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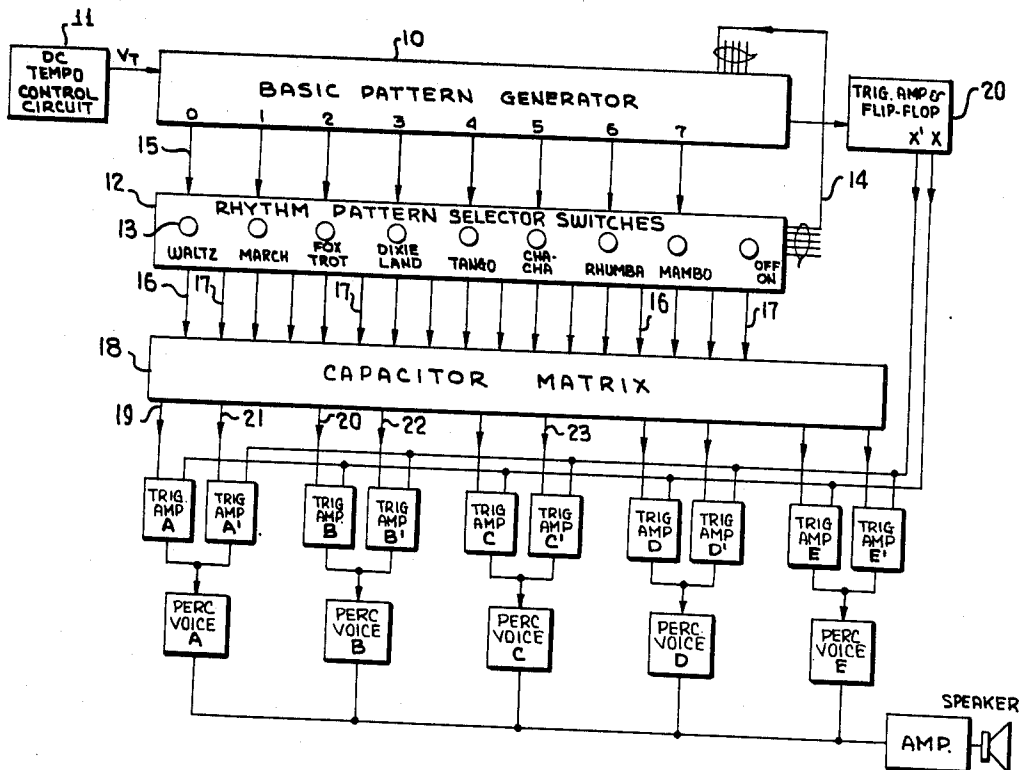
[54] **RHYTHMIC ACCOMPANIMENT SYSTEM
EMPLOYING AN ASYNCHRONOUS CHAIN OF
DELAY CIRCUITS**
35 Claims, 22 Drawing Figs.

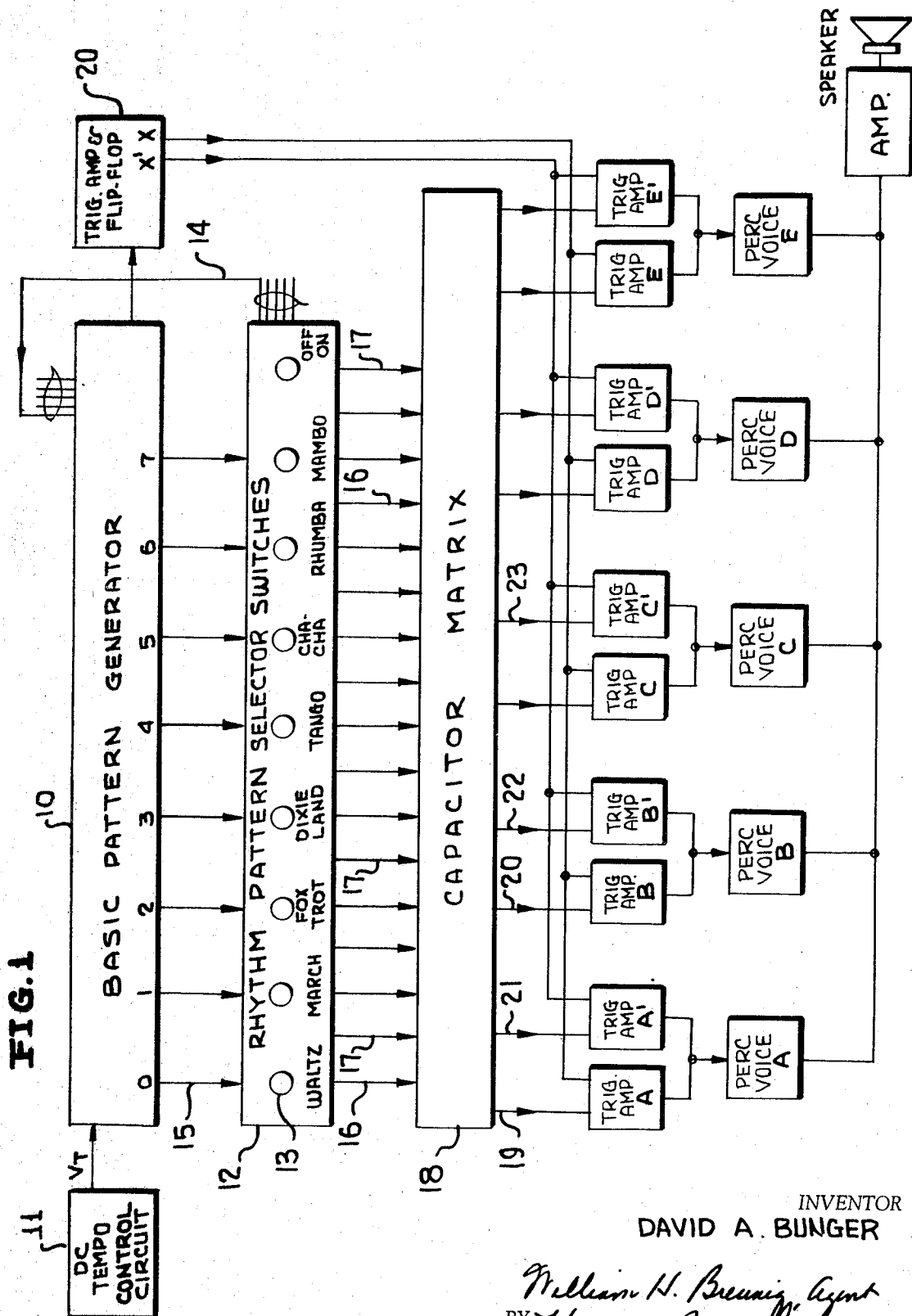
[52] U.S. Cl. 84/1.03,
84/1.19, 84/1.26
[51] Int. Cl. G10h 1/00
[50] Field of Search 84/1.01,
1.03, 1.11, 1.13, 1.17, 1.19, 1.24, 1.26(E,G,O)

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ABSTRACT: A rhythmic accompaniment system for a musical instrument, including a chain of cascaded monostable stages, which may be open ended or a closed ring, in which the delay per stage is adjustable in response to a control, which may be a control voltage, or insertion of a timing resistance, separably for each stage to modify tone pattern and simultaneously in the same sense and ratio for all stages to modify tempo. A matrix connects the stages selectively to tone signal sources, enabling generation of repetitive multitone patterns, the characters and/or the durations of which may be modified by suitably modifying the controls applied to the stages and suitably selecting interconnections by means of the matrix. Two control pulses may be inserted at a time, at different positions of the chain, and these may be derived internally or applied externally. A flip-flop circuit may be used to modify the connections of the matrix to the tone sources, for alternate measures. A more complex counter than a flip-flop may provide modification more infrequently than in alternate measures, say per three measures. The repetition may be partial by feeding back pulses from an intermediate point of the chain to the beginning, or from its end to a midpoint, i.e. there may be a chain within a chain, or a ring within a ring. Initiating a cycle of events in response to pedal actuation of an electronic organ, and utilizing an open chain, provides a semiautomatic system.





