

- [56]
- References Cited**

UNITED STATES PATENTS

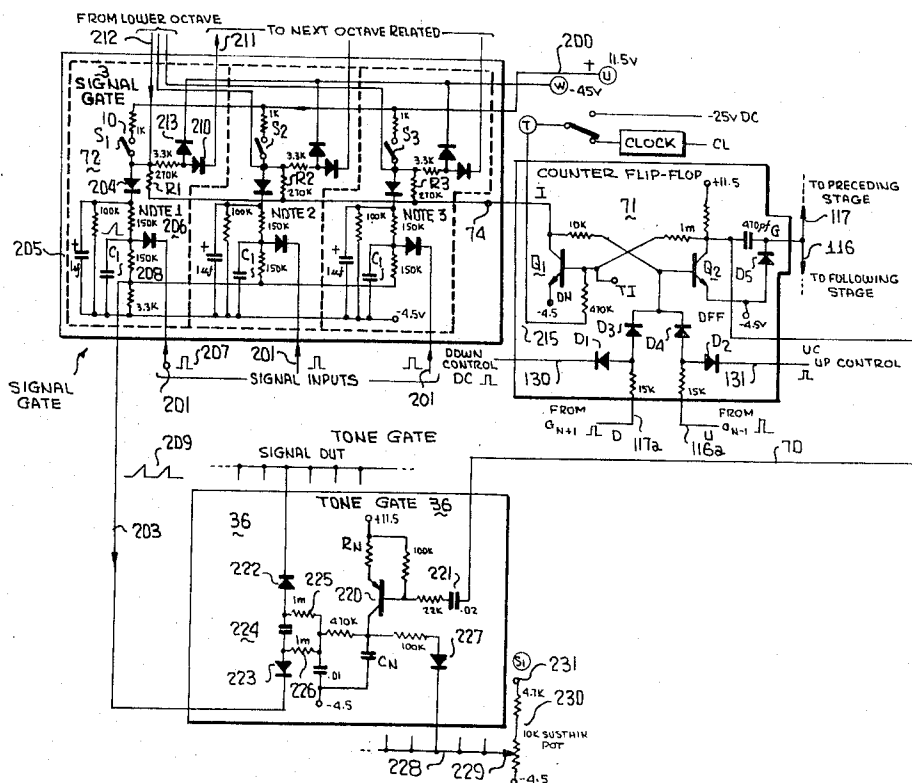
3,198,055	8/1965	Von Gunten	84/1.17 X
3,227,027	6/1966	Von Guten	84/1.17 X
3,358,070	12/1967	Young	84/1.17
3,478,633	11/1969	Mallett	84/1.03
3,499,091	3/1970	Bunger	84/1.03
3,499,092	3/1970	Bunger	84/1.03
3,518,352	6/1970	Plunkett	84/1.03
3,548,066	12/1970	Freeman	84/1.03

Attorney—W. H. Breunig et al.

[57] ABSTRACT

An automatic arpeggio system for an electronic organ, in which playing of a chord, or a single note, turns on tone signal gates for the played notes, and, at will, all octavely related notes, and initiates action of an asynchronous up-down multi-stage counter which sequentially reads out only the turned on gates, in sequence, either in an up-scan only, or up and then down. The gates lead to tone color filters, amplifiers and loudspeakers. Those counter stages which are selected to turn on gates are constrained to act as clock controlled bistable flip-flops, while the remainder act as monostable flip-flops with a time constant of the order of 30 microseconds, so that their set and reset involves inadequate time elapse to effect sounding of a note by closing of a tone gate.

