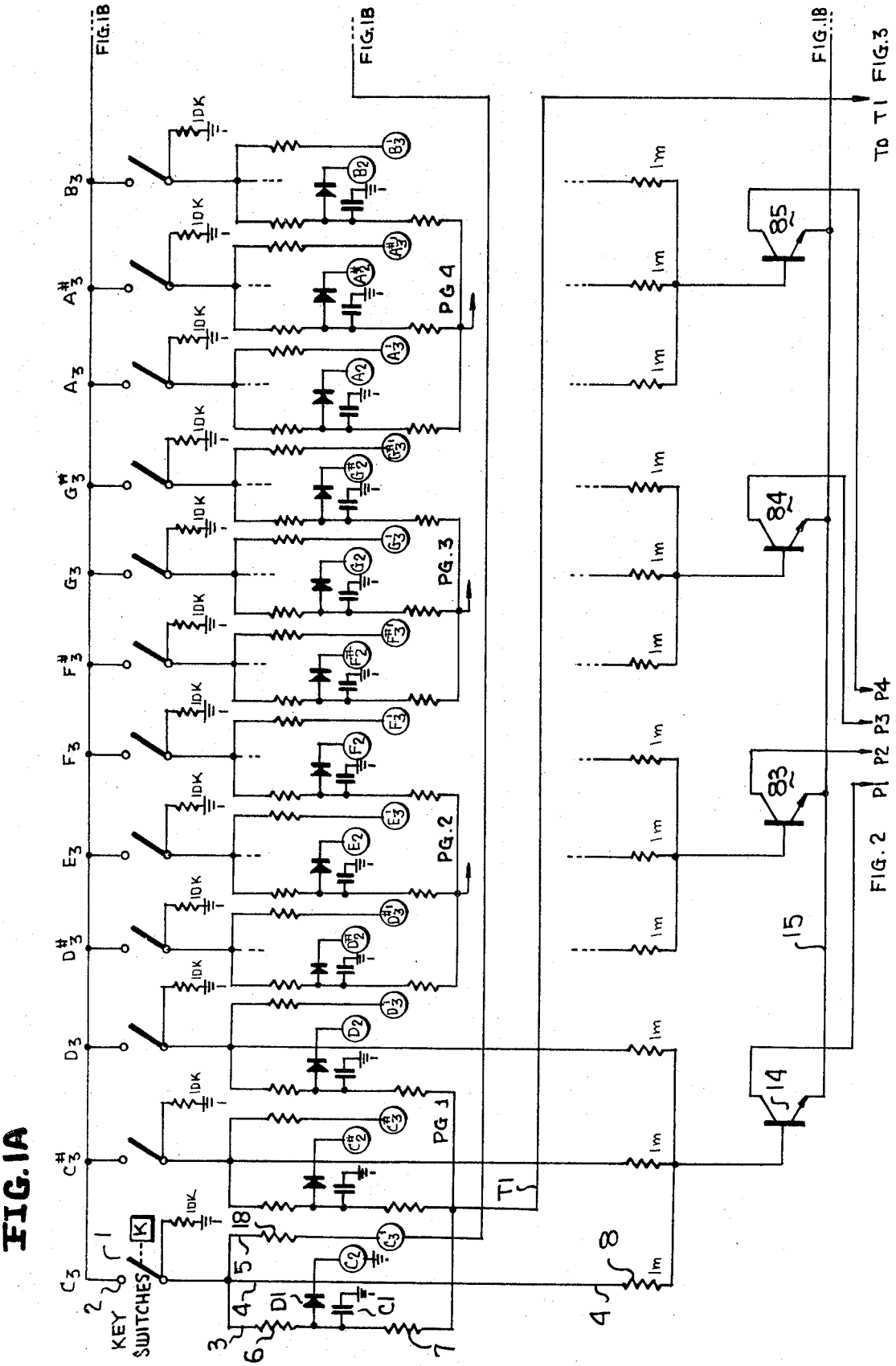

FIG.1A
KEY SWITCHES
K
1DK
1m
PG.1
PG.2
PG.3
PG.4
FIG.1B
TO T1 FIG.3
P1 P2 P3 P4
FIG. 2

FIG. 1B

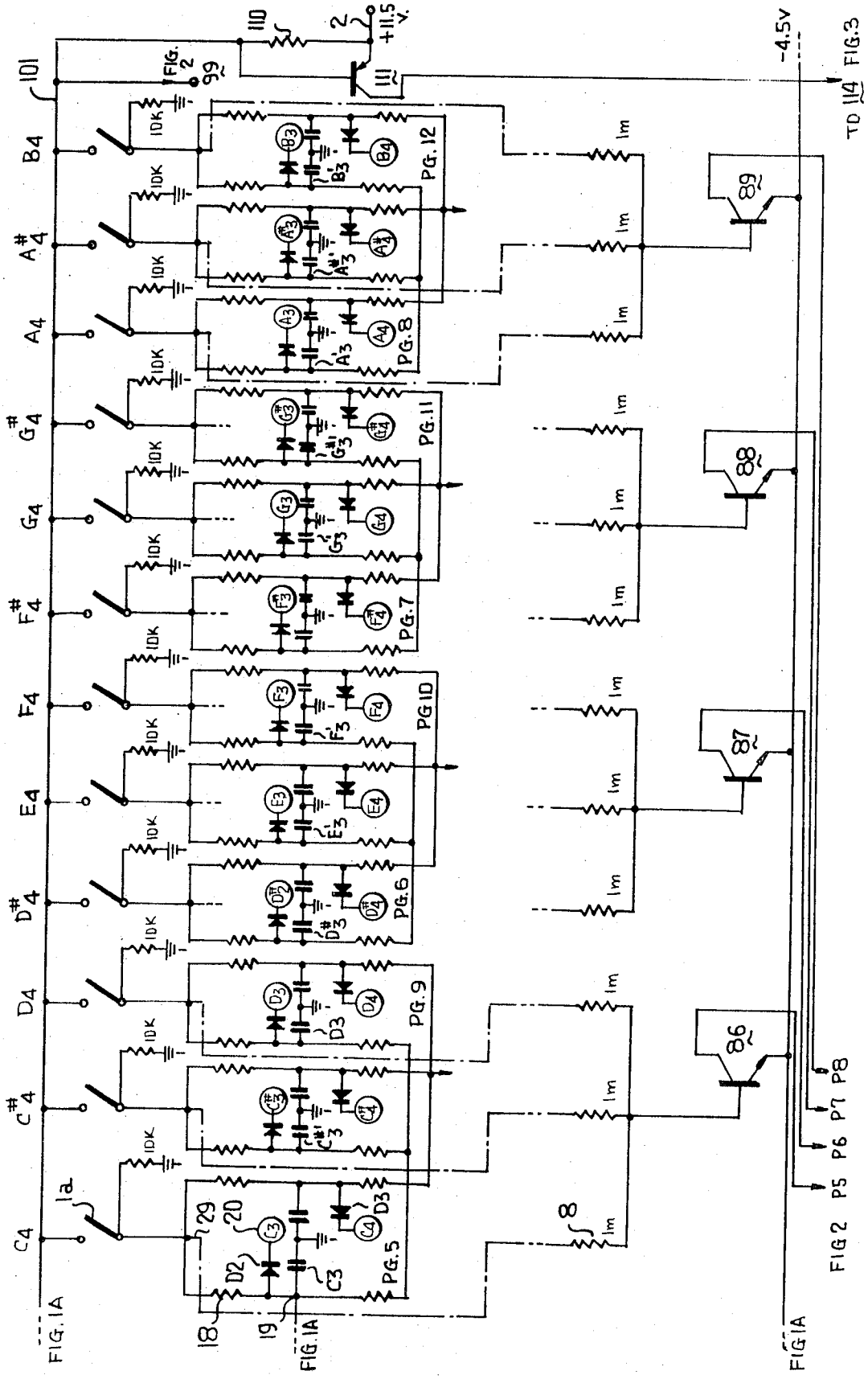

110
2
+11.5 V.
111
-4.5v
TO 114 FIG.3
101
FIG. 2
99
B4
A#4
A4
G#4
G4
F#4
F4
E4
D#4
D4
C#4
C4
10K
1m
PG.12
PG.8
PG.11
PG.7
PG.10
PG.6
PG.9
PG.5
89
88
87
86
1a
29
20
18
19
8
FIG. 1A
FIG. 1A
FIG. 1A
P5 P6 P7 P8
FIG 2