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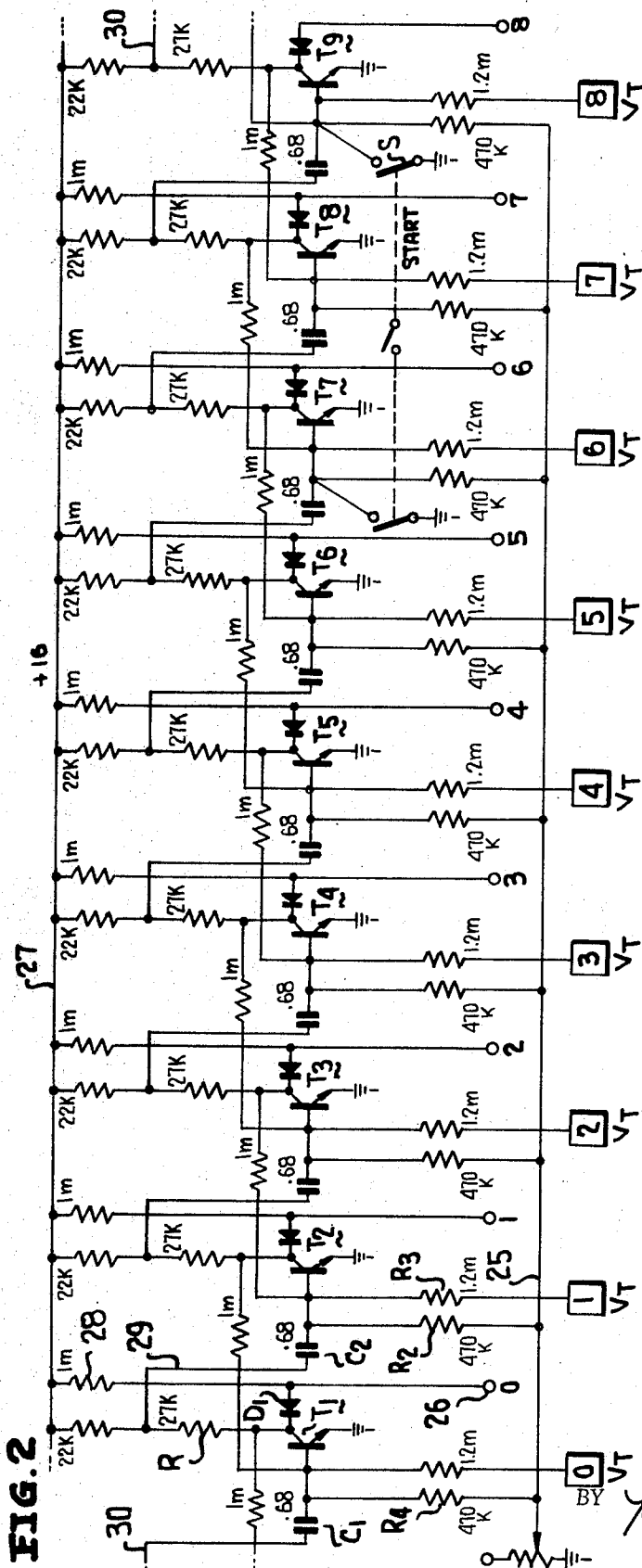


FIG. 3

OUTPUT #	T _{D0}	0	T _{D1}	1	T _{D2}	2	T _{D3}	3	T _{D4}	4	T _{D5}	5	T _{D6}	6	T _{D7}	7	T _{D8}	8
WALTZ	125	1000	125	125	125	250	83	333	125	458	125	583	83	667	83	750	125	
MARCH	125	1000	125	125	125	250	125	375	125	500	83	583	83	667	83	750	125	
FOX TROT	125	1000	125	125	125	250	125	375	125	500	83	583	83	667	83	750	125	
DIXIE LAND	125	1000	125	125	125	250	125	375	125	500	83	583	83	667	83	750	125	
TANGO	125	1000	125	125	125	250	125	375	125	500	83	583	83	667	83	750	125	
CHA-CHA	125	1000	125	125	125	250	83	291	83	375	125	500	125	625	125	750	125	
RHUMBA	83	1000	125	125	125	250	125	375	125	500	125	625	125	750	83	833	83	

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FIG. 5

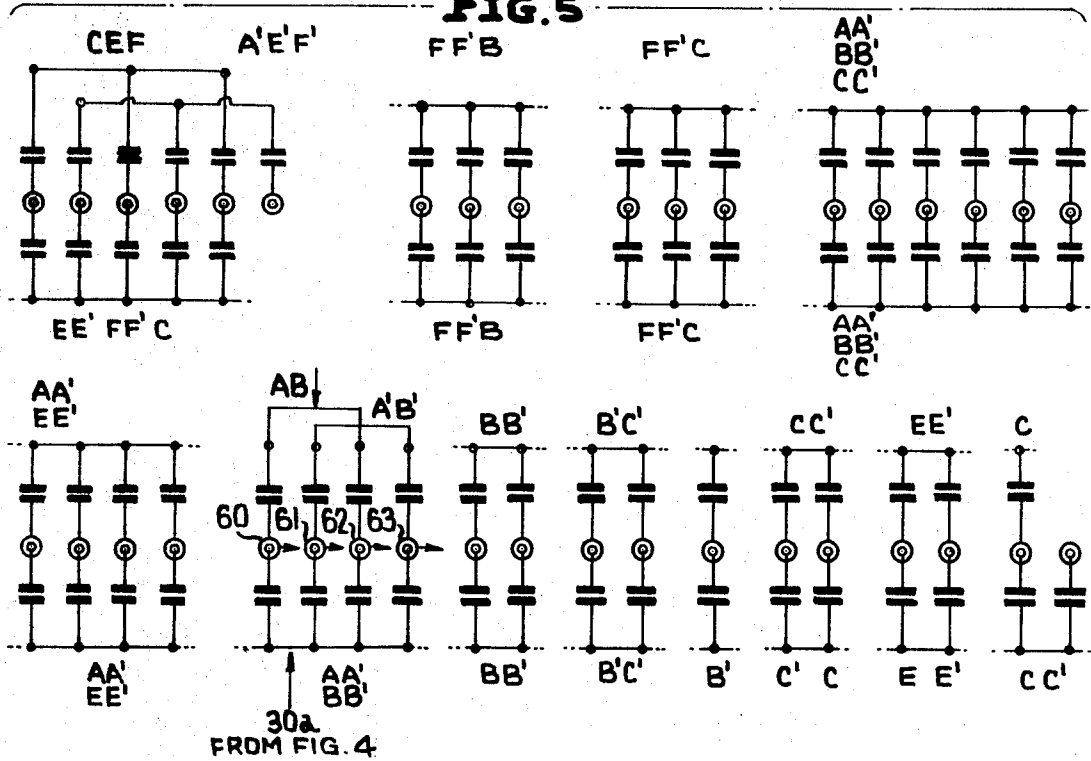
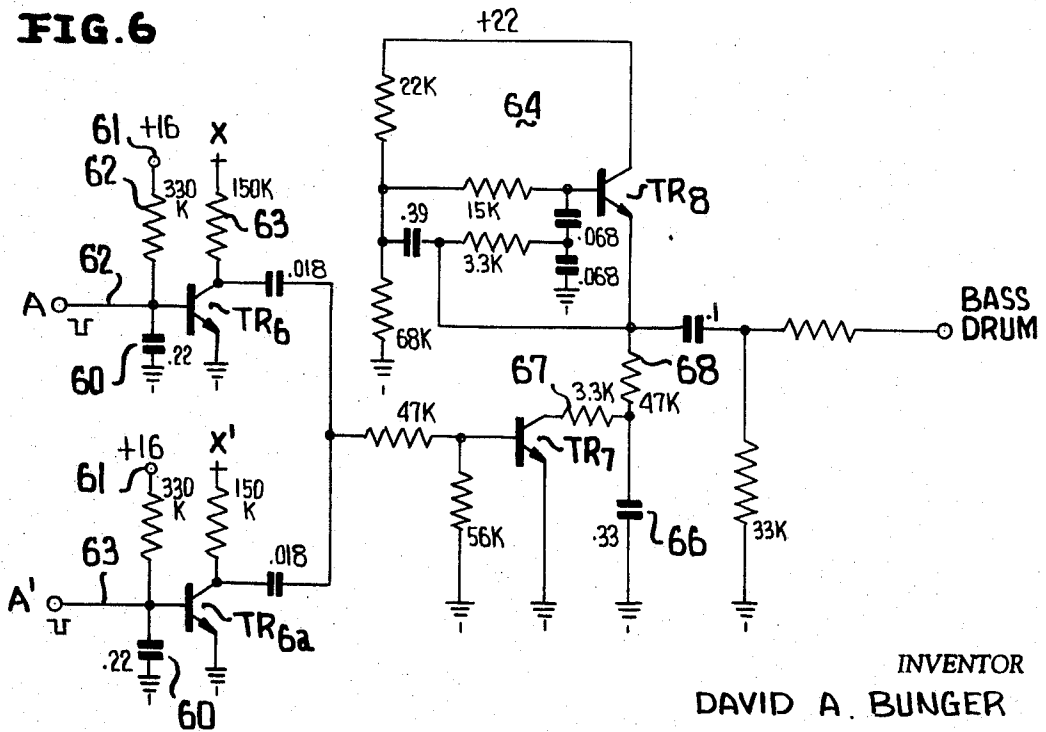