37 Claims, 8 Drawing Figures



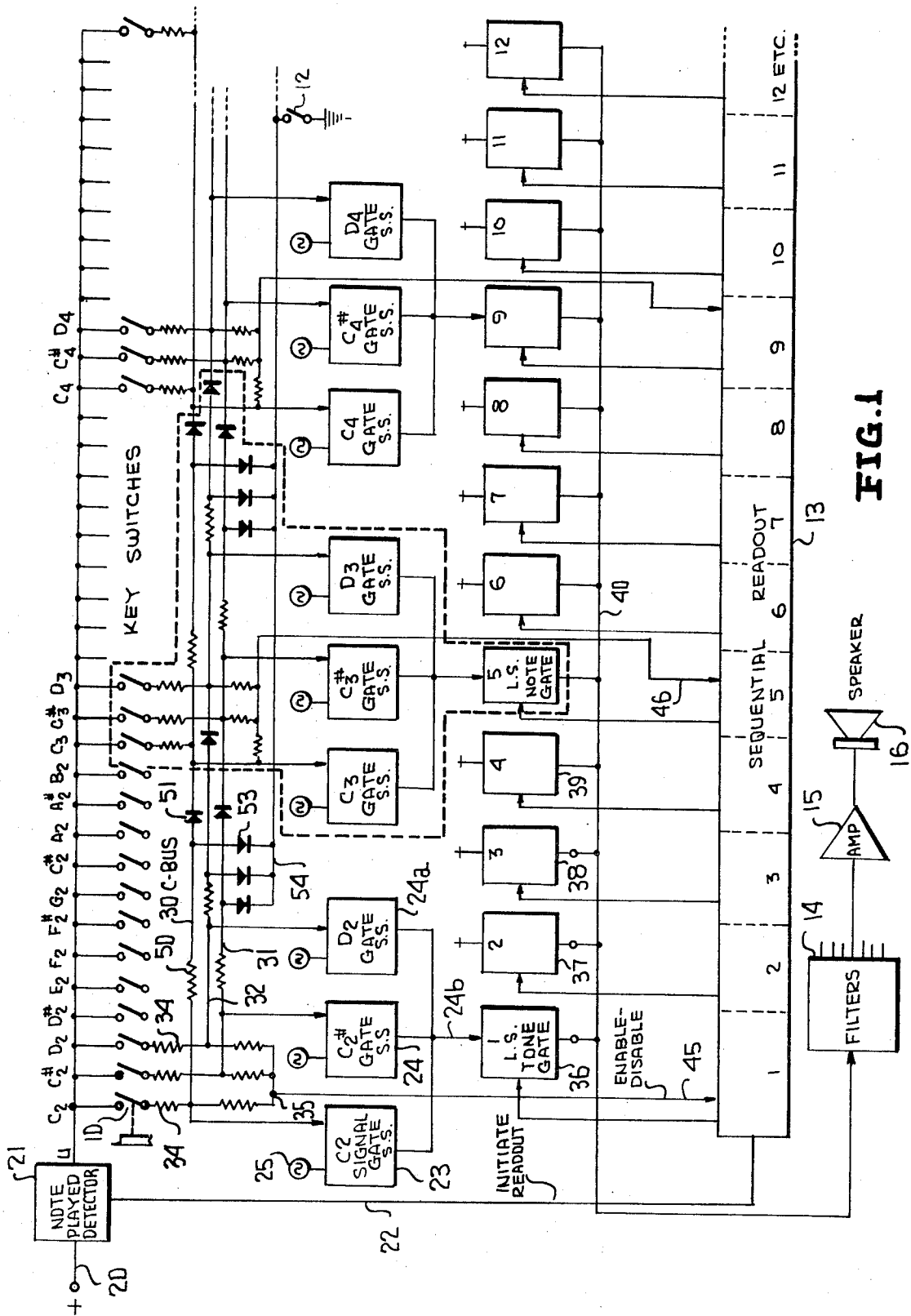
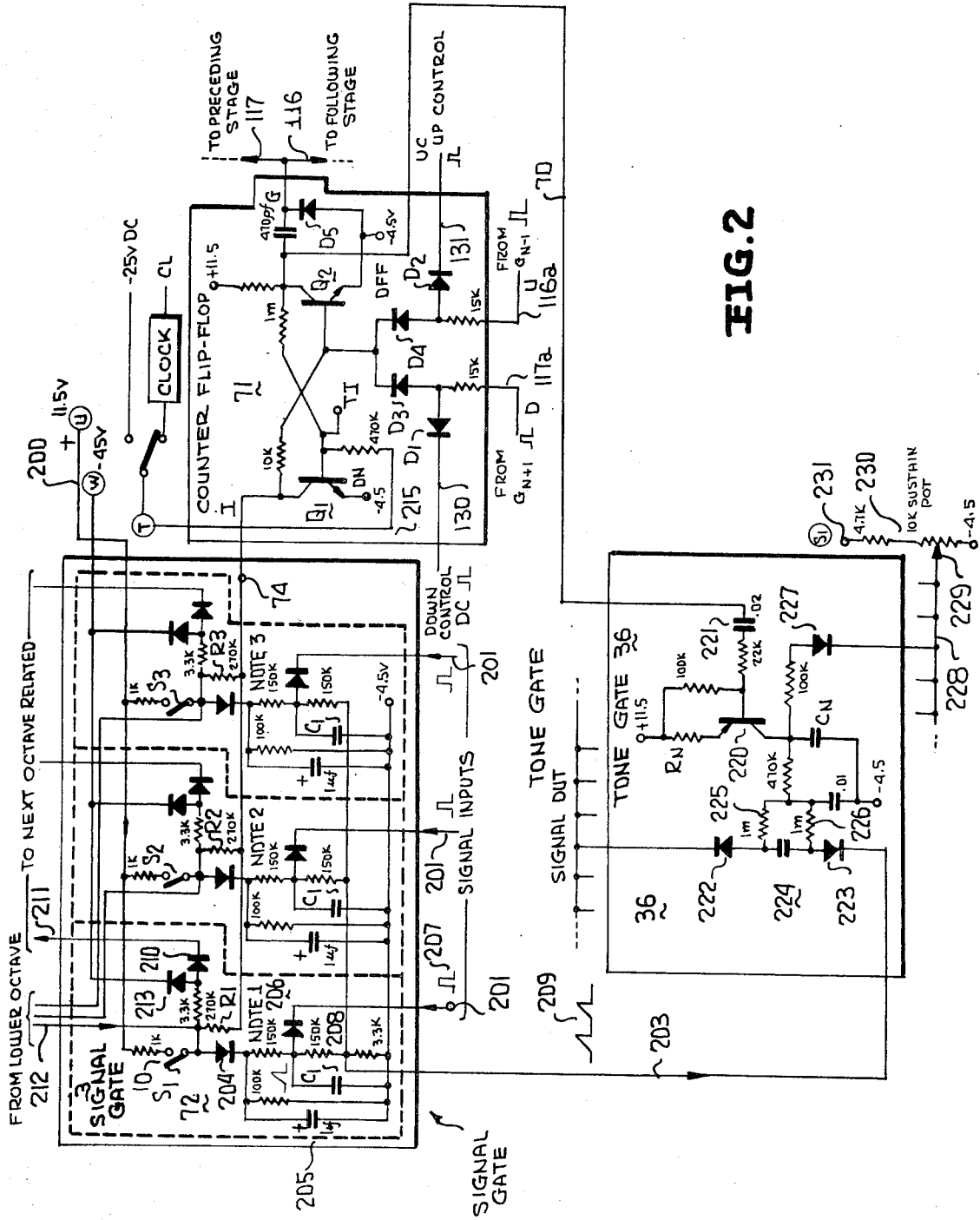
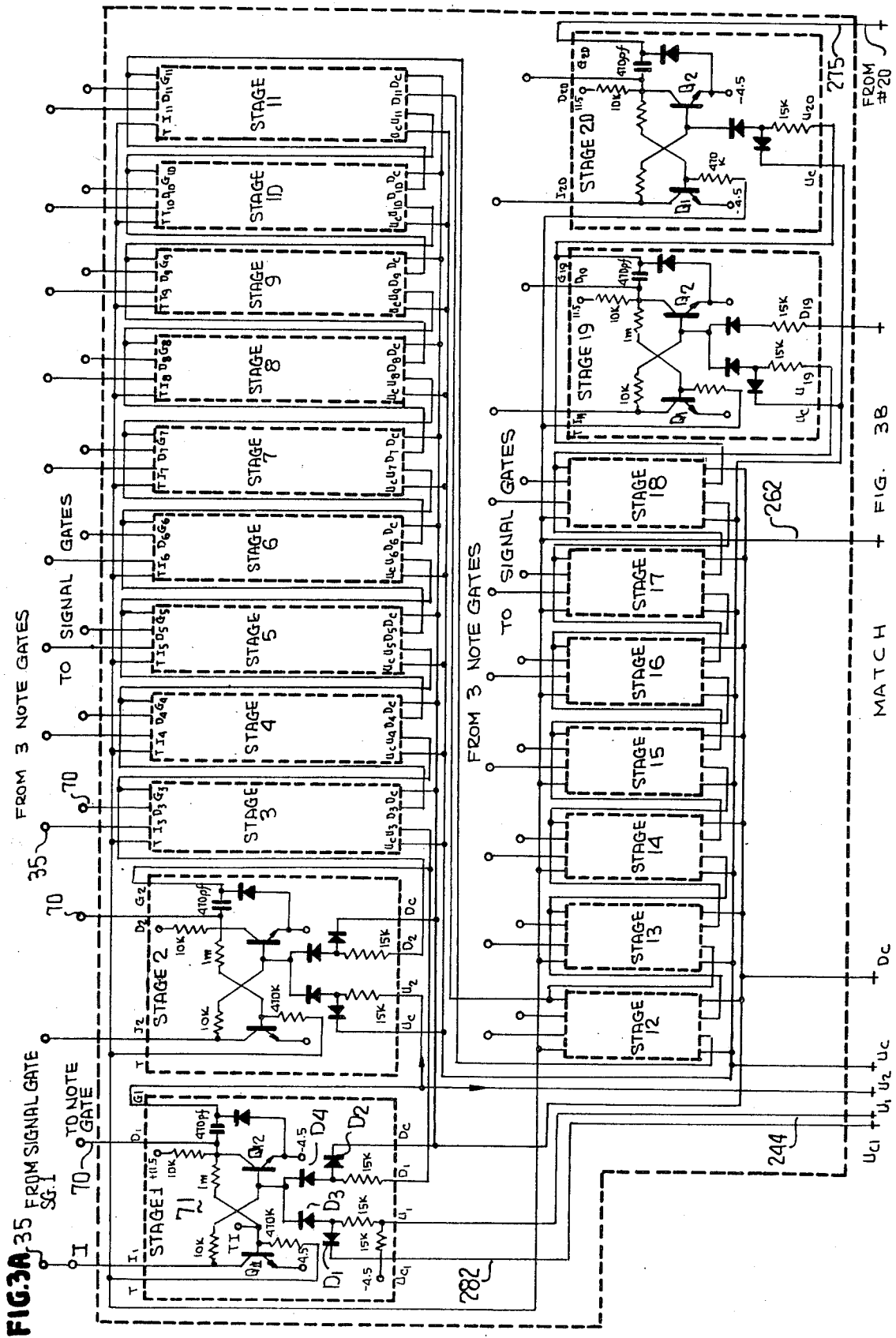
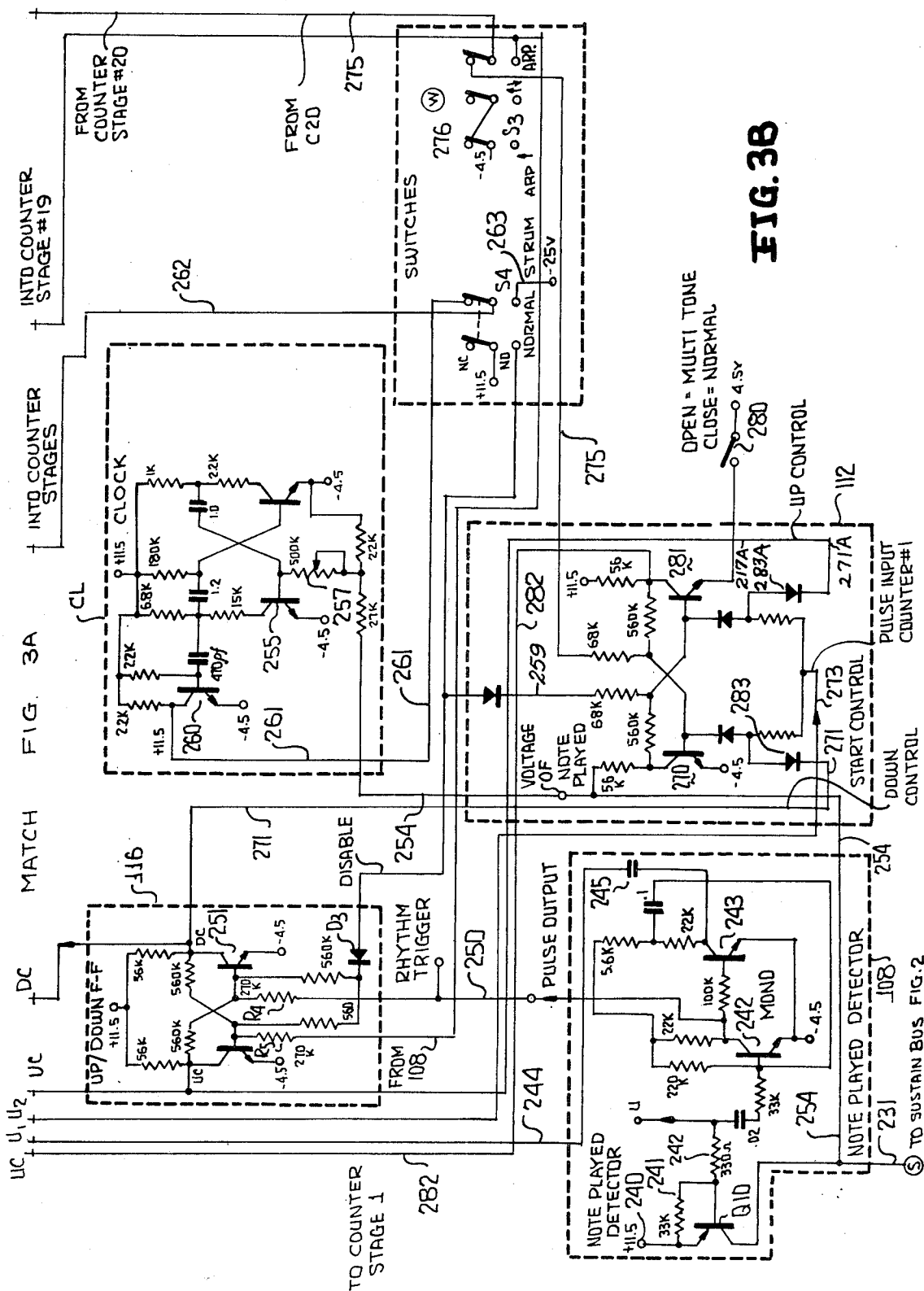
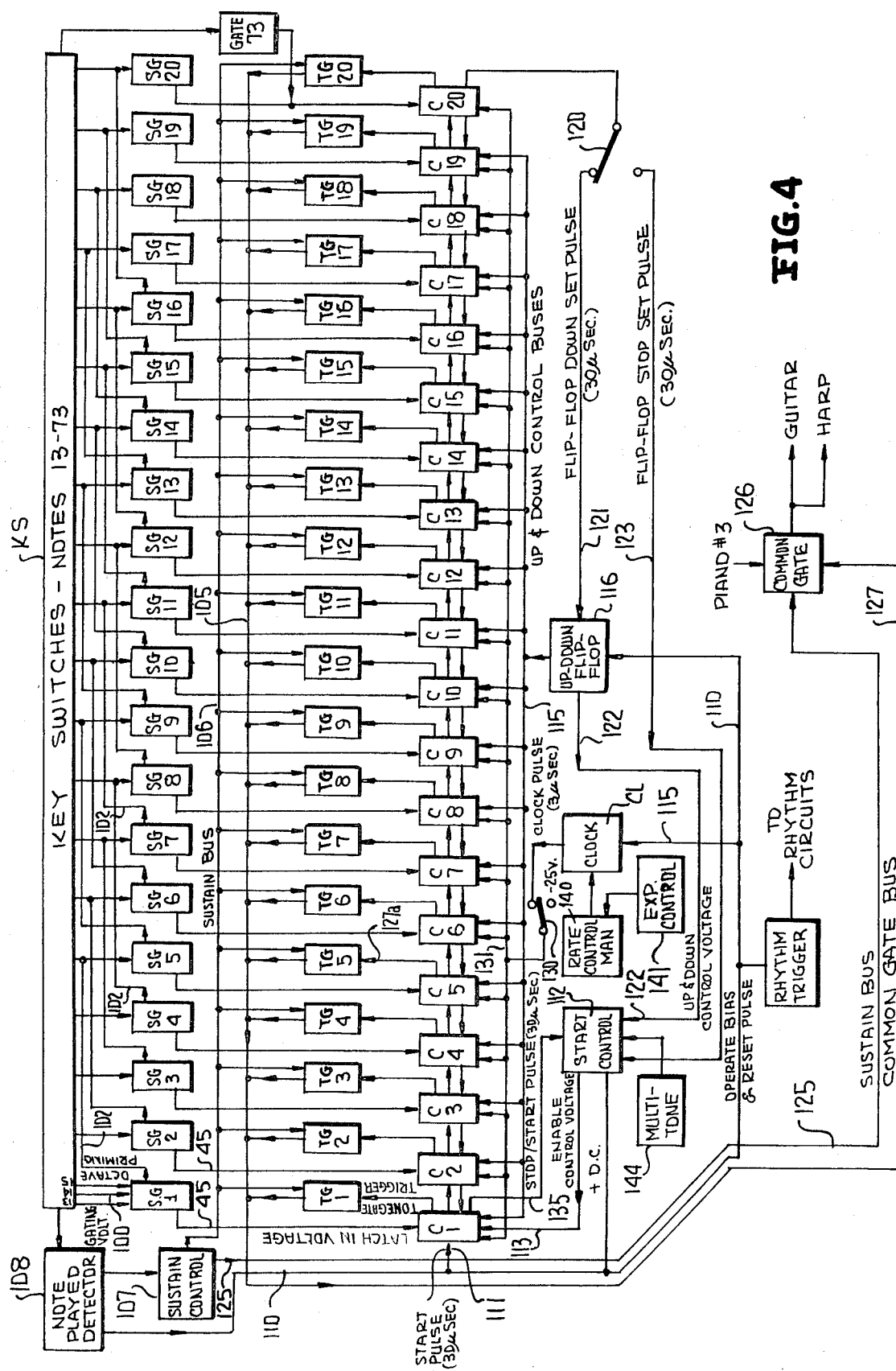