FIG. 2

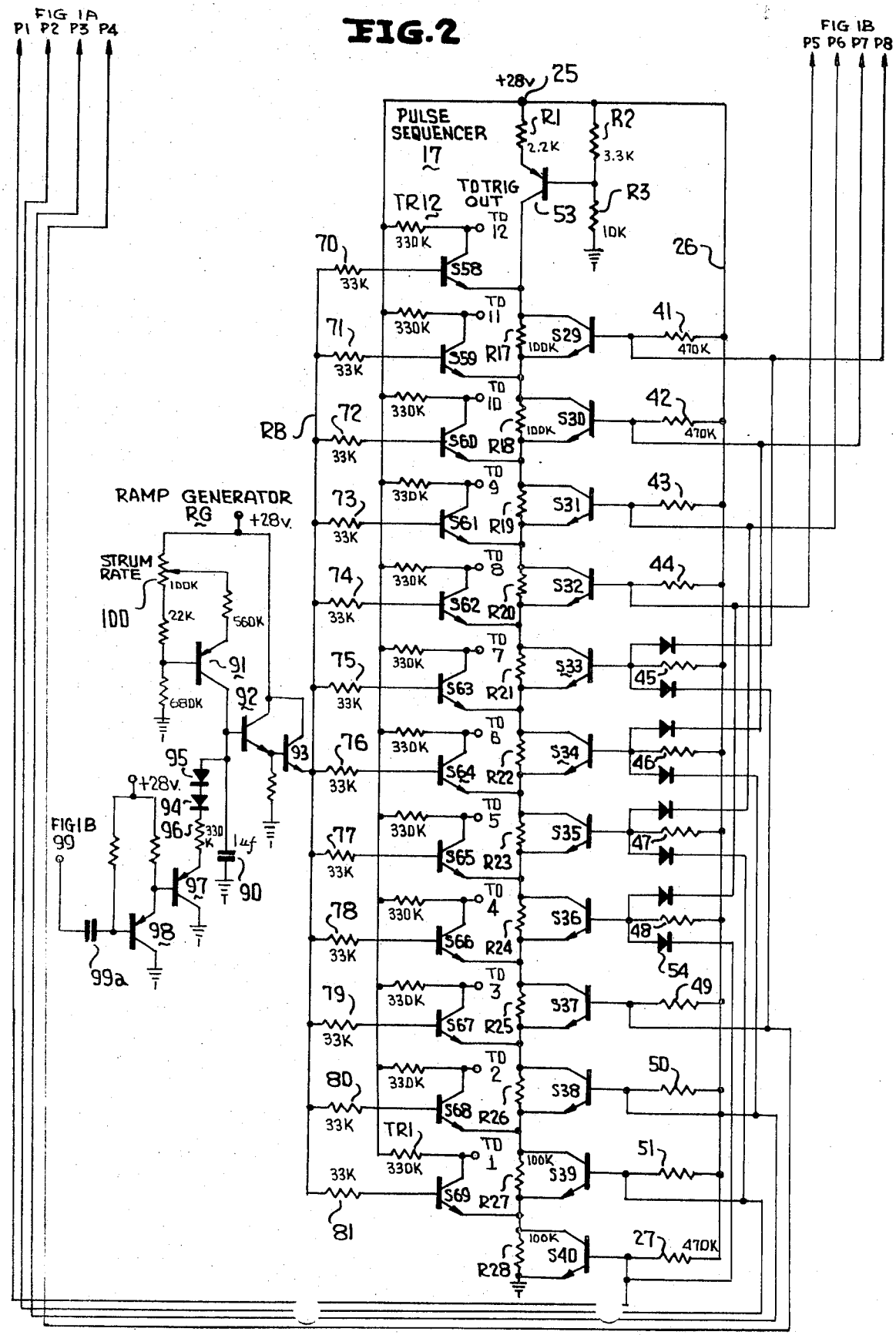
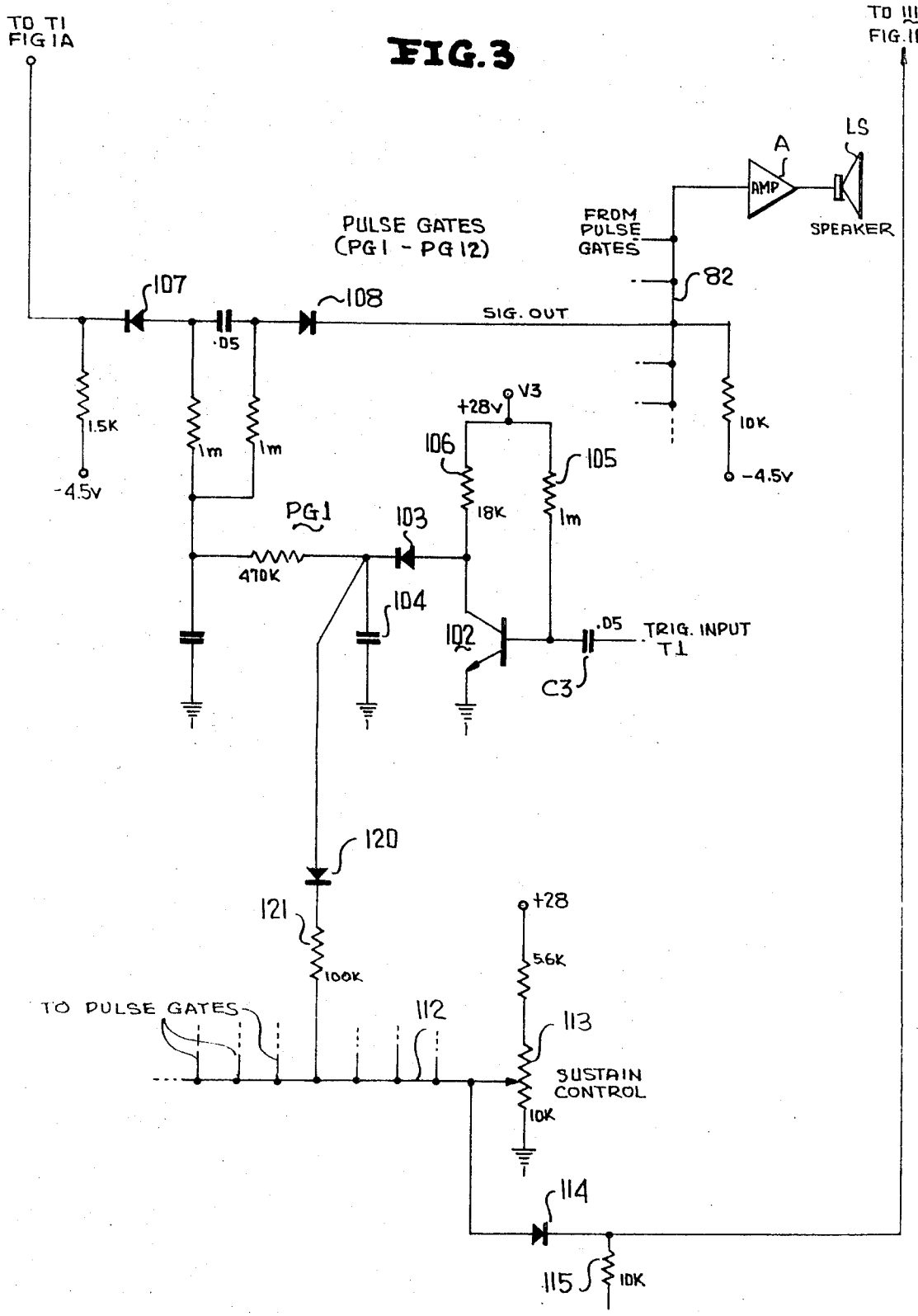