FIG. 6



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FIG. 7

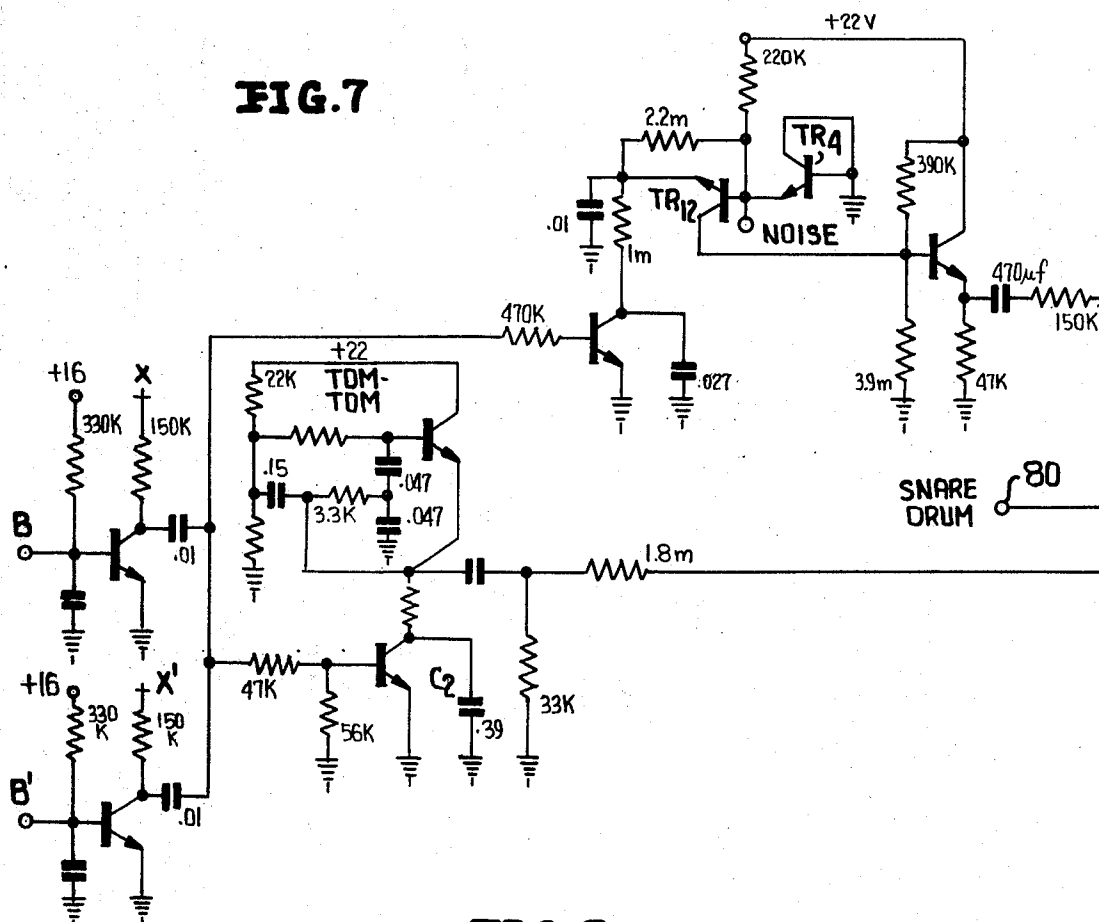
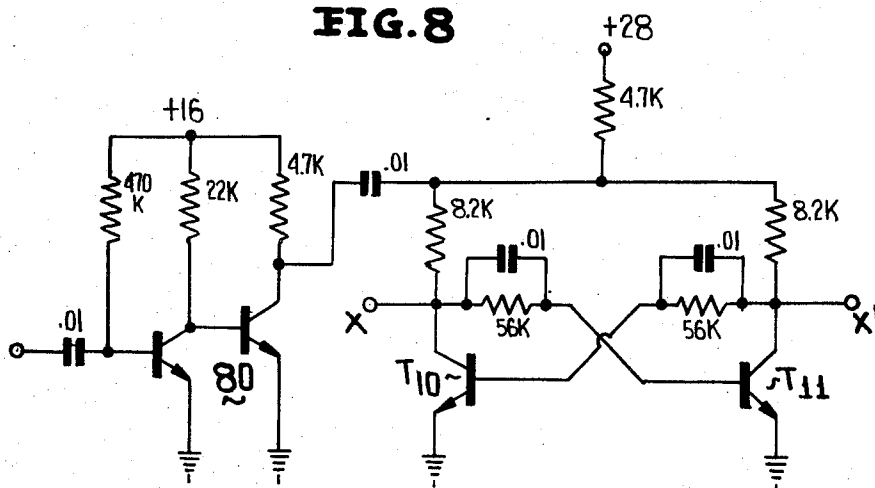
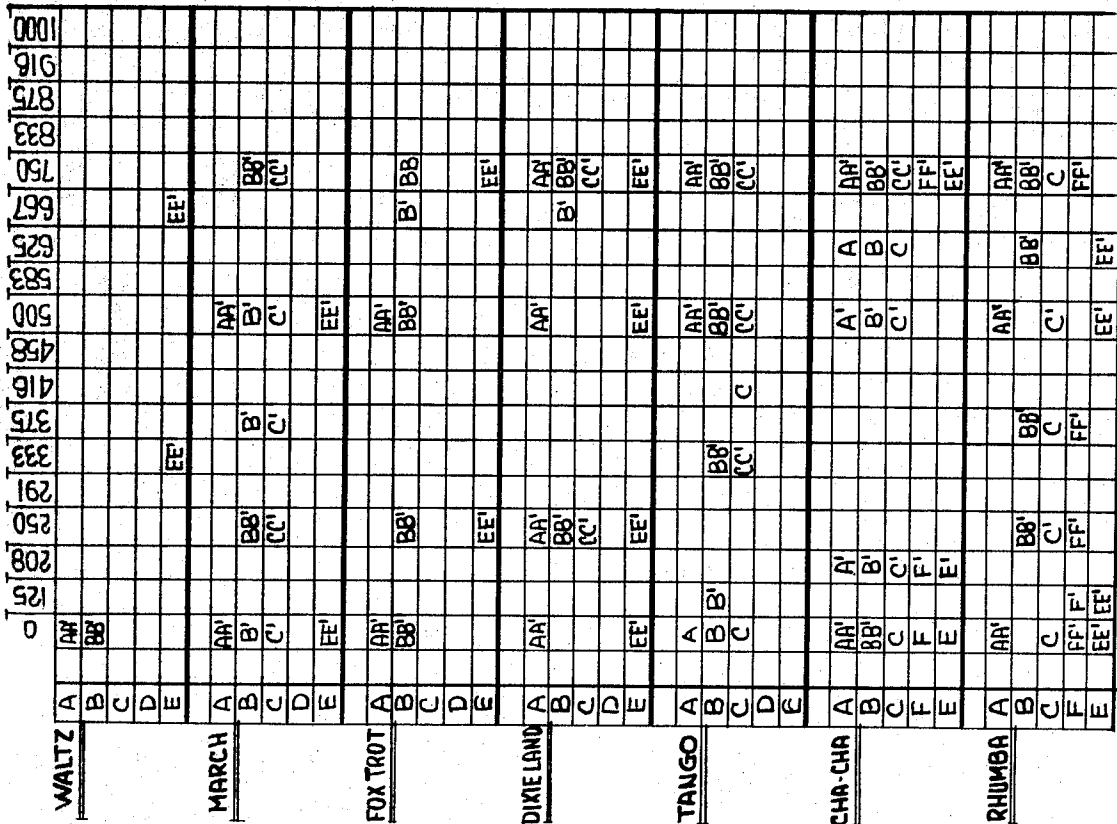
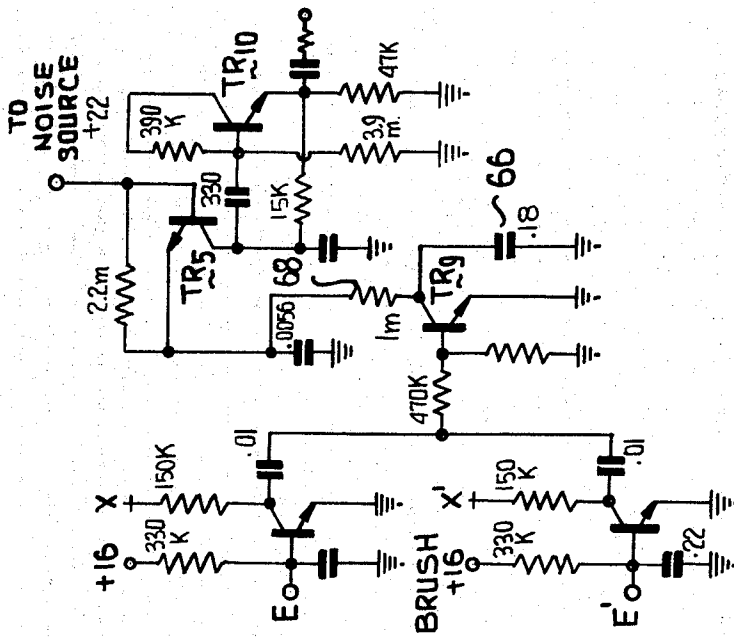