FIG. 1









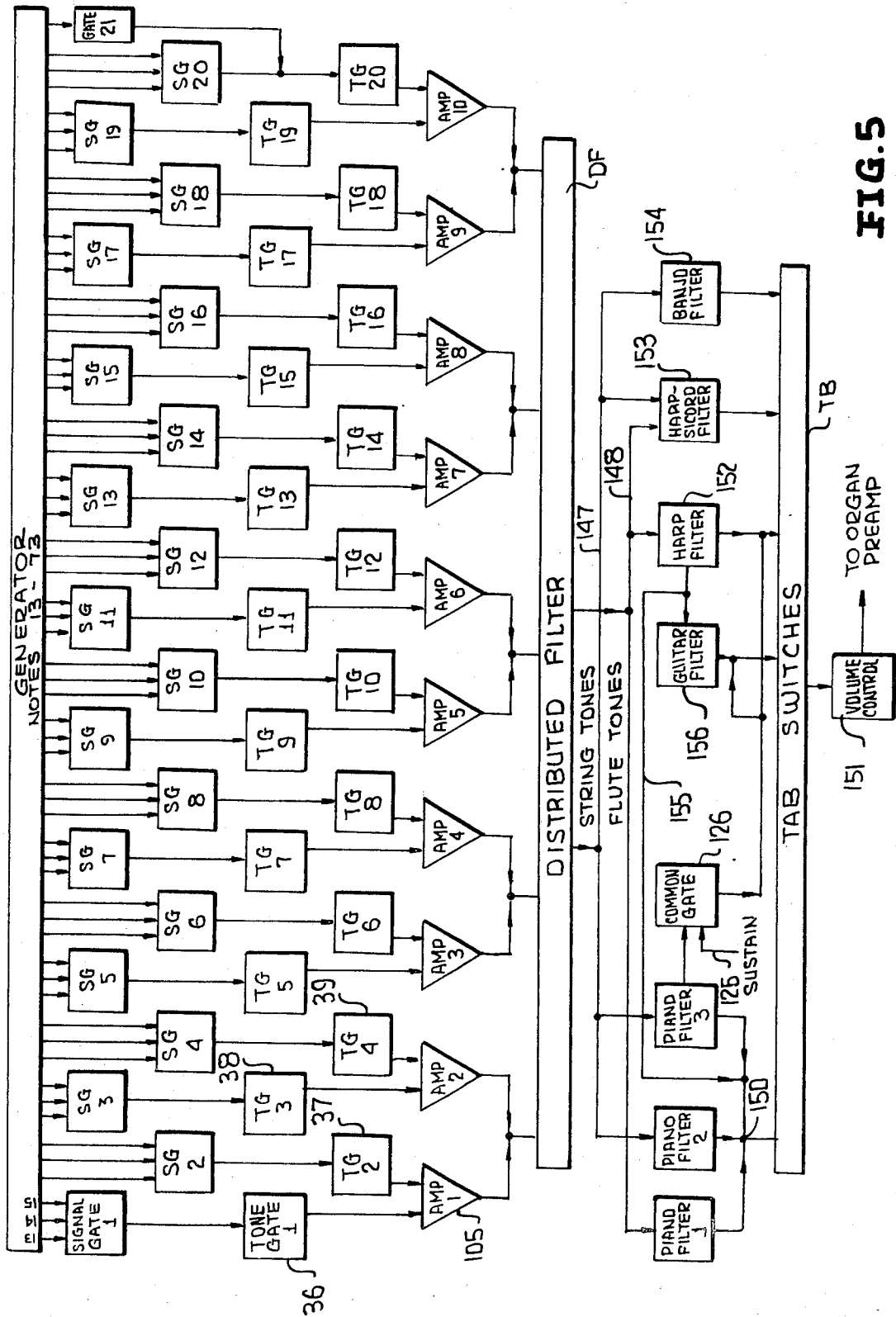
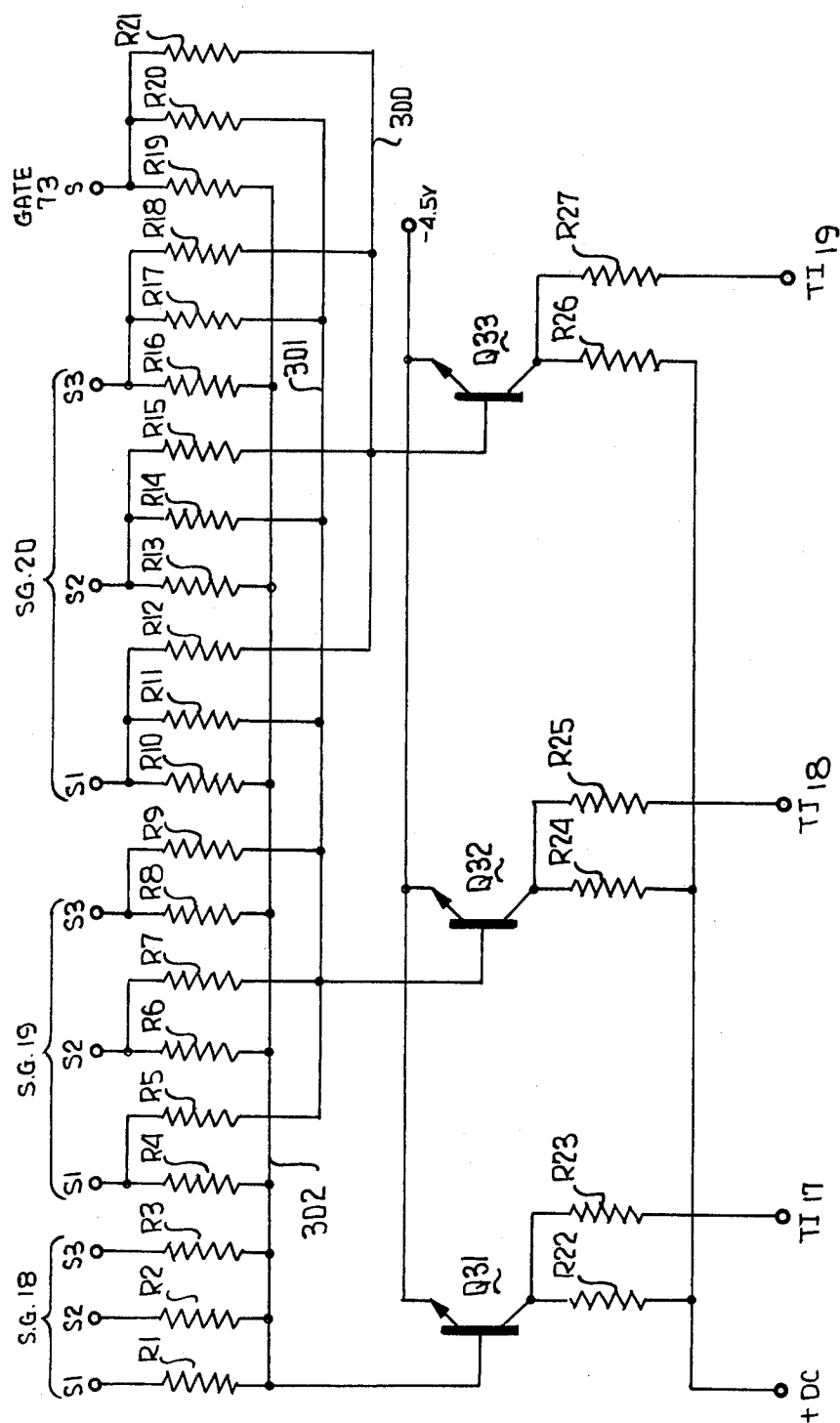


FIG. 7



ARPEGGIO SYSTEM FOR ELECTRONIC ORGAN

BACKGROUND

In an application for U. S. patent, in the name of David A. Bunger, Ser. No. 102,874, filed Dec. 20, 1970, and assigned to the assignee of the present invention, an automatic arpeggio system is disclosed which performs, in a broad sense, the arpeggiation functions of the present invention. That application discloses utilizing a ramp voltage for scanning the tone output gates of an electronic organ upwardly, and a triangular voltage wave for the up-down mode. The ramp or triangular wave must sequentially scan all possible notes which are called forth in an organ employing the system, plus all notes of corresponding nomenclatures, but must pass over all other notes. To accomplish this, a string of series connected diodes is scanned by the ramp voltage, certain of which, corresponding with non-called for notes, are shorted, and the others left open circuited in response to playing of keys. This has the effect of eliminating only the shorted diodes from the system during any scan, up or down, but scanning of the unshorted diodes sounds notes. When the ramp has up-scanned through the last of the conductive diodes, it can be caused to reverse and to scan the diodes in a descending sense, or it can be set for a further up-scan, and the slope of the ramp or triangular wave establishes the tempo of the arpeggio.