FIG 1A
P1 P2 P3 P4
FIG 1B
P5 P6 P7 P8
+28v
25
PULSE SEQUENCER 17
R1
2.2K
R2
3.3K
R3
10K
TO TRIG OUT
53
TR12
TD 12
330K
70
33K
S58
26
TD 11
330K
71
33K
S59
R17
S29
100K
41
470K
TD 10
330K
72
33K
S60
R18
S30
100K
42
470K
RB
TD 9
330K
73
33K
S61
R19
S31
43
TD 8
330K
74
33K
S62
R20
S32
44
TD 7
330K
75
33K
S63
R21
S33
45
TD 6
330K
76
33K
S64
R22
S34
46
TD 5
330K
77
33K
S65
R23
S35
47
TD 4
330K
78
33K
S66
R24
S36
48
54
TD 3
330K
79
33K
S67
R25
S37
49
TD 2
330K
80
33K
S68
R26
S38
50
TR1
330K
TD 1
33K
S69
R27
S39
100K
51
81
R28
S40
100K
27
470K
RAMP GENERATOR
RG
+28v.
STRUM RATE
100K
100
22K
560K
91
92
68DK
93
95
+28v.
94
96
330K
1uf
90
97
98
99a
FIG 1B
99

FIG.3


TO TI FIG 1A
TO III FIG. 1B
A
LS
AMP
SPEAKER
FROM PULSE GATES
PULSE GATES (PG1 - PG12)
82
107
108
SIG. OUT
.05
1.5K
1m
1m
-4.5v
+28v
V3
106
105
18K
1m
10K
-4.5v
PG1
103
470K
104
102
.05
TRIG. INPUT T1
C3
120
121
100K
+28
56K
TO PULSE GATES
112
113
SUSTAIN CONTROL
10K
114
115
10K

ARPEGGIO SYSTEM

BACKGROUND

The purpose of the present system is to play a fast arpeggio when a chord is played, which is equivalent to a strum as it would be sounded on a guitar, sounding six tones when a three note chord is played. For example, if one plays the keys C3-E3-G3, the system is required to play the notes C2-E2-G2-C3-E3-G3 in sequence. The player may thus actuate the keys in the C3 to B4 range, but sounds notes in the C2 to B4 range, appropriate to a six-string guitar. The direction of the strum is "up" only. In prior applications, assigned to the assignee of the present invention, and directed to producing arpeggio and strum patterns, the direction of tone scan can be up and then down, or even more complex time patterns may emerge. The present system is related to these prior applications, which are identified as follows:

David A. Bunger, Application Ser. No. 171,879, filed Aug. 16, 1971, and now U.S. Pat. 3,718,748;

David A. Bunger, Application Ser. No. 102,874, filed Dec. 30, 1970;

Walter Munch, Jr., et al., Application Ser. No. 171,997, filed Aug. 16, 1971; and now U.S. Pat. 3,725,562.