FIG. 8



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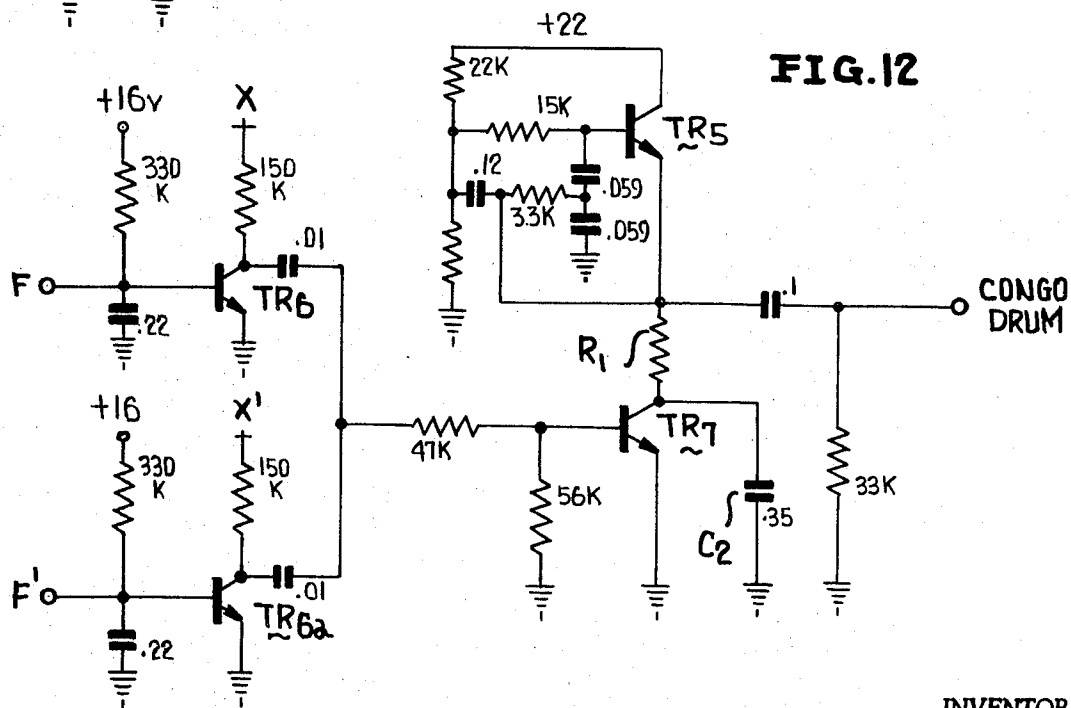
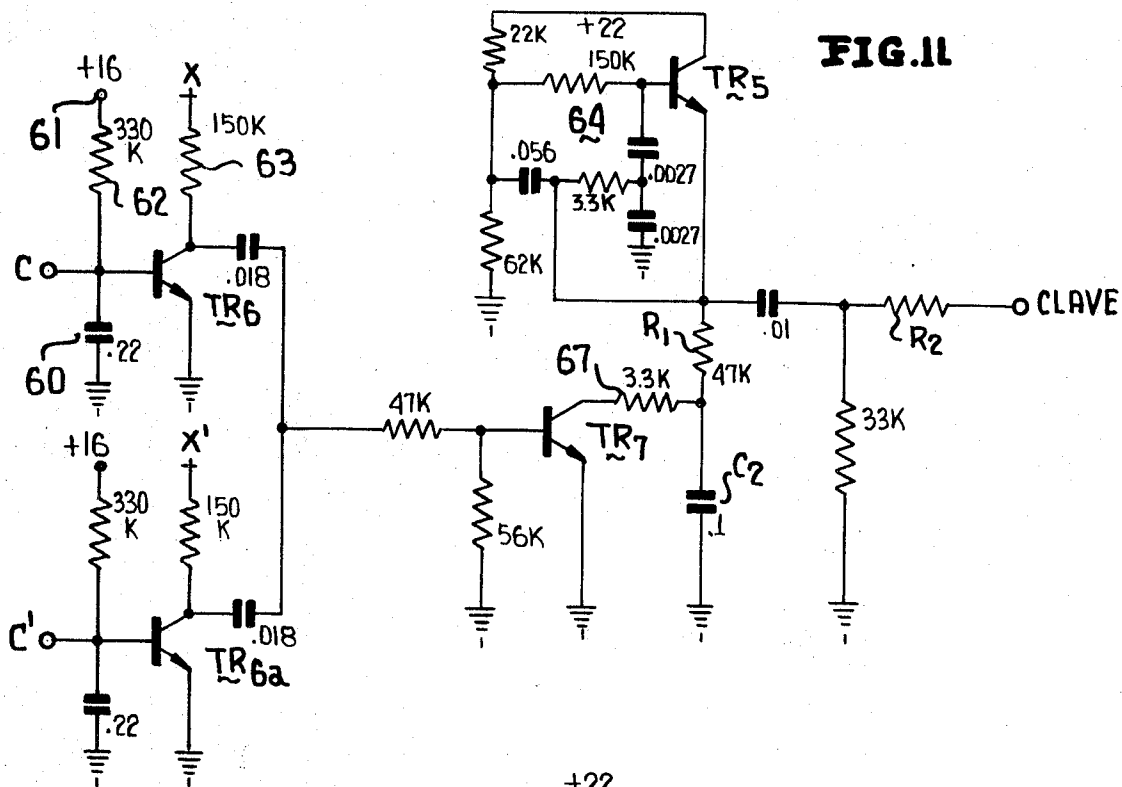
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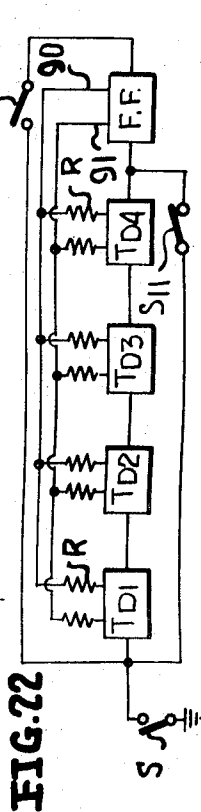
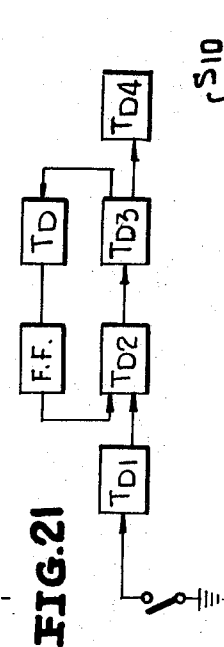
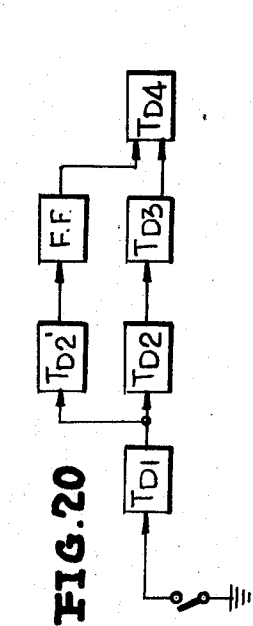
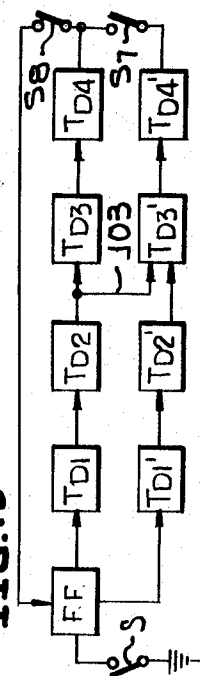
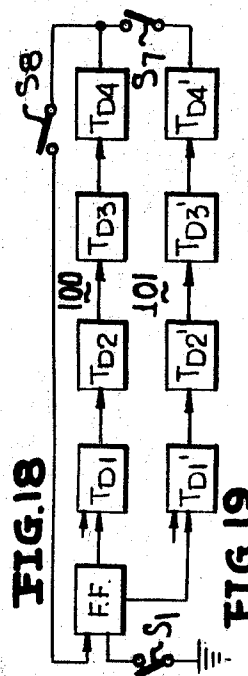
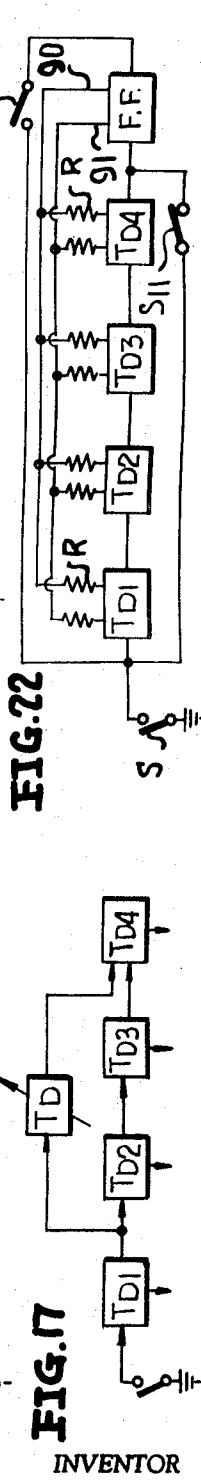
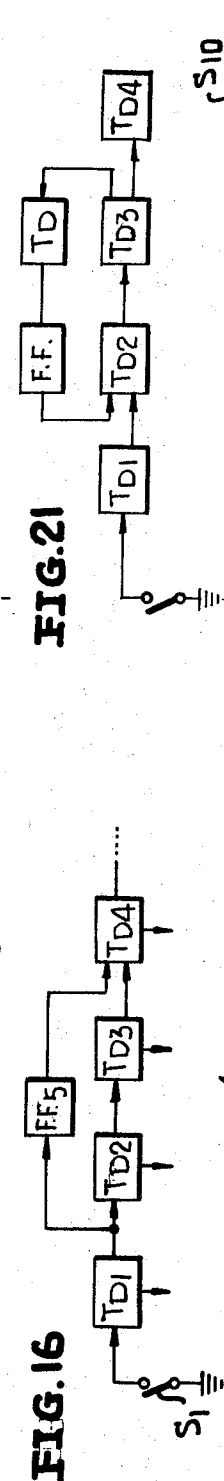
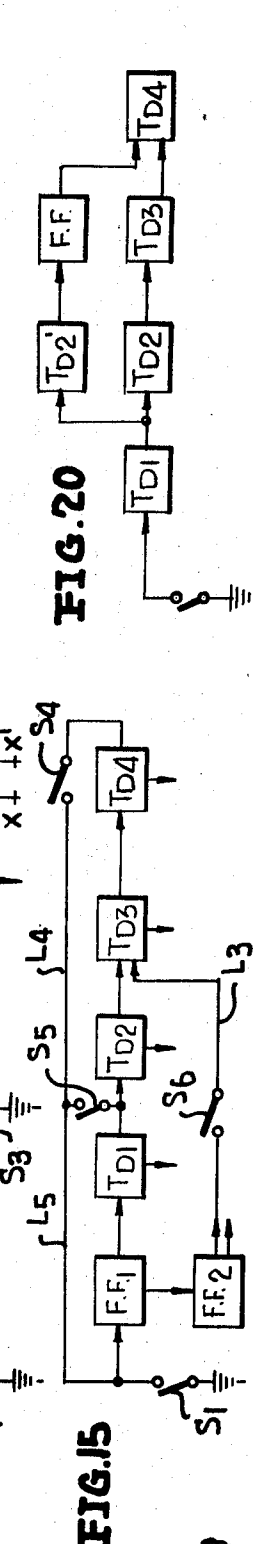
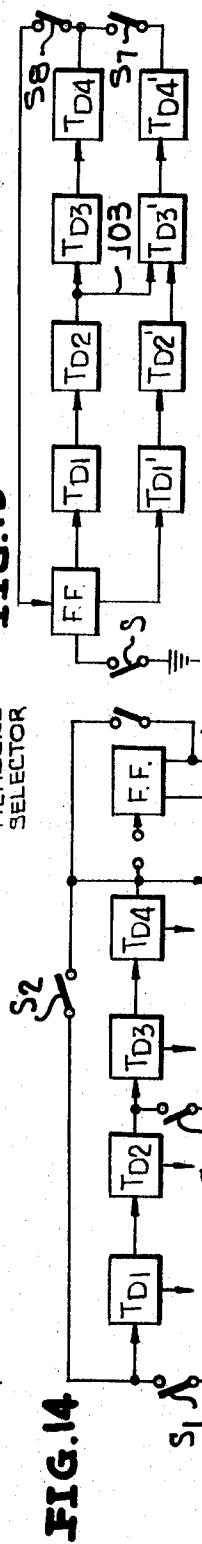
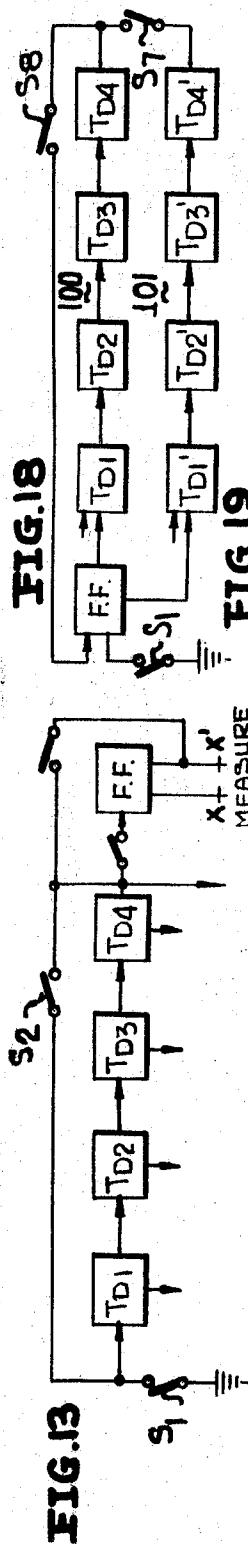
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RHYTHMIC ACCOMPANIMENT SYSTEM EMPLOYING AN ASYNCHRONOUS CHAIN OF DELAY CIRCUITS