In the system of the present invention, the ramp and diode scanning system is replaced by an up-down asynchronous counter chain, acting as a commutator. Certain of the flip-flop elements of which, corresponding to uncalled for notes and notes octavely related to the latter, are scanned through so rapidly that no sound is heard, whereas the actuated keys effect a sufficiently slow per stage operation that corresponding sounds are heard. The counter is constituted of flip-flops which have two modes of operation, depending on whether or not an associated key of an organ is actuated. In one mode of operation the flip-flop acts as a mono-stable device with an operating time of about 30 microseconds. When a key is actuated, the associated flip-flop is made bistable, and is timed by a clock. The tempo of an arpeggio is therefore controllable in terms of clock frequency.

SUMMARY OF THE INVENTION

A system for automatically generating arpeggios and strums in an electronic organ, including an up-down counter composed of a chain of flip-flops which can be individually set to operate monostably or bistably, and a clock to time the bistable stages, used to sequentially open tone gates for preset durations. Those flip-flops which relate to actuated keys of the organ and notes of the same nomenclature but higher in pitch are operated as bistable devices controlled by the clock, and those relating to unactuated keys operate as mono-stable devices of very short time constant (30 microseconds) independent of the clock. Controls are provided which establish various operational modes of the system — (1) a normal mode, in which tones sound as played; (2) a strum mode, in which notes directly called for by actuated keys are played in up-sequence only; (3) an up-arpeggio mode in which all notes of a given nomenclature including those of higher octaves and the same nomenclature, called for by actuating a key or keys, are

played in an up-arpeggio sequence; (4) an up-down arpeggio mode, in which each sequence (3) is automatically followed by a down arpeggio, involving the notes called for by the actuated keys. The down arpeggio can be interrupted and the up-arpeggio re-established by playing a note or notes during the down arpeggio; (5) a multi-tone mode which can be used in conjunction with the above strum mode or either arpeggio mode, in which the actuation of a key during a strum or arpeggio sequence introduces an additional strum or arpeggio sequence. Since notes can be added to or subtracted from any up arpeggio, or added to or subtracted from a called-for sequence, during any down arpeggio, simultaneous complex arpeggio sequences of tones can be induced, in the (5) mode, though all must proceed in the same direction at any given time.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is largely a block diagram of a system for automatically generating arpeggios, according to the invention, and duplicates FIG. 1 of Bunger, Ser. No. 102,874, referred to hereinabove;

FIG. 2 is a circuit diagram of certain controls employed in the system of FIG. 1;

FIG. 3A and 3B taken together constitute a circuit diagram of an up-down counter and controls therefor, corresponding with the block diagram of FIG. 1 and responsive to the controls of FIG. 2;

FIG. 4 is a logic diagram of the system of FIGS. 3A, 3B;

FIG. 5 is a tone flow diagram of the system of FIGS. 3A, 3B;

FIG. 6 is a circuit diagram of an alternative pedal controlled clock, utilizable in the system of FIGS. 3A, 3B; and

FIG. 7 is a circuit diagram of a system for avoiding double top notes in up-down arpeggios.

DETAILED DESCRIPTION OF THE DRAWINGS

In FIG. 1, key switches 10 are illustrated, and are labeled in respect to the notes called for. A positive voltage source 20 proceeds via a "note played detector" 21, common to all the key switches 10. The note played detector 21 provides a control voltage on lead 22 regardless of which key or keys 10 is actuated. If at least one key is actuated, this voltage is applied to sequential readout 13, to initiate and control its operation. The latter is a multi-stage counter.

Each key has a signal gate, as 23, for C2, 24 for C2# and each signal gate is connected to a tone signal source, as 25 for C2, which is of appropriate frequency, and of square wave character in the usual case. These key gates 23, 24 etc are all short sustain gates, to enable staccato piano simulation. Long sustain piano effects are achieved by connecting a long sustain gate in cascade with each short sustain gate, as in U. S. patent application Ser. No. 102,874, filed in the name of David A. Bunger and assigned to the assignee of this application.

All C switches of a manual connect to a bus 30, all C# switches to a bus 31 and all D switches to a bus 32, in each case via an isolating resistance 34, and so on for the remaining notes. There are therefore four sets of three busses per set to cover all the octaves and all the notes of each octave, each octave being divided into

four sets of three adjacent notes per set, three having been selected as economical, and not as a matter of principle. Only one set of busses is illustrated. There thus is provided a C bus, to which all Cs are connected a C# bus to which all C#s are connected, and so on, and it is these busses, rather than the key switches that are connected to key on the signal gates, as C2, C#, D2. The latter set has its outputs tied together at a common output terminal 35, and the signal output terminals 24b lead to tone gates 36, 37, 38, 39 etc. which have long sustain capability. The latter four gates cover the first octave, but each octave has its set of four tone gates. A total of 12 tone gates is illustrated, but to cover an organ keyboard of 61 notes, 20 tone gates are employed, the highest frequency tone gate collecting signal from four, instead of the usual three, signal gates. All the tone gates of the system lead to a common bus 40, which in turn proceeds to tab selected tone filters 14, conventional in electronic organs. The filters lead to amplifier 15 and loudspeaker 16. The tone gates are turned on or read out in sequence by sequential readout 13, for the arpeggio mode of the system, or for the strum mode, in which a guitar is simulated. If the piano mode is desired, sequential readout is disabled and all energized tone gates are enabled simultaneously, by means not shown in FIG. 1. However, the readout is so accomplished that only tone gates which have signal present at their input are read out, or scanned, and the others are effectively skipped.

The sequential readout has a limited number of readout positions, specifically 20, there being one readout position for each of tone gates 36, 37, etc. Each readout position is enabled or disabled, according to a control voltage on each of leads 45, 46, etc., which proceed each from a group of three key switches, as C2, C2#, D. If a position is enabled it is read out in sequence, but if not it is skipped so that any called for notes can be read out in orderly note sequence regardless of how randomly they may be positioned in the array of all possible notes. The speed of readout can be controlled at will. This readout controls and effects arpeggiation.

The busses 30, 31, 32 are divided into octave sections by series diodes 51 and shunt diodes 53. For example, the C bus starts with the C2 switch 10, and proceeds via a resistance 50, and a series diode 51, conductively poled, to the C3 switch, which in turn proceeds similarly to the C4 switch, and so on. The anode of diode 51 is connected via a shunt diode 53, to a bus 54. Every series diode is provided with a shunt diode, all connected to the same bus 54. If bus 54 floats, the shunt diodes 53 are totally ineffective and the series diodes as 51, are conductive, and all notes of the same nomenclature are then represented on bus 30, when they fall above the note actually called forth. However, if a note in the "3" octave is called for, the diode 51 acts to isolate the "2" octave gates, because of the polarity of diode 51. Therefore, all notes of a given nomenclature, called for by an actuated key, for all octaves above that key, are simultaneously gated on by the key, but no notes of that nomenclature in lower octaves are gated on.

If the cathodes of shunt diodes 53 are grounded, by grounding bus 54, at switch 12, no octaves are gated on which are higher or lower than the octave being played

in, since a series diode isolates the lower octaves, and a shunt diode isolates the higher octaves. However, a player can play a chord spanning two octaves, and all played notes will be heard together, either in the piano mode if that is called for, or sequentially in any of the remaining modes, "up only" or "up-down" as called for, by appropriate switches, hereinafter described.

It is evident that separate controls could have been provided for each separate set of three shunt diodes 53, if desired, and also that a sequential readout could have been provided for each signal gate, if desired, instead of for each set of three. The design actually selected presents a compromise between cost or complexity, and performance, which is justified by musical and economic realities.

Referring to FIG. 2, 71 is a flip-flop or counter stage (of which there are twenty in the present embodiment of the invention) which has two modes of operation, depending on the status of three key switches associated with the stage (four in the case of the twentieth flip-flop). Three signal gates, shown in FIG. 1 as 23, 24, 24a, are illustrated at 72. It is necessary that any of the three notes, on an OR basis, control the state of counter stage 71, so that any and every note called for be sounded, but it is also necessary that when a lower octave note is keyed, higher octave signal gates are actuated as well as the signal gate pertaining directly to the actuated key. Circuits for the latter purpose are illustrated in FIG. 1.

Signal inputs to the tone gate 36 are derived from three adjacent notes, as C2, C2#, D2, and each set of three notes in the system requires a tone gate, except for the highest four notes, which utilize a single tone gate.

A positive voltage source is available at lead U, which is conveyed via any one or more of the key switches 10, identified as S₁, S₂, S₃, to terminal 74, and thence to the collector of transistor Q₁, of flip-flop N, shown as 71. This transistor is normally on and Q₂ of flip-flop 71 is normally off. If voltage is applied to collector of Q₁, the flip-flop will act as a bistable flip-flop. If none of the key switches is closed, transistor Q₁ has no collector supply and the stage acts as a monostable device with a time constant of about 30 microseconds.

The trigger input to flip-flop 71 is a short duty cycle rectangular wave applied at T, from the clock.

Before proceeding further with details of circuitry, reference is made to FIGS. 4 and 5, of the accompanying drawings, where the logic of the present system is illustrated, in respect to control signals in FIG. 4 and tone signals in FIG. 5. KS is a series of key switches No. 13 - No. 73 of an electronic organ. Discussing key switches No. 13, No. 14, and No. 15, each supplies gating voltage, as via a lead 100, to a three signal gate SG, (23, 24, 25a of FIG. 1) pertaining to three keys, which sum and pass tone signal to tone gate TG1 via a single lead (shown in FIG. 5). Twenty signal gates SG1-SG20 are illustrated to encompass 61 key switches, SG 20 pertaining to the highest four key switches, and SG1 to SG19 to three key switches each.