One problem which is faced in electronic arpeggio and strum systems is that of reducing circuit complexity and cost. This is accomplished, according to the present invention, by proceeding on the assumption that three adjacent semi-tones will never be played simultaneously. Strum systems which simulate guitar playing involve actuation of keys for a three note chord, but it is desired to sound six notes, one for each string of the guitar. In the present system, for example, three octaves of notes may be sounded, in response to playing of two octaves of key switches, but this is accomplished with only 12 pick-off points of a pulse sequencer, a ramp generator, and 12 corresponding pulse gates, i.e., gates which gate through tone signals from tone generators to a loudspeaker. Essentially this is accomplished by having each key switch gate on two notes, an octave apart, and by grouping notes in terms of triples of adjacent semi-tones, treating each triple as if it were one note in controlling the pulse sequencer and pulse gates, on the assumption that only one note of each triple will ever in fact be called for. Thereby, 36 semi-tones may be sounded via 12 pulse gates controlled by a pulse sequencer which sequences in twelve steps, but is controlled by only eight key gates.

SUMMARY

A strum system for an electronic organ in which playing of a chord within a two octave range of an electronic organ effects sounding in time sequence of all the notes of the played chord and of all notes an octave below the notes of the played chord, or 36 notes, thereby to simulate the strum of a six string guitar, while employing only twelve pulse gates controlled by a twelve step sequencer.

DESCRIPTION OF DRAWINGS

FIGS. 1*a* and 1*b* are schematic circuit diagrams of tone signal sources of an organ according to the present invention;

FIG. 2 is a schematic circuit diagram of a pulse sequencer according to the invention, having connections to FIGS. 1*a* and 1*b*, and

FIG. 3 is a schematic circuit diagram of a pulse gate employed in the system of FIGS. 1*a*, 1*b* and 2.

DETAILED DESCRIPTION

Twelve keyer gates are provided, not all identical, but which may be identified with the note nomenclatures illustrated directly above the gates. The C3 gate is controlled by a key switch 1, which applies positive voltage deriving from a power terminal 2 to three leads 3, 4 and 5, in parallel. Lead 3 proceeds via an isolating resistance 6 to the anode of a diode D1, having a tone signal source C2 applied to its cathode. Connected between the anode of D1 and ground is a wave shaping capacitor C1, which converts the square wave provided by source C2 to sawtooth wave form. The latter is applied via isolating resistance 7 to an outgoing terminal T1. The lead 4 extends via a 1 m. resistance 8 to the base electrode of an NPN transistor 14, having its emitter directly connected to a bus 15 maintained at −4.5V and having its collector 16 connected to a point P1 of a pulse sequencer 17.

The lead 5 is connected via an isolating resistance 18 to a point 19 of the C4 gate. The C4 gate includes a C3 tone signal source 20 connected to the cathode of diode D2, the anode of which is connected to point 19. A positive source of voltage 25 is connected via lead 26 and resistance 27 to the collector of transistor 14, so that upon closing key switch 1, a gating voltage is applied to diodes D1 and D2, rendering them conductive of tone signals C2 and C3 and voltage is applied to the base of transistor 14 turning it on and providing −4.5V at the base of transistor S40, turning it off. The −4.5V at the base of transistor S40 is applied via diode 54 to the base of transistor S36, turning it off, thus, as will appear, setting up pulse sequencer 17 to turn on pulse gates PG1 and PG5 in sequence to sound notes C2 and C3 in sequence.

PNP transistor 53 has its emitter connected via resistance R1 to terminal 25 and its base connected to the junction of resistances R2, R3. Transistor 53 thus provides constant current to the series connected resistances R17 to R28, all equal. Each of resistances R17 – R28 therefore, if unbypassed by one of transistors S29 – S40, develops a predetermined voltage across itself, all the voltages being equal. However, resistances R17 – R28, respectively, are shunted by transistor switches S29 – S40, respectively, which are normally on, in response to voltage on lead 26, so that resistances R17 – R28 normally have essentially zero voltage across each. As the collector of transistor switches 14, 83 – 89, respectively, are pulled down to −4.5V, however, corresponding ones of transistor switches S29 – S40 are turned off and the corresponding ones of resistances R17–R28 develop voltages. When only key switch 1 is closed, points P1 and P5 are driven down to −4.5V, and transistor switches S40 and S36 are turned off, and resistances R28 and R24 develop voltage.

Ramp generator RG develops an increasing ramp voltage whenever closure of any key switch causes a voltage drop on bus 101, because of the presence of resistance 110 in series therewith. This voltage drop appears on lead 99 and is translated into a transient pulse by capacitor 99*a*. This pulse initiates a ramp voltage on bus RB (the circuitry of ramp generator RG will be de-

scribed hereinafter.) The ramp voltage is applied via ramp bus RB in common to the bases of transistor switches S58–S69, which have emitters respectively connected to the high voltage sides of resistances R17–R28, respectively, and their collectors connected via load resistances TR1-12, which are connected to positive terminal 25. It follows that as the ramp voltage increases, and applies a greater voltage to the bases of transistor switches S69–S58 taken in that order, than exists at its emitters, pulses are developed at the terminals T01–T012, in the order recited.