BACKGROUND OF THE INVENTION

It is known to provide continuous repetitive rhythm patterns to accompany a musical instrument, such as an electronic organ or a guitar. In such systems it is requisite to provide adjustments for duration of each measure of music, i.e. tempo, so that the patterns may be synchronized with the playing, or vice versa, and it is necessary to provide for a wide variety of rhythms. It is also desirable to provide a variety of tone colors, such as those of the trap, the drum, the clave, or the brush cymbals, occurring together or separately at various positions of the pattern. Some rhythmic accompaniment instruments are slaved to the instrument they accompany. This can be accomplished, in the case of the electronic organ, by initiating a pattern in response to predetermined pedal tones. This system is called semiautomatic. Or, the patterns may run at some predetermined tempo and the musician be constrained to follow the accompaniment unit. This system may be called free running.

In one known system, a master oscillator, the frequency of which can be adjusted, drives a counterchain, which essentially acts to spread spatially the output of the oscillator. The outputs of the counterstages are selected by a matrix, and the outputs of the matrix used to turn on tone sources selectively for different tone patterns. Instruments of this type can be free running, or slaved to another instrument, and if slaved can be fully slaved, as to beginnings and terminations of measures, or can be slaved only as to measure initiations and free running otherwise.

In order to provide a practical system of the type briefly described in the last preceding paragraph, it is necessary to have an oscillator which provides a pulse for every time position for which a tone may be desired, and a corresponding number of counter stages and matrix crossovers. The system is therefore complex and costly, for the reason that a very large number of stages is required in a sophisticated instrument.

In accordance with the present invention, monostable stages are cascaded, and operated asynchronously, to provide spatially distributed pulses. It is feasible to modify delay time per stage independently, or delay time of all stages simultaneously, to provide the possibility of generating an infinite number of tone patterns with a small number of stages.

A wide variety of patterns can be achieved by means of a relatively small number of stages, and each stage need only involve one transistor. The chain may be a closed ring, for a free running system, or an open chain for a semiautomatic or automatic system. Multiple pulses may traverse the chain, so long as they are adequately spaced, i.e. are separated by at least one stage, and feedback and feedforward expedients may be employed, as well as playing of diverse patterns for alternate measures. The system is of extreme flexibility, yet can be achieved at relatively low cost.

SUMMARY OF THE INVENTION

A system for generating a wide variety of complex accompaniment tone patterns, by means of a chain of cascaded stages which have adjustable delays therebetween. The chain may be open or closed, automatically synchronized with playing of an accompanied instrument or free running, and controls, by means of a matrix, a plurality of diverse tone sources in any desired groupings, within a pattern.

BRIEF DESCRIPTION OF THE DRAWINGS

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

FIG. 2 is a schematic circuit diagram of the basic pattern generator of FIG. 1.

FIG. 3 is a chart providing illustrative delay times of the basic pattern generator of FIG. 2, for various tempos.

FIG. 4 is a schematic circuit diagram of rhythm pattern selector switches of FIG. 1.

FIG. 5 is a schematic circuit diagram of capacitive matrices of FIG. 1.

FIG. 6 is a schematic circuit diagram of trigger amplifiers A and A₁ of FIG. 1, coupled to a base drum tone generator.

FIG. 7 is a schematic circuit diagram of trigger amplifiers B and B₁ of FIG. 1.

FIG. 8 is a schematic circuit diagram of a flip-flop 20 of FIG. 1.

FIG. 9 is a circuit diagram of a brush tone generator.

FIG. 10 is a chart of the tone patterns and colors available in the system of FIG. 1.

FIG. 11 is a circuit diagram of a clave tone generator.

FIG. 12 is a circuit diagram of a congo drum tone generator.