The tone signal paths are illustrated in FIG. 5. Each tone gate is a linear gate of known type and carries, without intermodulation, one, two, or three tone signals, according to which key or keys are actuated. In addition each signal gate, SG1-SG20, controls signal

gates an octave above itself, in respect to notes of the same nomenclature, as indicated by leads 102 in FIG. 4. So SG1 primes SG5, which primes SG9, which primes SG13, etc. The circuits required are illustrated in FIG. 1, involving busses 30, 31, 32. Any key which is actuated thus can close the gates which serve to pass all notes of the same nomenclature as the key which is actuated, in higher octaves. Circuit details to this end are illustrated in FIG. 1. The tone signals passed by the signal gates SG1-SG20 are passed to the tone gates NG1-NG20, respectively.

The outputs of the tone gates are tone signals which pass to summing amplifiers 105 (FIG. 5), each amplifier serving two tone gates. The tone gates are normally open (nonconductive) and are closed by signal on a lead 70 from terminal 0 of the associated counter stage (FIG. 2). The sustain time of the tone gate is controlled by sustain circuit 107 (FIG. 4) which is turned on whenever any associated key switch of KS is closed, in response to a note played detector 108 which senses the playing of any note as a voltage variation.

Whenever one of SG1-SG20 is operated by playing one or more of the notes of the gate a latch-in voltage is applied to the appertaining counter stage C1-C20 via a lead 45, which transfers that stage from its normal configuration as a monostable flip-flop, which stays on for only a few microseconds when triggered, to a bistable flip-flop which must be reset or timed by a clock CL. The note played detector 108 supplies a variety of signals via lead 110, i.e., a 30 microsecond pulse to the first stage C1 to initiate a scan cycle of the counter, at lead 111, a +D.C. voltage to an enable or start control circuit 112, which supplies voltage via lead 113 which enables the counter C1 to respond to the pulse on lead 111. The latter so operates that once the counter starts it can complete its up sequence regardless of whether or not a new key is depressed during the up sequence, in normal up arpeggio or strum mode. The start control 112 also serves to enable restart of a cycle of the counter, for example, if all controlling key switches are opened.

The time between the playing of notes is established by a clock CL, normally inoperative, but which is started into operation and terminated via +D.C. control signal on lead 115, the latter being supplied from lead 110. This +D.C. signal is the same as is supplied to start control 112.

The counter C1-C20 can count up or down, i.e. it is reversible, according to the character of a control voltage supplied by up-down flip-flop 116. The bus 110 supplies a pulse to up-down flip-flop 116 when a note is played, to assure that it is in the up state, and will therefore cause the counter chain always to count up immediately after a key is depressed.

A manual switch 120 supplies signal from the last counter C20 of the chain, selectively, to a lead 121 or a lead 123, selectively. If to lead 121, a pulse is supplied to up-down flip-flop 116 from counter C20 which transfers the entire counter chain into a downwardly counting chain, and at the same time transfers information to the start control 112 via lead 122 which will permit the next pulse from C1, signifying termination of a down count, to set the start control in a state which allows the introduction of a new pulse from lead 110 into the counter chain at C1, thereby initiating a new up count sequence.

If switch 120 is in its down position an output pulse at C20, signalling that the counter chain C1-C20 has completed an up sequence, proceeds via lead 123 to start control 112 and sets it forthwith in condition for a new sequence of up counts, starting at C1.

Sustain control 107 supplies a sustain control signal via lead 125 to a common gate 126. This gate is triggered on via voltage on lead 127 connected to common bus 105, which is supplied with a pulse as each note of gates NG1-NG20 is turned on by counter chain C1-C20, via leads 127a.

The present system has five modes of operation, called for purpose of identification, (1) normal (2) strum (3) arpeggio up (4) arpeggio up and down (5) multi-note.

In the normal mode no arpeggio is desired, but the instrument responds to each key as it is actuated. -25V is applied via switch 130 to lead 131, common to all the counters. This converts the counter stages to a mode in which they are essentially pulse amplifiers. Therefore, any note played transfers a gating pulse from a signal gate to a counter stage and thence to a tone gate, which transfers that note to one signal amplifier, say 105 (FIG. 5) for notes 13, 14, 15, and the note is sounded. Another output of each TG gate proceeds to lead 105 (FIG. 4), which operates common gate 126, which transmits notes which have passed through a tone color filter.

The clock CL, when the switch 130 connects it to lead 131, applies a positive pulse to the counter stages and these then if bistable, are timed. The clock CL is normally inoperative, and starts operation in response to playing of a note, which causes +D.C. to be applied to the clock CL via lead 115.

The strum mode is the same as the arpeggio-up mode, except that only notes actually played produce sounds, and higher octave notes are not sounded. It therefore corresponds with a limited range arpeggio.

To illustrate what occurs we may assume that two notes are played simultaneously, one encompassed by three note gates SG1 and the other by SG2. If both were encompassed by SG1, for example, they would sound together, and no strum effect would occur. But, if both SG1 and SG2 are actuated, the note played detector applies a start pulse to C1. C1 and C2 are latched into the bistable state via leads 45 from SG1 and SG2, the clock CL is started, and the up-down flip-flop 116 is placed in the up mode. The stages C1 and C2 then operate in sequence under control of the clock and cause gates TG1 and TG2 to pass tone signal in sequence. The remainder of the counter stages are not latched into the bistable state and therefore ignore the clock CL, operating as monostable circuits. The count then ripples up the chain very rapidly after passing C1 and C2 and on achieving stage C20, a pulse is passed via lead 123 to start control 112, which applies a count complete signal to counter stage C1. Holding down the two notes thus does not cause a repeated strum. But if at least one of the played keys is released and pressed again, the note played detector 108 produces signals which cause the sequence to repeat, since the note played detector 108 detects depression of a key whether or not other keys are then depressed.

In the up-arpeggio mode, operation is the same as for strum, except that each note played enables the gates SG of octavely related notes, higher in pitch. Actuating

a D2 note key, for example, renders conductive the D3, D4, D5, etc. gates, along with the D2 gate, just as if the D3, D4, D5 keys had been actuated.

The C1, C5, C9, C13, etc. counter stages are then set into bistable state, and are read out in sequence under control of the clock CL. The tempo for the latter is not affected by the counter stages which are rippled through because ripple time is so short relative to clock-on time.

For arpeggio up and down the output of C20, instead of re-establishing start control 112 in condition to receive a new note, resets the up-down flip-flop 116, which establishes all the counter stages C1-C20 into the down counting mode. The start control 112 is now controlled by C1 via lead 135 in conjunction with the signal on lead 122, so that the start control is prepared for a new start signal if one appears on lead 111, and the down count has been completed through C1. However, if a note is played while the arpeggio is moving down, a pulse via lead 110 from note played detector 108 throws up-down flip-flop 116 into its up mode. A new pulse can still not be inserted at C1, but the count now proceeds up, and any bistable stages cause notes to sound. Whenever a new note is played, up-down flip-flop 116 goes into up mode, if it is not already there.

The clock CL has a manual rate control 140. But that rate can be modified by movement of the expression pedal of an organ, by means of an expression control 141. The latter increases clock rate as a function of loudness called for by the expression pedal.

The start control 112 can operate in two states. It can, in one state, prevent C1 from accepting a further pulse, after an arpeggio has started, until control 112 has been reset by a pulse on lead 123 in the up arpeggio mode, or by a pulse on lead 135 in conjunction with information on lead 122 in the up-down arpeggio mode. In this state when an up arpeggio has been started it cannot be modified until it has been completed. If in the up-down arpeggio mode, and in the down count condition, the actuation of a key will reverse the direction of the arpeggio, but will have no effect on C1.

In the other state, the start control 112 does not prevent C1 from accepting additional pulses from the note played detector 108 via leader 110 and 111 of FIG. 4. Therefore each time a note is played a new start pulse is introduced into C1 and this pulse is free to proceed up the counter chain. Due to this condition of start control 112, multiple stages of the counter, which are in the bistable state due to the actuation of a key, can be read out simultaneously. The identities of the stages that are read out simultaneously are variable and under control of the operator by his actuation of additional keys during the counting sequence. Since each bistable stage that is read out sounds the note or notes present at the corresponding signal gate SG through the corresponding tone gate TG, multiple notes can be played and the combination of these notes controlled by the operator. This is called the multi-tone effect, since multiple notes can be heard simultaneously or plural arpeggios can be proceeding simultaneously. Whether start control 112 will operate in the normal of the multi-tone mode is determined by control 144.

In FIG. 5 is illustrated the tone signal paths of the present system. The signal gates SG1-SG20 pass signals from the sources 13-72, each gate handling three

notes, or in effect constituting three gates with a single output. That single output for each of SG1-SG20, (SG21 handles only signal 73 and its output is summed to SG20 output), is applied to its tone gate, so that 20 tone gates TG1-TG20 are required.

Ten amplifiers 105 convey the outputs of the 20 tone gates to a distributed tone color filter DF, which is well known, per se, from which two groups of tone colored signals are taken, string tones on lead 147 and flute tones on lead 148.

The string tones proceed to two piano tone filters, No. 2 and No. 3, of diverse tonal characteristics, while the flute tones on lead 148 proceed to a third piano filter, No. 1. The outputs of piano filters No. 1, No. 2, No. 3 are summed at node 150, and lead via tab switches TB to volume control 151 and thence to the amplifiers 15 and loudspeakers 16 of the organ, shown on FIG. 1.

The flute tones on lead 148 proceed to a harp filter 152 and a harpsichord filter 153. to the latter is also supplied string tone from lead 147, and a banjo filter 154 is likewise supplied. The output of the harp filter is supplied via lead 155 directly to node 150, and the output of piano filter No. 3 via common gate 126 to the output of guitar filter 156 and harp filter 152. The guitar filter is supplied with the output of the harp filter. Common gate 126 supplies a pluck effect to the initial moments of a guitar or harp note. Common gate 126 is turned on with an output of any tone gate TG1-TG20, as evidenced by lead 105 (FIG. 4), and its sustain time is controlled from bus 125. The tone filtering system is per se well known, and forms no part of the present invention, and, accordingly, specific circuit details are not supplied.