Pulse gate PG1 has signal input at T1 because key switch 1 is closed, but is, as are all of pulse gates PG1 to PG12, normally non-conductive. When a negative going voltage is applied to trigger input terminal TI1 of pulse gate PG1 from TO1, transistor 102, normally on due to bias from resistance 105, turns off. This causes capacitor 104 to charge via diode 103 and resistance 106 from voltage source V3, and positive voltage to be applied to the anodes of gating diodes 107, 108, and these become conductive, passing tone signal from T1 to tone bus 82, and thence to amplifier A and loudspeaker LS. On termination of the pulse formed by capacitor C3, transistor 102 turns on again, and capacitor 104 discharges slowly, causing the tone signal on bus 82 to decrease exponentially. Diode 103 prevents the capacitor 104 discharging through transistor 102. Sustain capacitors for the 12 gates required are scaled as shown in Table I, so that higher frequency pulse gates have shorter sustain times than do lower frequency pulse gates.

TABLE I

Gate No.	Trigger Input	Capacitor
1	1	.68
2	2	.68
3	3	.68
4	4	.56
5	5	.56
6	6	.56
7	7	.47
8	8	.47
9	9	.47
10	10	.39
11	11	.39
12	12	.39

The rate of decay of voltage on capacitor 104 is set by the voltage on the slider of sustain control potentiometer 113, since decay can occur via diode 120 and resistance 121 to ground via the sustain potentiometer. So long as at least one key switch is closed voltage is developed across resistance 110 and transistor 111 is one, supplying reverse bias to the cathode of diode 114, so that discharge cannot occur via resistance 115 to ground. When all key switches are open, transistor 111 is off, diode 114 is no longer reverse biased and a low resistance path is provided via diode 114 and resistance 115, for discharge of capacitor 104. All pulse gates become rapidly non-conductive, as soon as all keys are released, but so long as any key is actuated, notes are sounded percussively with a length of sustain determined by the setting of 113. Release of all keys therefore rapidly prepares the system for a further strum, but each strummed note occurs only for a time and with tone sustain which is adjustable and predetermined.

Charge of sustain capacitor 104 occurs rapidly via small resistance 106. Discharge can occur initially via larger resistance 121 but can only occur through that path to a value of voltage such that diode 120 becomes back biased by the voltage at the tap of sustain control potentiometer 113. After that point in the discharge is attained, further discharge can only occur via the gate PG1, which implies that the further discharge occurs via two 1 m. resistances in parallel, and is very slow.

Rise time of each tone is compounded of a rapid charge of capacitor 104 via resistance 106 and a slower discharge via resistance 121. Decay of each tone is at a double rate, initially more rapidly through resitance 121 and thereafter very slowly, which simulates precisely the decay of the tone produced by a guitar string, while the peak value of the voltage on capacitor 104 is nearly independent of the setting of the sustain control 113.

Following through the operation of the pulse gate, a short negative pulse is applied at the base of transistor 102, which turns off the transistor. At that instant voltage V3, equal to +28.V is applied via resistance 106 and diode 103 to capacitor 104. That capacitor is initially discharged and therefore represents a direct short to ground, so that no current appears in resistance 121. The capacitor 104 charges rapidly, sustain control voltage back biasing diode 120 to prevent any discharge. Eventually the voltage on capacitor 104 becomes sufficiently high that the back bias of diode 120 is overcome and a slow discharge commences, but charge is rapid and in due course the voltage across the capacitor is established by the voltage divider composed of resistances 106, 121 and part of the sustain potentiometer 113. The latter is small relative to other values present, so that the peak charging voltage on capacitor 104 is substantially the same regardless of the setting of the sustain control. When the control pulse terminates, transistor 102 turns on. Capacitor 104 cannot discharge through diode 103, and hence proceeds to discharge through resistance 121 and the sustain control 113. The setting of the latter controls decay time, until diode 120 becomes back biased by the voltage at the tap of sustain control 113. Thereafter decay occurs directly through gate, and is very slow since two 1 m. resistors are involved.

RAMP GENERATOR

A source of positive voltage +V is applied to capacitor 90 via transistor 91. Transistor 91 has a fixed voltage emitter to base and is of PNP type. It therefore acts as a constant current generator, and capacitor 90 charges linearly. The voltage across capacitor 90 is applied to bus RB, via isolation transistors 92, 93, and the charging rate is adjustable by adjusting the tap of potentiometer 100, to adjust the rate of rise of the ramp and hence the rate of the strum.