FIGS. 13-22 are functional block diagrams of modifications of the basic pattern generator of FIGS. 1 and 2.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. 1, 10 is a basic multishape pattern generator of the asynchronous type, having facilities for modifying time delay between stages, and having also means 11 for varying a common parameter of all the stages in the same sense and ratio, to produce a tempo change without a pattern change. The counter may be a ring, i.e., may close on itself, or it may be an open chain. It may operate to initiate a pattern in response to closure of a control switch, or actuation of an organ pedal, or it may be free running. The common parameter controls tempo, and the interstage delay times determine rhythmic pattern. If delay time is increased at one point of the chain, it must be correspondingly decreased at another point, if tempo is to remain the same.

The rhythm selector switches 12 operate to select a rhythm by selecting certain output stages of the pattern generator 10 and ignoring others. The pattern generator 10 has delays, in the preferred embodiment. This is quite adequate for equating one cycle of the generator with one measure of 4/4 time by collecting alternate pulses, having all equal delays. If the same generator is to be used for 3/4 time, the delays may be suitably modified, and only three of these taken off, per cycle. The selector switches 12 then abstract from an extensive pattern, made available by generator 10, and comprising, for example, nine pulses, the times between adjacent ones of which are subject to control, into another pattern, usually of reduced number of pulses, and representing the pattern which is to be heard. But the latter pattern may not involve suitable delays, i.e. if the waltz button 13 is actuated, this may call for pulses from outputs 0, 3, 6, of generator 10. Leads 14 represent the insertion of voltages or resistances into the generator 10 which change interstage times appropriately to provide 3/4 pattern at outputs 0, 3, 6. The pattern selector switch 12, then, selects output stages, at leads 15 of the pattern generator 10, and also selects interstage time delays, such that a desired input pattern is achieved. Each input position of the pattern selector 12 leads to two or more output leads, as at 16, 17, which carry duplicate pulses. The leads 16, 17 proceed to a capacitive matrix 18, which applies many input pulses to relatively few utilization devices.

In FIG. 1, it is assumed that there are five percussive voice sources, A-E. These may be drum, clave, etc. Each of these is turned on by an applied pulse. The pulses proceed to the voice sources via either of two channels, represented by a primed and an unprimed trigger amplifier, as A, A', B, B', etc. These are selected by a flip-flop 20, which changes state in response to each completion of a cycle of pattern generator 10, so that the pattern changes for alternate measures.

In operation, a tempo is set into the system, in terms of a control voltage V_T, which simultaneously adjusts all the delays of basic pattern generator 10 in the same ratio. A rhythm is selected by pressing a selected one of pushbuttons 13, which not only selects a set of output leads 16, 17, but also feeds appropriate individual delay variations via leads 14 into basic pattern generator 10, so that a desired temporal pattern in the selected tempo will be achieved. This pattern is spatially dis-

tributed over leads 16, 17, some of which carry duplicate pulses. Assume that leads 16 do so, and also that leads 17 do so. The capacitor matrix 18 distributes the sequence of pulses to voice sources. For example, one lead 16 may proceed to lead 19 and another lead 16 to lead 20. One lead 17 may proceed to lead 21, another to lead 22, another lead 23. We assume that each of these leads will receive a pulse, on each run of a pattern. But these leads proceed sometimes to a primed trigger amplifier, as at A', and sometimes to an unprimed trigger amplifier, as A. The primed and unprimed trigger amplifiers are selectively rendered operative on alternate pattern runs, by flip-flop 20. It follows that on a first run amplifier A will energize voice A, and amplifier B, voice B, but that on a succeeding run amplifier A', will trigger voice A, amplifier B', voice B and amplifier C', voice C. For 3/4 time only voice A may sound, for both pattern runs, if desired, or voice A may sound for one pattern and voice B for the alternate patterns. Or, all patterns may be duplicate; or, for a 3/4 pattern, we may hear the sequence of voices A, B, C, D, E, A. Any desired sequence may be programmed into the system in terms of the wiring of capacitor matrix 18. At some increase of complexity, selective manual switching to voices A—E may also be employed, if extreme flexibility is desired.

In FIG. 2 is illustrated a simple form of asynchronous basic pattern generator chain, having provision for adjustable interstage delay and for adjustable overall delay, or tempo.

Each stage of the chain employs an NPN transistor T₁, T₂ etc., having a grounded emitter and a resistive collector load R. The base of T₁ is connected to a common lead 25, carrying a voltage +V_T, which normally maintains the transistors fully conductive. A steering diode D₁ leads from the collector of T₁ to an output terminal 26, labeled 0 to represent 0 time. The anode of D₁ is connected to the positive supply lead 27 via a 1M resistance 28. The output terminal 26 is normally at or near ground potential, when T₁ is conductive. On arrival of a negative pulse at the base of T₁, via coupling capacitor C₁, T₁ cuts off, causing the voltage of 26 to rise to the voltage of line 27, i.e. to about 16.v. At the same time, lead 29, connected to a point of load resistance R, rises in voltage. If V_T is suitably selected, the capacitor C₂ becomes charged, say, so that its right-hand plate, as seen in FIG. 2, is more negative than its left-hand plate. It follows that as soon as T₁ resaturates, on termination of the negative pulse applied to its base, the voltage of the left-hand plate decreases, by about 8.v. This forces the voltage of the right-hand plate to decrease by the same amount, instantaneously, because the voltage of a capacitor cannot, when it is in series with a charging resistance, change instantaneously. If the voltage on lead 29 drops sufficiently the base of T₂ will go momentarily negative and cut off T₂. C₂ will then charge via R₂, until T₂ again saturates. The time required for this to occur is determined by adjusting the value of V_T, or by paralleling the resistance R₂ with another resistance, as R₃, connected to a voltage source also labeled V_T.

The operation described in respect to T₁ and T₂ applies for a chain as long as desired, and the chain of FIG. 2 extends to T₃, T₄—T₈, inclusive, provide output pulses at times 0, 1, 2—7, while T₉ supplies signal to flip-flop 20, causing it to change state. Each base is permanently connected to V_T via a resistance, and is also provided with an optional resistance R₃. V_T is adjustable, and the R₃ resistances may be connected in circuit 2 or omitted, at will, to vary tempo and pattern, respectively.

In FIG. 3 is illustrated a pattern of time delays which may be employed in the present system. It is assumed that switch S is opened to start a cycle. Switch S normally maintains the base of T₉ grounded, and when opened permits that base to rise in voltage, producing a negative going pulse at lead 30, which transiently cuts off T₁. T₁ recovers after a time delay TD₀, to provide a negative pulse at terminal 0, at time 0. It will be noted that the delay is 125, where a full measure is 1,000, for all tempos except rhumba, for which it is 83. This implies that R₄ is out of circuit except when a rhumba tempo is desired. Alternate tempos are waltz, march, fox trot, dixieland, tango,

cha-cha. Delays are set up as in the table of FIG. 3, for the terminals 0—7 inclusive, with delay TD₀ bringing the system back to zero time. Taking the columns of FIG. 3 from left to right, the first column, labeled TD₀ to represent delays at the input of T₁; TD₁ delay at the input of T₂, and so on for all eight transistors. The columns labeled 0, 1, 2 etc., represent total elapsed time, at the output terminals 0, 1, 2 etc. Total elapsed time per measure must always be 1,000, on an arbitrary basis, as representing one measure of music. The actual time represented by 1,000 is established by varying V_T, and the time delay per stage is always either 125 or 83, in the present embodiment of the invention. 4/4 time is then established in terms of 125 + 125 = 250 while 3/4 time is established in terms of 125 + 125 + 83 = 333. Other rhythms may be more complex, as cha-cha, but use of only two basic time delays can provide any desired pattern.

The rhythm selector switches are illustrated in FIG. 4, which has been simplified to clarify the disclosure by avoiding drawing of all wiring of the system. Inclusion of all wiring could only serve to obscure.

For each tempo of FIG. 4 are shown eight sets of two terminals each, labeled 50—57, inclusive. These are in the form of squares. Certain of these squares are encircled to show their particular significance, and they are labeled. For example, waltz 0 is labeled A A' B B'. A = Bass Drum, B = Snare Drum, C = Clave, E = Brush Cymbal, F = Conga Drum. An unprimed letter implies the first of two measures and a primed letter implies the second, the measures being in immediate succession.

When a waltz is called for, the pairs of contacts 30, 31 under the heading waltz are connected together and to a common bus 32, which extends under the top row of contact pairs, in FIG. 4. To this bus is applied the 0 time pulses, deriving from the counter of FIG. 2. The particular character of the switching system is accidental, and occurs because of availability of a particular switch, described in detail and illustrated in U.S. Pat. No. 3,253,091, issued to William L. Fritz and assigned to the assignee of this application. Any known switching matrix could have been employed, i.e., a diode matrix. The contact 30 is connected to contacts 33, 35, 36. The contacts 37 are connected together, as are the contacts 38, 39, 40, 41. These contacts are labeled 3 and 6, which represent values of voltage V_T for these time slots in the basic pattern. The contacts 42, 43, 44, 45 are interconnected, and contact 44 is labeled EE'. The contacts 47, 48, 49, 50 are interconnected and the contact 49 is labeled EE'.