Proceeding now to discuss circuit details for implementing the logic of FIG. 4, in FIG. 2, 200 is a source of voltage, 11.5 v., which is connected to three key switches S1, S2, S3, in parallel. The gates 72 are all the same, so that only one will be described. All the gates derive signal inputs at 201, in the form of square waves, positively going, and the outputs of the three gates are applied via a common lead 203 to a tone gate 36. The applied D.C. voltage proceeds, when S1 is closed, via diode 204 to charge a capacitor C1 via high reactance 206. Discharge of C1 is under control of the tone source, a square wave 207 of the proper frequency for the pitch called for by the key switch S1. C1 therefore slowly charges while the square wave 207 blocks diode 208, and then discharges rapidly when diode 208 is unblocked. The resultant wave on lead 203 is 209.

Closure of switch S1 also supplies positive voltage via diode 210 and lead 211 to a gate of corresponding nomenclature, one octave higher in pitch, and so on through all such gates. For the D. C. voltage supplied by key switch S1 can be substituted a voltage arriving via lead 212 from a gate of the same nomenclature, but of one octave lower pitch.

In the strum or normal mode of playing it is desired that higher octaves not be primed when a note of a lower octave is played. To defeat transfer of signal on lead 211, -4.5V can be supplied at W, which renders diode 213 conductive and shorts out lead 211. Any one or more of the three gates, herein denominated a signal gate, when energized via a key switch, as S1, or via a lower octave key switch from a line 212, transfers D.C.

voltage on lead 74 to a counter slip-flop 71 of counter chain 13, that voltage being applied to the collector of transistor Q1, having an emitter at $-4.5V$, and a base connected to lead 215 which proceeds to, selectively, clock CL or $-25V$., according to the position of switch 130, FIG. 4. If the $-25V$. supply is applied Q1 is held cut off, which implies that the base of Q2 is supplied with the steady voltage on lead 74, while a key of three note gate 72 is depressed and remains conductive, its emitter being at $-4.5V$. Incoming leads to the typical stage 71 are 116a and 117a. With $-25V$ applied via lead 215 the counter stage 71 is inoperative to count, and this applies to all counter stages. But when a key switch is closed, the lead 74 applies a positive voltage to the base of Q2, which generates a drop in voltage at its collector, which in turn appears as a transient pulse at the base of transistor 220 of tone gate 36, transient because of coupling capacitor 221. Because transistor 220 is PNP this pulse turns the transistor transiently on, and passes current into the diodes 222, 223 of linear gate 224, via 1 megohm resistances 225, 226, respectively. The linear gate is per se well known. It is normally non-conductive, and is rendered conductive as a function of bias current applied to the anodes of its two diodes 222, 223. When transistor 220 passes current capacitor Cn is charged positively, and immediately commences to discharge. Part of the discharge, at least, takes place via the gate and turns the gate on. There is also a discharge path through diode 227 to sustain bus 228. That bus is held at a voltage variable by adjusting slider 229 of potentiometer 230. The terminal 231 of potentiometer 230 is supplied with positive voltage from the note played detector (FIG. 3B.) terminal S1 and the potentiometer 230 at its low voltage end is at $-4.5V$. It follows that the $-4.5V$. biases the gate 224 off through diode 227, but when a note is played the voltage at point 229 rises. The rate of discharge from Cn is thus modified according to the position of slider 229, which provides a discharge path in parallel with the gate 224. If the slider is at 10 V for example, there is no by-pass and the gate has a long sustain, but if the voltage is at $-4.5V$. sustain is very short. The output of tone gate 224 may be one, two, or three notes, depending on which of S1, S2, S3 are closed, but since the gate is linear no intermodulation occurs. Clearly, in theory, the system could have been devised to utilize one, two, four or five signal gates per tone gate, the actual number, three, being a compromise choice.

If the clock is connected to terminal T, the counter is permitted to count and each state acts as a bistable or monostable flip-flop depending on whether or not there is voltage applied to the stage on lead 74 via one, two or all of the key switches 51, 52 or 53. Referring to counter flip-flop 71 of FIG. 2 (no keys activated), the initial state of each stage ((no keys activated) is Q1 on and Q2 off) is Q2 off; and, Q1 is biased to become conductive or on when a key is actuated. The actuation of a key switch and resulting application of voltage to the collector of Q1 provides the necessary supply to make the stage act as a bistable flip-flop. Each stage is read out by the application of a positive ripple pulse either on lead 117a or 116a which is coupled to the base of Q2, and saturates that transistor. This changes the state of this stage and provides a negative step at the collector of Q2 which is coupled to transistor 220 in the tone

gate and sounds the corresponding note. The next positive clock pulse that appears at terminal T saturates Q1 and changes the state of the flip-flop. This transistor provides a positive step at the collector of Q2 which appears at terminal G as a positive pulse and is connected to 117a of the preceding stage and 116a of the succeeding stage. Depending on the state of the up down flip-flop, the succeeding or preceding stage is then provided with a positive ripple pulse which causes that stage to be read out or rippled through.

If there is no latch in voltage on lead 74, reception of a ripple pulse at the base of Q2 will saturate it only for the duration of that pulse, which is too short to activate the note gate transistor 220. Upon coming out of saturation this stage transmits a ripple pulse to the next counter stage. One of the leads 130, 131 may be connected to $-4.5V$. If so ripple pulses are grounded by one of the diodes D1, D2 and do not reach the base of Q2; thus the voltage condition of leads 130, 131 control the direction in which ripple pulses will progress, either up or down the counter. Essentially, each stage transmits ripple pulses both up and down, but one of these pulses is inhibited and the other not, to establish the direction of the count.

When no keys are actuated there is no current flow through resistors 241 and 242 which hold Q10 (FIG. 3B) off because its base and emitter are at the same voltage. U is a supply terminal for all key switches. If one of these is closed, current flows from terminal 240 through resistances 241, 242, to terminal U, lowering the voltage at the base of Q10, which then fires, passing 11.5 V. to the sustain bus 231 (FIG. 2). At the same time a negative pulse is applied to the base of transistor 242, forming part of a monostable flip-flop with transistor 243, which transmits a pulse on lead 244 via capacitor 245. This pulse is applied to lead 116a of counter stage 1 (FIG. 2), and starts a count. It is also required that the note played detector supply D. C. to the start control 112 and operate bias to the clock CL and a reset pulse to the up-down flip-flop 116 to assure that it is in the up state. The transistor 242 supplies a pulse via lead 250 to the base of the transistor 251 of the up-down flip-flop, which resets the latter. The clock derives its D. C., so long as any key switch KS is closed, from terminal S (FIG. 3B) of the note played detector 108, via lead 254 to the base of transistor 255. The latter normally has no voltage applied, and is cut off so that the clock cannot operate. When positive voltage is supplied to the base of transistor 255 of clock CL, that transistor is biased on and the clock, consisting of a multivibrator, can proceed to oscillate. Its timing or frequency is set by the value of resistance 257, which sets the bias for transistor 255. An alternate pedal controlled clock is illustrated in FIG. 6.

The output of clock CL proceeds via amplifier 260 and lead 261 to the upper contact of switch S4. If the upper switch contact is closed the output pulses proceed to lead 262, and thence to all the counter stages. If the switch arm S4 is down $-25V$. is applied to lead 262, via lead 263 and the counter does not count.

When no keys are actuated the start control 112 is forced into the start state in which transistor 281 is off and 270 is on. This state is insured because, with no keys actuated, lead 259 is at $-4.5V$, which prevents transistor 281 from being on. The state of the up-down

flip-flop is not forced under these conditions, and therefore it can be either in the up or down count state.

When one or more keys are actuated the note played detector provides collector supply voltage to transistor 270 of the start control via lead 259 but does not change the state of the start control. Therefore, the collector of transistor 281 is high, which provides a reverse bias on diode D1 of counter stage 1 (71 in FIG. 3A). This permits the introduction of the positive pulse from the note played detector on lead 254 which starts the counter counting. At the same time, a positive pulse is fed from the note played detector 108 via lead 250 to the base of transistor 251 of the up-down flip-flop 116, to set it in the up count state. Now that these two controls are set the counter begins to count up. the up 281

The purpose of the start control 112 is to prevent more than one pulse from being introduced into the counter from the note played detector while a count sequence is in progress. This is accomplished by feeding the output of counter stage 1 to the start control flip-flop via lead 273. This pulse is directed via diodes 283 and 283A and leads 271 and 271A. These leads are connected to the down control bus and up control bus, respectively, such that when in the up count state, the output of counter stage 1 is directed to the base of transistor 281. This saturates that transistor and changes the state of the start control 112 to keep transistor 281 saturated, which places a forward bias on diode D1 of counter stage 1. Diode D1 shunts any input pulse on lead 244 to -4.5 V and prevents it from operating counter stage 1. If in the strum or the up arpeggio mode, the output of counter stage 20 is fed via lead 275 and switch S5 to the base of transistor 270 which saturates that transistor and changes the state of the start control flip-flop so that it will allow a new pulse to be introduced into the counter chain. This is done, because stage 20 represents the end of an up count sequence. If, however, the device is in the up-down mode, S5 is open and the output of stage 20 is not fed to the base of transistor 270. Instead the second output from stage 1, that occurring while the up-down flip-flop is in the down count state, is directed to the base of transistor 270 via lead 273 and diodes 283 and 283A, and leads 271 and 271A. This changes the state of the start control flip-flop so that it will permit the introduction of a new pulse into the counter chain, which is necessary because the second output of counter stage 1 indicates the end of an up-down count sequence.

In the multi-tone mode, switch 280 is opened, allowing the emitter of transmitter 281 to float, which prevents lead 282 dropping its potential, so that ripple pulses can be introduced at any time. This implies that any closure of a key will start a new count sequence. If the switch 280 is open and the system in the arpeggio up only mode, pulses can be introduced at any time at stage No. 1, and will travel up the counter, regardless of other pulses then in process of proceeding along the counter. If the system is in the up-down mode and pulses are introduced on the way down, the count direction will be reversed simultaneously with their introduction.

It is not illustrated, but if there were separate up and down counters, new pulses could be introduced into each at any time, producing simultaneous up and down arpeggios. In the present system the counter must be

either proceeding up or proceeding down, and any key closure occurring while the counter is counting down reverses the direction of travel.

While the simple clock of FIG. 3B is suitable generally, an alternative more sophisticated clock is provided in FIG. 6, which has its rate controlled in two modes or by two complementary controls.