Normally capacitor 90 is fully charged. When a negative gating pulse is applied via line 99 and capacitor 99*a*, transistor 98 momentarily turns off and transistor 97 turns on, discharging capacitor 90 via diodes 94, 95 and transistor 97. The two diodes establish a minimum voltage for capacitor 90, which is just insufficient to turn on transistor 69. When transistor 98 turns on again, on termination of its input pulse, the ramp voltage commences to rise, turning on transistor switches 69 – 58, inclusive, in sequence, and generating pulses at output terminals TO1 – TO12 in sequence, according to the pattern of voltages on resistor chain R28–R17. These output pulses proceed to twelve pulse

gates PG1–PG12, of which only one is illustrated, having input TI1, connected to TO1.

Following through the gating, the C3 key switch provides tone C2 at pulse gate PG1 and C3 at pulse gate PG5. The C4 key switch provides tone C3 at gate PG5 and C4 at gate PG9. The D4 key applies D3 to PG5 and D4 to PG9. The general philosophy is followed through of applying three adjacent semi-tone signals to each pulse gate. If the C4 and D4 key switches were simultaneously closed, PG5 would be supplied with two tone signals, C4 and D4, and both would be sounded, without intermodulation since the pulse gates are linear. The logic of the system enables 36 semi-tones to be handled by only 12 pulse gates, and musically this is sound since only normal chords are to be played. When the C4 key is actuated a D3 tone signal cannot be applied to PG5 because the D3 tone signal must pass through three isolating resistances to reach PG5. In each case the key switch supplies voltage to two steps of the pulse sequencer 17, and these two steps are coordinate with the tone signals which can be called for, and such that only two pulse sequencer steps are actuated for any triplet of key switches, as C3, C3 #, D3, or D3 #, E3, F3, etc.

The circled elements which are primed, as C'_3 in FIG. 1A, do not indicate actual tone sources, but merely indicate that a tone source of that nomenclature is to be gated on. So lead 5 proceeds to gate PG5 in FIG. 1B and supplies gating voltage to diode D2 to gate on an actual source C3, which is not primed in order to indicate that an acutal source is intended.

What is claimed is:

1. An arpeggio generator for an electronic organ, comprising an array of at least two octaves of keys, means responsive to simultaneous actuation of any plurality of said keys from 2 to 5 for calling forth tones corresponding with all said plurality of said keys sequentially in an arpeggio sequence of equal time intervals.

2. In an electronic organ, an array of at least two octaves of keys corresponding with notes of the musical scale, means responsive to actuation of a plurality of said keys for sounding three octaves of tones corresponding in nomenclature with said keys in an ordered single arpeggio sequence, said last means including a sequential readout operative to scan only notes of nomenclatures called for by the actuated keys for a number of keys in said plurality.

3. In an electronic organ, an array of at least two octaves of keys corresponding with notes of the musical scale, means responsive to actuation of each of a plurality of said keys for sounding plural tones of nomenclatures corresponding with said keys in an ordered single sequence, said last means including a sequential electronic readout operative to scan all the notes of said nomenclatures called for by the actuated keys for a variable number of keys in said plurality.

4. In an electronic organ, an array of keys corresponding with notes of the musical scale, and means responsive to actuation of a plurality of said keys for sounding tones of nomenclatures corresponding with the nomenclatures of the actuated keys in an ordered time sequence, said last means including a sequential electronic readout operative to scan all the notes of said nomenclature comprised in said organ in an arpeggio sequence extending over at least any notes-called for by the actuated keys.

5. A musical instrument comprising a series of tone signal producing means having frequencies corresponding to a chromatic musical scale, a keyboard having a series of keys, a set of key switches actuatable by said series of keys, means responsive to the actuated ones of said series of keys for providing keying potentials, a series of normally non-conductive electronic control gates connected to said series of tone signal producing means and respectively responsive to said keying potentials to render said control gates conductive of said tone signals, sequential electronic readout means for successively applying pulses deriving from said keying potentials to the conductive ones of said control gates in time sequence, and switching means for initiating operation of said last means.

6. An arpeggiator for an electronic organ, comprising a plurality of keys, said keys being grouped by threes of adjacent keys, said threes having no duplications and no overlaps, gate means responsive to each different one of said threes for generating a pulse representative of that three, and means for calling forth tones corresponding to actuated ones of said keys in a sequence established by a spatial distribution of said pulses.

7. An arpeggio generator for a musical instrument comprising a series of tone producing means having frequencies corresponding to a chromatic musical scale, a full keyboard, said full keyboard including a series of keys corresponding with respective ones of said tone producing means to control tone signal production, a set of key switches under the control of the keys of at least a portion of said keyboard connected for providing concurrent keying potentials to two octavely selected gates in response to closure of one of said switches, a series of normally off electronic gating means responsive to output of said octavely related gates, a switch connected for providing a potential in response to actuation of any of said keys, and means responsive to the potential from said switch for successively applying spaced pulses of on gating potential to said series of gating means such as to generate said arpeggio.