For the waltz only position, time positions 0, 3, 6 are to sound. Position 0 will sound AA', BB'. Positions 3 will sound EE'. Position 6 will sound EE'. Appropriate values of V_T per position are selected for stages 3, 6, 7, and 5, as is required by the chart of FIG. 3, to introduce the appropriate time delays. As a sequence of pulses travels down the terminals 50, 51, 52—57, timing delays, pulse to pulse, of these pulses are appropriate to the waltz, because values of V_T per stage have been appropriately set, to achieve the desired sequence of tones.

Taking 30 as a typical contact, a lead 30_a extends therefrom. This lead extends to a capacitive matrix, FIG. 5, the output terminals of which are 60, 61 for A and A', respectively, and 62, 63 for B and B', respectively. These output terminals are connected to the A and A' terminals of FIG. 6, respectively, and to the B and B' terminals of FIG. 7, respectively. The connection procedure described for the 0 time waltz tone is followed throughout the switching matrix, and the latter is associated with the several capacitive matrices as suggested for the 0 time waltz tone. The output of stage 8 proceeds to a flip-flop, I FIG. 8, which provides two alternate outputs at terminals X and X'. The output pulse is amplified by pulse amplifier 80, and the amplified pulses applied jointly to the collectors of transistors T₁₀, T₁₁, which are cross-connected in a conventional flip-flop or bistable configuration. It follows that a first of two successive input pulses generates a control voltage at X, and a second at X', and that each completion of a pattern effects a transfer.

Referring again to FIG. 6, two gates are provided. These employ normallyton transistors TR_6 and TR_{6a} . To the bases of TR_6 and TR_{6a} are applied the A and A' outputs of the capacitor matrix. The bases of TR_6 , TR_{6a} are connected to ground through capacitors, as 60 and to a positive voltage terminal 61 via a timing resistance, as 62. The capacitors 60 are normally charged, and the transistors TR_6 , TR_{6a} normally conductive. The collectors of TR_6 , TR_{6a} are resistance loaded, by resistances 63 and capacitively coupled jointly to the base of a sustain transistor TR_7 , normally nonconductive, having a grounded emitter and a collector connected in series with the emitter of transistor TR_8 of tone oscillator 64, normally inoperative because TR_8 has no current path.

Taking TR_6 as typical, its collector is normally at ground potential. A negative control pulse is applied to its base, turning the transistor off transiently. After the pulse terminates, capacitor 60 recharges slowly to +16v. The input circuit of TR_6 is a pulse lengthener, but capacitor 60 also has a decoupling effect between stages. Meanwhile, a positive voltage has appeared at the collector of TR_6 and is transiently transferred to the base of TR_7 , turning the latter on. TR_7 has a timing capacitor 66 connected between its collector and ground, with an interposed small resistance 67.

Capacitor 66 is normally charged. On turning TR_7 on, capacitor 66 discharges through TR_7 , which times the turn on of oscillator 64, i.e., of TR_8 . TR_7 then turns off. The oscillator continues to oscillate, as capacitor 66 charges through resistance 68 and TR_8 , but with gradually decreasing amplitude until capacitor 66 becomes fully charged. TR_8 is then cut off because it has no current path.

Oscillator 64 is an RC oscillator, conventional per se, and has a frequency of 100 cps. Timing or sustain is established to simulate the bass drum. As pulses arrive at A, A' at the beginning of each pattern, a drum sound occurs.

It may be objected that TR_6 , TR_{6a} are unnecessarily duplicated, and that the flip-flop of FIG. 8 is not required, for the tone above described. This is true for the particular case. But it is not always true, as it clear from consideration of FIG. 10, a chart of all the tone patterns available. In the case of the cha-cha, for example, A is used at one time and A' at another, that is, they are used in alternate measures at different times. The sounds are the same, but the connections to the switching matrix are not the same, since A is the sound at time 625 and A' at time 500, and these times derive from diverse parts of the matrix.

The clave tone generator of FIG. 11 is essentially the same as the bass drum tone generator of FIG. 6, a difference residing in oscillator frequency, which is 2,100 c.p.s. for clave and 100 c.p.s. for bass drum. A typical congo drum tone generator is illustrated in FIG. 12, for which oscillator frequency is 250 c.p.s. Additional distinctions reside in delay times employed, and these are determined by R_1 , C_2 .

Brush sounds are produced by gating through a noise signal illustrated in FIG. 9. Here TR_9 is the sustain gate, responsive to a control pulse. When TR_9 is turned on, a current path is provided for TR_9 , to the base of which is connected a noise source. The collector of TR_9 is connected to an active pass-band filter employing transistor TR_{10} , peaking at about 10kc. 66 and 68 provides the necessary sustain time constants, as in the case of FIG. 6.

Noise is obtained from noise source NPN transistor TR_4 , (FIG. 7) operated in the Zener breakdown mode, i.e., with its base and collector grounded and its emitter connected to +22.v. via a load resistance. The phenomenon is well known, noise voltage appearing at the emitter. That noise voltage is applied to the base of TR_{12} , and to the base of TR_9 , (FIG. 9) all in parallel. Obviously, each of these instrumentalities might have been provided with a separate noise source. Snare drum sound is obtained by simultaneously gating on a TOM-TOM voice and noise gate TR_{12} , to provide the snare drum voice at terminal 80.

In general, the tone sources employed represent a matter of choice and the specific tone sources employed have been

derived from commercially sold electronic organs, and represent no novelty, but are included for completeness of this disclosure.

The system of FIG. 1 represents a basic system, which, however, is subject to many variations.

For example, in FIG. 13, is shown a chain of delay stages, TD_1 , TD_2 , TD_3 , TD_4 , four only being included for purposes of simplification, although, as in FIG. 2, nine might be included in a commercial system. A starting pulse can be inserted by opening of switch S_1 , normally closed to break the chain, and a flip-flop FF included at the output of the chain. If now switch S_1 is operated, as by the pedals of an electronic organ, or if S represents a tone responsive semiconductor switch, we have a semiautomatic accompaniment system. If we desire a free-running system, we may open switch S_1 and close switch S_2 , which makes a closed ring out of an open chain. Once a pulse is inserted it will continue to run around the ring until S_2 is opened or switch S_1 is closed. However, the circuit from TD_4 to TD_1 may also be completed via FF, whereupon after two passes through the ring, the ring completion is interrupted at FF.

The system of FIG. 13 is amplified in FIG. 14, by inserting two pulses into the chain, as by means of switches S_1 and S_3 . These will follow each other, either in the open or ring configuration, without mutual interference, provided they are separated by at least one delay stage.

Referring now to FIG. 15, opening of switch S, produces an input control pulse which travels down the stages TD_1 — TD_4 , with predetermined but not necessarily equal interstage delays. The input control pulse is directly employed to transfer the state of a flip-flop FF_1 , so that alternate input control pulses are ineffective in respect to TD_1 . The flip-flop FF_1 drives a frequency divider flip-flop FF_2 , which in turn supplies control pulses to TD_3 via lead L_3 . It is assumed that switches S_4 , S_5 , S_6 are open. S_5 transfers control pulses from the output of TD_2 to the input of FF_1 via line L_5 ; S_4 transfers control pulses from the output of TD_4 to the input of FF_1 , via lines L_4 , L_5 , S_6 when closed transfers control pulses from FF_2 to the input of TD_3 , at half the rate provided by FF_1 .

In operation, with S_4 , S_5 , S_6 open, and assuming that S represents an electronic switch operated in response to onset of pedal tones, or a mechanical switch operated in response to pedal key operation, or manually, only alternate operations of S will start a pulse down the chain, and four pulses will appear on leads L_7 to L_{10} , that is, FF_1 interdicts one pulse and passes the next.

However, with switch S_6 closed, the pulse which FF_1 interdicts is passed FF_2 , which transfers a pulse to TD_3 on alternate interdiction pulses, and provides output pulses from TD_3 and TD_4 in sequence. The sequence of sounds, if S is closed once per measure, is L_1 , L_2 , L_3 , L_4 for the first measure and L_3 , L_4 for the second measure.

If S is actuated twice per measure, a more complex sound pattern is generated. With S_6 open, the first closure of S starts a pulse at L_1 , and the second is inactive. Therefore, a pulse will traverse the chain completely in response to each odd closure, and nothing will happen in response to the even closures. With S_6 closed, each fourth closure will provide a control pulse directly to TD_3 , if one side of FF_2 is used. Assume:

	Sound sequence position			
	1	2	3	4
Closure:				
1.....	L_1	L_2	L_3	L_5
2.....				
3.....	L_1	L_2	L_3	L_4
4.....			L_3	L_4

This represents the useful embodiment.

If now either S_5 or S_6 is closed, or both, the chain becomes a closed ring or a partial closed ring, and feedback takes the

place of closures of S_1 , but the operation otherwise remains unchanged. Feedback via S_5 is equivalent to two pedal actuators per measure, and feedback via S_4 is equivalent to one pedal actuation per measure.

FIGS. 16 and 17 illustrate the feed forward of pulses from an early to a late stage of a chain, via flip-flop FF_s, in the case of FIG. 16, and via a time delay circuit TD in the case of FIG. 17. Again open chains or closed rings may be employed.