Q11 to Q14 represents an astable multivibrator of conventional character per se, having its last stage Q14 coupled to its first stage Q11 via a capacitor C22. The frequency of the oscillator is determined by the current injected into the capacitor 22, which is controlled by transistor Q19. The latter operates as a constant current source, i.e. as if it possessed sufficiently high internal resistance that current flow into the capacitor C22 is constant, regardless of voltage across C22. When transistor Q14 turns on, the negative step at its emitter is coupled via capacitor 22 to the base of transistor Q11 which turns that transistor off by driving its base to approximately -9 v. Transistor Q11 cannot turn on again until capacitor 22 charges up to approximately -4 V. This charging period is controlled by the current from constant current source Q19 and therefore this source controls the frequency of the clock. The negative step at the collector of transistor Q11 when the transistor turns on, is coupled via transistor Q12 and capacitor C1 to the base of transistor Q13 which turns that transistor and transistor Q14 off. The period of this section of the cycle (Q13 and Q14 off) is not variable and is determined by the time constant of C1 and R3. When the base of transistor Q13 recovers from the negative pulse from transistor Q11, Q13 turns on which turns on Q14 and couples a negative step from the emitter of Q14 to the base of Q11, which is the beginning of another cycle.

The transistors Q15, Q16 constitute a pulse amplifier and wave shaping circuit which is conventional per se, and therefore is not described in detail.

When a note is played $+11.5$ V. is applied to terminal 290, from note played detector 108, a current path is provided through lead 291, variable resistance 292, diode 293, resistance R21, the emitter of transistor Q19, the collector of Q19, capacitor C22, the emitter of Q14, and back to -4.5 V. When the capacitor is to be charged, Q14 is conductive, so that effectively the charge on the capacitor C22 is referenced to -4.5 V.

The current delivered by transistor Q19 is $I = 11.5$ V $-VB - VBEVD / R21 + R28$

In the equation, VB is the voltage at the base of Q9, VBE the voltage drop base to emitter of transistor Q19, VD the drop in diode 293 and R21, R28 the values of the resistances in series with transistor Q19, and all are constant. The voltage at the emitter of Q19 will follow the voltage at the base of Q19, less about 0.5 V., so that by controlling the base voltage the current flow into C22 can be controlled and will remain constant regardless of the instantaneous voltage on the capacitor, and further this current can be controlled by varying circuit resistance, i.e. at R28.

A transistor Q20 has its collector connected to the collector of Q19, its base maintained at low voltage via R22, R23, and its collector coupled by capacitor C24 to the terminal 290, which is supplied with $+11.5$ V. when and only when a note is played. Since the emitter of Q20 is connected to -4.5 V, and the base is con-

connected via R23 to -50 V, if there is no voltage on lead 290 (no keys played) transistor Q20 turns on thereby holding the base of Q11 at -4.5 V. Transistor Q20 is "on" in the sense that its emitter to base circuit is conductive, and in such case the collector assumes essentially the voltage of the emitter. This stops the clock when no keys are played and assures the same starting conditions on the clock. Capacitor C24 provides a positive pulse at the base of Q11 when the first key is played to sync the clock to the playing of the first key or keys. The voltage on lead 290 is a step voltage, positive at 11.5V while a key or keys are depressed. On initial depression of a key or keys a transient voltage proceeds via capacitor 24 directly to the base of Q11. Thereafter, the steady +11.5V reduces the voltage at the base of Q20 to a value such as to render the transistor "off," i.e., its emitter to base circuit is non-conductive, and its collector therefore is at the voltage of the collector of Q19, to which it is tied.

A variable voltage divider is provided in terms of R19 and Q18, the latter having its bias controlled by R17, R18, acting as a voltage divider. Current flow into the base of Q18 determines its resistance so that it is, effectively, a variable resistance controlled by Q17. The latter has its emitter connected to a known constant voltage, its collector connected directly to the base of Q18, and its base connected to a source of voltage controlled by the expression shoe of the organ containing the present system.

If ES is open the sole control for the current supplied by Q19 to capacitor C22 is variation of the value of R28, manually controlled. If ES is closed, a bucking voltage is applied to the cathode of D3 as follows. An NPN transistor Q21 is connected across a voltage source. A potentiometer 292 is connected from its collector to its emitter, and the slider of the potentiometer 292 is connected to the base of the transistor which is collector loaded. Current flow into the collector is then a function of slider position, which is controlled by expression pedal EP. The voltage conveyed from the collector of Q21, via lead 294 is variably positive and therefore controls the voltage at the base of Q17 and hence its collector voltage. Accordingly, the position of the expression pedal EP controls the resistance of Q18, which in turn controls the bias of Q19 and hence current flow into C22.

As the expression pedal is pressed downward, the loudness of the organ increases. Similarly, the voltage at the base of Q21 increases and current flow out of Q19 increases, increasing arpeggio rate.

The pedal of the organ thus becomes a useful and convenient device for changing rate of arpeggiation as the arpeggio proceeds, up or down, and the expedient is musically sound because soft music is appropriately associated with slow arpeggio, and vice versa. Of course, other devices may be substituted for the pedal. For example, a knee operated potentiometer may be employed. The crucial point is to provide a voltage controlled clock such that it may be controlled while the hands are occupied with playing of the organ, and use of the pedal provides a particularly pleasing effect, musically.

It is desirable to prevent the top note in an arpeggio from being played twice, when the present system is in the up-down mode. If the top note played pertains to

counter stage C20, there is no problem, since only up-going pulses affect this stage and therefore there can be no repetition of the top note. But, for example, if the top note pertains to counter stage No. 19, the system will play that top note, ripple through to stage No. 20 in negligible time, and back to No. 19. Therefore the top notes will play twice with negligible time interval. This distorts the tempo of the arpeggio.

To solve the problem of double top note pulses in the up-down mode, the key switches which pertain to counter 20 (and note No. 73), provide a voltage on lead 300 via isolating resistances R12, R15, R18, R21 (FIG. 7). Those key switches pertaining to counter stages No. 19 and No. 20 provide voltage at lead 301, and those key switches pertaining to counter stages No. 18 and No. 19 and No. 20 to lead 302, all via appropriate ones of isolating resistances R1-R21, inclusive.

There are three transistor gates, Q31, Q32 and Q33, which are of NPN type, and have their collectors commonly connected to D.C., the down control voltage from the up-down flip-flop 16 (see FIG. 3B), via load resistances R22, R24, R26. The emitters of the three transistors are commonly connected directly to -4.5 V. and the collectors respectively connected via resistances R23, R25 and R27 to the bases of the Q1, stages of the C17, C18 and C19 counter stages, labelled TI in FIG. 2, which illustrates one typical counter stage.

The device is inactive while the arpeggio is proceeding up, since D.C. is not available. When the down control voltage D.C. is applied, it is routed to the TI leads of counter stages C17, C18, C19. However, a gate of SG18 will be routed via R1, R2 or R3 to turn on Q31, which removes the down control voltage from TI17, so that the stage TI17 can be free to operate normally in the down arpeggio. Similarly, gate voltage from signal gate SG19 will turn on Q31 and Q32, removing the down control voltages from TI17 and TI18, and a gate voltage of SG20 will remove down control voltage from terminals TI17, TI18, TI19, by turning on Q31, Q32, Q33. Thus, the down control voltage appears only on the counter corresponding to the highest note played, regardless of which of the No. 17, 18, 19 or 20 tone gates is involved.

The transistors Q31, Q32, Q33, when open or unfired, permit the D.C. voltage to proceed to the TI bases thereby preventing corresponding notes from sounding, but when saturated by a voltage from SG18, SG19 or SG20, they remove the control from the TI lead, whereupon the corresponding counters can respond to the clock and enable production of sound.

It follows that if and only if a No. 20 gate is keyed on, will counter stages No. 17, No. 18, No. 19 be able to sound a note during down arpeggio. If a No. 19 gate is the highest keyed on, gates No. 17 and No. 18 will be able to sound in down arpeggio, but not No. 19, and if gate No. 18 is the highest keyed on, stage No. 17 will be able to sound in down arpeggio but not No. 18.

The down control voltage appears at the counters only for the highest note played, only on the way down. For a note in SG20, no controls are needed, and if SG19 and SG20 are energized simultaneously, SG19 will sound on the way down. But if, for example, SG19 is the highest note played, it must be silent on the way down and sound only on the way up.

Operation of the present system is summarized as follows. The up-down counter necessary to produce sequential pulsing consists of twenty counter flip-flops, illustrated in FIG. 2. Each of these flip-flops has two modes of operation, which depend on the state of the three (or four in the case of stage 20) organ key switches associated with that stage. If one or all of these key switches are closed (or in the case of arpeggio any key associated with a lower note that is octavely related to the notes associated with the stage under consideration) the flip-flop acts as a bistable flip-flop with initial state of Q1 on, Q2 off. If none of these keys is depressed the flip-flops act as monostable flip-flops with an operating time of approximately 30 microseconds. In either case the initial condition of the flip-flop is Q1 on and Q2 off. In strum and arpeggio modes of operation, but not normal mode, the trigger input T is a 10 volt square wave with short duty cycle. Each stage has two inputs which provide the means to switch out of the initial state: one is used for the up count and one is used for the down count. These inputs require a positive pulse, and have means (diodes D1 and D2) to cancel any attempt to switch the state of the flip-flop through either or both inputs. These stages are interconnected, as shown on FIG. 3, with the output of each stage (Gn for the Nth stage) feeding to the up count input of the next stage (Un+1) and also to the down count input of the preceding stage (Dn-1). Stage 1 receives the first pulse at its up count input (U₁) from the note played detector, as shown in FIG. 3. The clock is also synchronized with this note played detector so that the first clock pulse occurs simultaneously with the playing of a note and the switching of stage 1. An "up-down flip-flop" is also set in the up count mode from the note played detector. When the output of stage 1 (G1) has a positive transient it switches stage 2 via the up count input (U₂). This switching of stage 2 will take place either at the next clock pulse if stage 1 has been energized (that is if the conditions were met to make stage 1 act as a bistable flip-flop) and in a much shorter time (the operating time of the monostable) if stage 1 has not been energized. This sequence is repeated until the counter reaches and switches stage 20 at which time the counting stops if the system is in the strum or up arpeggio mode. If it is in the up-down arpeggio mode G20 is connected to the down count input of stage 19 (D19) and to the "up-down flip-flop" which changes the state of this flip-flop to the down count state, and conditions the counter for down count. The pulse introduced into stage 19 by stage 20 is now free to proceed down the chain in the same manner as the up count pulse proceeded up.