8. A musical instrument according to claim 7, in which said means for applying spaced pulses comprises, a circuit connected to be triggered by each cycle of operation of said switch for providing a ramp potential that increases for a period of time at least as great as a desired arpeggio duration, and a circuit means having a series of stages arranged to be progressively responsive to said ramp potential to provide said spaced pulses of gating potential.

9. A musical instrument according to claim 8, including means in said circuit connected to be triggered for selectably adjusting said period of time.

10. A musical instrument according to claim 8, in which said circuit connected to be triggered produces a ramp potential which varies linearly with time.

11. In an electronic musical instrument, an array of keys, a separate key switch means actuatable by each of said keys, a series of tone signal sources, a pulse sequencer arranged to generate a ramp voltage wave form and a sequence of spatially distributed time sequential pulses in response to said ramp voltage wave form, a series of normally non-conductive control gates connected in cascade, respectively, with said tone signal sources, means responsive to said spatially distributed time sequential pulses for rendering said control gates conductive in sequence, a switch responsive to

actuation of any one of said keys, and means responsive to each operation of said switch for initiating an operation of said pulse sequence.

12. The combination according to claim **11,** wherein said pulse sequencer includes an array of normally off transistor switches having bases commonly responsive to said ramp voltage and having emitters, and means for establishing diverse voltages on the emitters of the said transistors of said array such that said transistors are turned on in sequence by said ramp voltage wave form.

13. An electronic musical instrument according to claim **12,** wherein said ramp voltage wave form is linear.

14. An arpeggio system for an electronic organ comprising a series of voltage dropping elements, means for selectively shorting certain of said voltage dropping elements while leaving others of said voltage dropping elements unshorted, means for applying a current through said voltage dropping elements, means for scanning said voltages and deriving a pulse of substantial amplitude only while scanning the unshorted ones of said voltage dropping elements, a series of normally inoperative tone signal sources, and means responsive to said pulses for rendering said tone signal sources operative in sequence, an array of keys of said organ, and means for selecting the unshorted ones of said voltage dropping elements in accordance with the actuated ones of said keys.

15. The combination according to claim **14,** wherein said voltage dropping elements are resistances.

16. An arpeggio system for an electronic musical instrument, comprising an aray of two octaves of keys, an array of three octaves of sources of tone signal, an electronic sequencer, means responsive to operation of said electronic sequencer operative for converting in a sequence of tones of increasing pitch those of said tone signals which correspond in nomenclature with actuated ones of said keys, a switch responsive to actuation of any of said keys, and means responsive to operation of said switch for initiating an operation of said electronic sequencer.

17. The combination according to claim **16,** wherein said electronic sequencer includes a series of voltage dropping devices connected in a series chain, a source of voltage connected across said series of voltage dropping devices, and a source of ramp voltage extending in amplitude through the sum of voltages available across all said voltage dropping devices, and means for sensing when said ramp voltage equals the voltage across any grouping of said voltage dropping devices and for generating a control pulse in response to said sensing, said means responsive to operation of said electronic sequencer being responsive to said control pulses.

18. The combination according to claim **17,** wherein said tone signals corresponding with the keys of said array include plural tone signals of the same nomenclature corresponding with each of said keys.

19. A musical instrument comprising a series of tone signal producing means having frequencies corresponding to a chromatic musical scale, a keyboard having a series of keys, a set of key switches actuatable by said series of keys, means responsive to the actuated ones of said series of keys for providing keying potentials, a series of normally non-conductive control gates connected to said series of tone signal producing means and respectively responsive to said keying potentials to render said control gates conductive of said tone signals, and sequential readout means for successively applying pulses deriving from said keying potentials to the conductive ones of said control gates in time sequence.

20. A musical instrument comprising a series of tone producing means having frequencies corresponding to a chromatic musical scale, a keyboard, said keyboard including a series of keys connected to respective ones of said tone producing means to control tone production, a set of key switches under the control of the series of keys of said keyboard connected for providing keying potentials, a series of control gates respectively interconnecting said key switches with musically corresponding ones of the tone producing means associated with the right-hand portion of said keyboard to control tone production independently of the directly associated keys, and means for successively applying spaced pulses of gating potential to said series of control gates.

21. A musical instrument according to claim **20** in which a plurality of octavely related ones of said control gates are connected together to receive keying potential simultaneously from the corresponding key switch.

22. A musical instrument according to claim **21** in which a plurality of octavely related ones of said key switches are connected together.

23. A musical instrument according to claim **20** in which diodes are located in series between said key switches and said control gates.

* * * * *