FIG. 18 indicates the utilization of two parallel chains, which are operated in alternation. The chains are 100, 101. Assume that on opening of S_1 , FF feeds a pulse to chain 100 but not to chain 101. The pulse travels down chain 100 and on completion switches FF and starts a train down 101. If switch SW₇ is closed, the pulse now resets FF and starts down 100. The result is a closed ring of effectively eight units. If SW₇ is open, the chain 101 is open. If SW₈ is open, successive closures of S are required for each half of the chain. This can be useful if two pedal notes are played per measure, or to provide alternative patterns for successive measures.

FIG. 19 represents a system in which cross coupling of parallel chains occurs at 103, but otherwise is the system of FIG. 18. Either feed-forward or feedback may occur in any chain, via a flip-flop to provide alternate measure variation, directly or via a delay device. See FIGS. 20 and 21.

In FIG. 22 is illustrated a system having two patterns. The flip-flop FF supplies voltage V₇ to either lead 90 or 91. But this voltage is applied to the delay stages via diverse sets of resistances R. These are selected to provide the same tempo, but diverse patterns, on a per measure basis. FF can assure two passes of a pulse for each closure of S, if $S_1,0$ is closed and $S_1,1$ open. But feedback can occur from TD₄ to TD₁ directly, providing a free-running closed ring, with alternate patterns per measure, if $S_1,0$ is open and $S_1,1$ closed.

I claim:

1. In an automatic rhythm system, a stepping circuit comprising:

plural stages, each of said stages having an on state and an off state;

a time delay circuit connected between each of said stages and a succeeding stage of said stepping circuit, each of said stages being responsive via the intervening delay circuit to a change of state of a preceding circuit to change its own state, said stages being responsive to a common control voltage to modify in the same sense and in the same ratio all said delay times;

means for varying said voltage; and

means responsive to selected ones of said changes of state for generating tone signals.

2. The combination according to claim 1, wherein are provided plural tone signal sources; and

a switching matrix selectively interconnecting said stepping circuit and said tone signal sources for selectively interconnecting said stages with said plural tone signal sources.

3. The combination according to claim 2, wherein said plural stages are connected in an open chain.

4. The combination according to claim 2, wherein said plural stages are connected in a closed ring.

5. The combination according to claim 2, wherein is provided means included for varying individually, the delay times of said delay circuits.

6. The combination according to claim 2, wherein said stages are responsive individually to control voltages to modify the delays of said delay circuits.

7. The combination according to claim 5, wherein is included means for modifying the interconnections of said matrix with said plurality of tone sources in response to control signals generated by said stepping circuit flip-flop.

8. The combination according to claim 7, wherein is included means for producing the control signals in timed succession of even and odd measure signals and for enforcing one interconnection of said matrix with said plurality of tone sources in response to the even measure control signals and a

different interconnection of said matrix with said plurality of tone sources in response to the odd measure control signals.

9. An electronic musical instrument for generating continuous repetitive pattern repetitions at a frequency corresponding with the basic tempo of said instrument,

an asynchronous multistage delay circuit having a plurality of two condition cascaded stages arranged for providing a sequence of relatively delayed spatially distributed pulses; means introducing adjustable interstage delay times between said stages,

voltage responsive means for varying said delay times;

a plurality of rhythm tone circuits; and

a matrix interconnecting said delay circuits with said rhythm tone circuits for energizing said rhythm tone circuits selectively according to the conditions of said stages.

10. The combination according to claim 9, wherein said voltage responsive means is operative to vary all said delay times concurrently in the same sense and ratio.

11. The combination according to claim 9, wherein said voltage responsive means is operative to vary said delay times individually.

12. An electronic musical instrument for generating continuous repetitive tone patterns, comprising:

a ring circuit having a plurality of cascaded two condition stages;

variable delay circuits intercoupling said stages;

a plurality of normally inactive rhythmic tone signal sources; and

matrix means for selectively activating said normally inactive rhythmic tone signal sources in response to the conditions of said stages.

13. An electronic musical instrument for generating continuous repetitive patterns, comprising:

a closed ring circuit having a plurality of cascaded two condition stages intercoupled by delay circuits;

means at will for adjusting said delay circuits to provide individual delays providing a range of diverse total delays per completion of a cycle of said ring circuit;

at least one normally inactive tone signal source; and

means responsive to operation of said ring circuit for actuating said normally inactive tone signal source in one of said patterns.

14. The combination according to claim 13, wherein said last means is a switching matrix interconnecting said ring circuit with said at least one inactive tone signal source and having means for varying said pattern by modifying the interconnections of said ring circuit with said at least one tone signal source.

15. The combination according to claim 13, wherein is provided a single source of DC voltage having a range of values, means for adjusting the values of said DC voltage, and means responsive to the adjusted values of said DC voltage for commonly varying said delay times concurrently in the same sense and in the same ratio, whereby said pattern can be maintained while said total delays are varied.

16. An electronic musical instrument for generating repeated patterns of sound, comprising:

a plurality of cascaded two condition stages intercoupled by variable delay circuits;

means for at will adjusting said delay circuits to provide individual delays providing a total delay time over all said stages equal to the total time of one of said patterns;

at least one normally inactive tone signal source; and

means responsive to operation of said stages for actuating said at least one normally inactive tone signal source in said one of said patterns.

17. An electronic musical instrument for generating repetitive patterns of sound, comprising:

a system including a plurality of two state monostable stages;

adjustable delay circuits connecting the individual stages of said circuit in cascade;

means for individually adjusting the delay times of said delay circuits to adjust the temporal character of said patterns;

means for simultaneously adjusting the delay times of all said delay circuits in the same sense and ratio to modify the durations of said patterns;

at least one normally inactive tone signal source; and means responsive to changes of state of preselected ones of said individual stages for activating said tone signal source, wherein said stages each has a normal stable state and transiently changes state from said normal state in response to a control signal, and wherein each of said stages provides said control signal to a succeeding stage of said system via one of said delay circuits.

18. The combination according to claim 17, wherein said delay circuits are voltage responsive delay circuits.

19. The combination according to claim 18, wherein said system is a closed ring of said cascaded stages.

20. The combination according to claim 18, wherein said system is an open chain of said cascaded stages.

21. An electronic musical instrument for generating repetitive patterns of sound, comprising:

a system including a cascaded plurality of two state monostable stages, each of said stages having a stable state and an unstable state attained in response to operation of a transient control signal;

means responsive to attainment of an unstable state of each of said stages for transmitting one of said control signal to a succeeding stage after a predetermined delay time;

means for commonly adjusting said delay times to adjust the total duration of each of said patterns;

at least one normally inactive tone signal source; and means responsive to the states of selected ones of said stages for activating said at least one signal source to provide a pattern of tones.

22. The combination according to claim 21, wherein is further provided means for individually adjusting the delay times of said stages to adjust the character of said patterns.

23. The combination according to claim 22, wherein said delay times are controllable as a function of the values of control voltages.

24. The combination according to claim 23, wherein said system is a closed ring of said cascaded stages.

25. The combination according to claim 24, wherein said system is an open chain of said cascaded stages.

26. In an automatic rhythm system:
plural stages having each a plus state and a minus state, the

plus state being achieved in response to a control pulse and the minus state in response to absence of said control pulse;

a plurality of pulse time delay circuits connecting said stages in cascade, and each arranged to transfer one of said control pulses from a stage to a succeeding stage;

a counter connected in cascade with one of said stages and actuable to count control pulses delivered by said one of said stages; and

means responsive to only predetermined counts fewer than all the counts of said counter for feeding a control pulse to another one of said stages, and tone signal sources responsive to predetermined transitions of said states.

27. The combination according to claim 26, wherein said one of said stages is the last of said cascade, and said another one of said stages is the first of said cascade.

28. The combination according to claim 26, wherein is included means for inserting plural one of said control pulses concurrently into different ones of said stages.

29. The combination according to claim 26, wherein said plural stages include two parallel chains of said stages, wherein said counter is a flip-flop, and wherein said flip-flop has two control pulse output points connected respectively to different ones of said two parallel chains.

30. The combination according to claim 29, wherein said flip-flop has an input terminal and is arranged to change state in response to a control pulse applied to said input terminal, and wherein is provided means for deriving said last named control pulse externally of said chains.

31. The combination according to claim 29, wherein said flip-flop has an input terminal and is arranged to change state in response to a control pulse applied to said input terminal, wherein is provided means for deriving said last named control pulse from at least one of said chains.

32. The combination according to claim 31, wherein said at least one of said chains is both of said chains.

33. The combination according to claim 29, wherein is provided means for transferring one of said control pulses from one of said chains to the other of said chains.

34. The combination according to claim 26, wherein is included means for modifying said time delays in response to each transfer of one of said control pulses to a predetermined one of said stages.

35. The combination according to claim 34, wherein said last named includes a flip-flop arranged to change state in response to said last named transfer.

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