The start control (FIG. 3) determines when a start pulse can be applied to the up count input of stage 1. This control has four inputs, two of which are driven by G1 and each controlled by the "up-down flip-flop." If we are in the up count operation a positive pulse at G1 will set the start control so that no new pulse can be introduced. If we are in the down count mode a positive pulse from G1 will set the start control so that new pulses can be introduced. If we are in the up arpeggio or strum, stage No. 20 is connected to the start control so that after the up-down counter has counted up through stage No 20, another pulse can be introduced into stage 1. When in the up down arpeggio mode the connection

between stage No. 20 and the start control is broken so that no new pulses will be introduced into stage 1 until the down count is complete. In the multi-tone mode, the start control is essentially disabled so that a new pulse can be introduced at any time.

In the normal mode switch S1 disables the up down flip-flop through diode D3 and places the start control in a state so that no pulses can be introduced into stage 1. It therefore disables the up down counter. Now any key played will provide current through I_N of the counter flip-flop which will saturate Q2 and provide a negative pulse at O_N. This current is not diverted through Q1 because the trigger input has now been switched and the trigger is now a negative voltage which will prevent Q1 from latching in an on position. A gating pulse is therefore passed by the counter stage operating as an amplifier.

What is claimed is:

1. In an electronic organ, a multi-stage counter, a plurality of tone signal sources, a separate key for each of said sources, means for differentially priming diverse stages of said counter in diverse manners in response to actuation of said keys, means responsive to actuation of any one of said keys for initiating a count of said counter, and means for enabling only selected ones of said tone sources in sequence according to the manners of priming of said stages.

2. The combination according to claim 1, wherein each of the stages of said counter is arranged and adapted to be selectively monostable and bistable, and wherein the manners of priming said stages are that said stages are each selectively rendered bistable and monostable, and wherein the time constants of the stages while monostable are of the order of less than a millisecond, and wherein said counter is asynchronous.

3. In an electronic organ, an asynchronous multi-stage counter, each of the stages of said counter being selectively bistable and monostable and when monostable having a time constant of the order of less than 500.μ's, a plurality of normally inoperative tone sources allocated respectively to said stages, a plurality of key switches, means responsive to actuation of any of said key switches for initiating an up count of said counter, and means responsive only to the bistable stages of said counter for rendering operative tone sources allocated to said bistable stages.

4. In an electronic organ, a multi-stage counter, a plurality of normally disabled tone sources allocated respectively to the stages of said counter, a plurality of key switches, means responsive to actuation of any of said key switches for initiating an up count of said counter, means responsive to the count of said counter as said counter counts up for enabling said tone sources in sequence, and means for selectively rendering inoperative selected ones of said stages whereby only those tone sources are enabled which are not operatively associated with an inoperative counter stage.

5. The combination according to claim 4, wherein in response to actuation of one or more of said key switches all stages not allocated to the actuated key switches are rendered inoperative.

6. The combination according to claim 5, wherein said counter is asynchronous, and wherein said operatively disabled stages are arranged to count for a time

inadequate to enable tone sources and the enabled stages for a time adequate to enable said tone sources to produce audible tone when enabled.

7. The combination according to claim 6, wherein said disabled stages are monostable and the enabled stages are bistable.

8. In an electronic organ, an up-down multi-stage counter, a plurality of key switches, means responsive to simultaneous actuation of any of said key switches for initiating an up count of said counter, means responsive to completion of said up count for initiating a down count of said counter, means allocating said key switches to the stages of said counter, respectively, said stages of said counter having counts each of selectively two diverse characteristics, means responsive to the actuated key switches for selecting the one of the two characteristics which shall pertain to any stage of said counter allocated to said key switches, a plurality of normally disabled tone sources, and means responsive to the stages of said counter of one of said characteristics only as said counter counts up and down for selectively and sequentially enabling said tone sources.

9. In an electronic organ, a keyboard, means responsive to playing of at least one key of said keyboard for sounding an up and then a down sequence of all notes of nomenclature corresponding with the nomenclature of said at least one key other than notes of octave lower than called for by said at least one key, and means responsive to playing of another key while said sequence subsists for reversing the direction of said sequence, said last means including an asynchronous counter which scans in sequence all notes which can be called forth by a portion of said keyboard and selects only the sounded notes within that portion.

10. In an electronic organ, a plurality of tone signal sources encompassing at least three octaves of the musical scale, a plurality of key switches, an electronic commutator arranged to scan said at least three octaves of tone signal sources in an arpeggio sequence, and means responsive to simultaneous manual actuations of plural ones of said key switches for determining which of said at least three octaves of said tone signal sources shall be converted to tone signals by said electronic commutator, said electronic commutator being a multi-stage counter.

11. The combination according to claim 10, wherein is further provided means for initiating a count of said counter in response solely to said actuations of said key switches.

12. In an electronic organ, a plurality of tone signal sources, a plurality of key switches, an electronic commutator arranged to scan said tone signal sources in sequence, and means responsive to simultaneous actuations of plural ones of said key switches for determining which of said tone signal sources shall be converted to tone signals by said electronic commutator, said commutator being a multi-stage counter, means for initiating a count of said counter in response to said actuations of said switches, wherein said multi-stage counter is a reversible counter.

13. The combination according to claim 12, wherein is included means responsive to completion of an up count of said counter for reversing the direction of count of said counter.

14. In an electronic organ, a plurality of tone signal

sources, a plurality of key switches, an electronic commutator arranged to scan said tone signal sources in sequence, and means responsive to simultaneous actuations of plural ones of said key switches for determining which of said tone signal sources shall be converted to tone signals by said electronic commutator, said commutator being a multi-stage counter, means for initiating a count of said counter in response to said actuations of said switches, wherein said electronic commutator is a multi-stage counter having stages corresponding with said key switches and means responsive to said actuations for converting those stages of said counter which correspond with the actuated key switches to bistable stages, said stages being normally monostable.

15. In an electronic organ having a keyboard, means responsive to playing of keys of said keyboard for sounding an arpeggio of notes both corresponding with and octavely related to said keys, said means including an electronic multi-stage counter, said counter including normally mono-stable stages connected in cascade and corresponding one for one with said keys, and means responsive to playing of said keys for rendering bistable those stages corresponding with the played keys, the reset times of said monostable stages being inadequately long to sound one of said notes.

16. The combination according to claim 15, wherein said arpeggiation is an up arpeggiation.

17. The combination according to claim 15, wherein said arpeggiation is an up followed by a down arpeggiation.

18. The combination according to claim 17, wherein is included means for at will reversing the direction of said down arpeggiation.

19. An electronic organ having a keyboard, comprising an electronic counter including plural stages, said stages being normally monostable devices, organ key operated means for converting selected ones of said stages to bistable stages, means for controlling the timings of the resets of said bistable stages, a plurality of tone signal sources, and means responsive to said bistable stages only for converting said tone signal sources to tones.

20. The combination according to claim 19, wherein said counter is asynchronous.

21. The combination according to claim 20, wherein is provided means responsive to actuation of any of said organ keys for initiating a count of said counter.

22. The combination according to claim 21, wherein said counter is reversible.

23. The combination according to claim 22, wherein is included means for reversing the count of said counter on completion of an up count of said counter.

24. The combination according to claim 23, wherein is included means for reversing a down count of said counter in response to actuation of any of said keys during a down count.

25. In an electronic organ, a keyboard, a multi-stage counter, a plurality of signal gates, one gate for each key of a section of said keyboard, means for summing the outputs of said gates in triples of adjacent gates, a separate linear note gate connected in cascade with each of said triples of adjacent gates, and means responsive to actuation of one key of said section for forming an arpeggio of the outputs of said linear gates, said arpeggio including octavely related notes, said last

means including said counter.

26. The combination according to claim 25, including means for initiating a count of said counter in response to said actuation, said counter having one stage for each of said linear gates and being asynchronous, said counter having stages which are normally monostable, means responsive to actuation of said key for converting plural stages of said counter to bistable stages, and means responsive only to said bistable stages when attained in the count of said counter for rendering said linear gates conductive of tone signals.

27. In an electronic organ, a keyboard, a multi-stage counter including one stage for each three adjacent keys of a section of said keyboard, means including said counter responsive to actuation of a key in the lowest octave of said section of said keyboard for initiating an arpeggio of notes tonally related to the note called for by the actuated key and means responsive to actuation of said key for initiating a count of said counter.

28. In an electronic organ, a multi-stage counter, a plurality of tone signal sources, a separate key for each of said sources, means for differentially priming diverse stages of said counter in diverse manners in response to actuation of said keys, means responsive to actuation of any one of said keys for initiating a count of said counter, and means for enabling only selected ones of said tone sources in sequence according to the manners of priming of said stages, wherein is provided means for deleting the topmost of said tone signals only during reverse direction count of said counter.

29. The combination according to claim 8, wherein is further provided means for disabling the highest of said tone sources only during down count of said counter.

30. In an electronic organ, an array of keys, an array of tone signal sources each corresponding with one of said keys, a counter comprising a cascaded array of flip-flops, each of said flip-flops including means for

rendering said each of said flip-flops selectively normally monostable with a time constant of the order of 30 microseconds and bistable, means establishing a correspondence between said keys and the stages of said counters, a load circuit including a loudspeaker, means responsive to actuated ones of said keys for rendering the corresponding ones of said stages of said counter bistable, and means for transferring all said tone signals corresponding with bistable stages of said counter to said load circuit in response to a count of said counter.

31. The combination according to claim 30, wherein is provided means for resetting said counter in response to completion of a total count of said counter.

32. The combination according to claim 30, wherein said counter is a reversible up-down counter and wherein is provided means responsive to completion of a total count of said counter for reversing the count of said counter and completing a down count of said counter.

33. The combination according to claim 32, wherein is further included means for at will reversing the count of said counter during a down count of said counter.

34. The combination according to claim 33, wherein said means for at will reversing is means responsive to actuation of any of said keys.

35. The combination according to claim 30, wherein is included means for at will disabling said counter and for transferring all of said tone signals corresponding with actuated ones of said keys to said load circuit concurrently.

36. The combination according to claim 30, wherein the corresponding ones of said stages include only those corresponding with tone signals of the same octaves as said keys.

37. The combination according to claim 30, wherein the corresponding ones of said stages include tone signals of octaves higher than the octaves of said keys.

* * * * *

40

45

50

55

60

65