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SEMI-AUTOMATIC RHYTHM ACCOMPANIMENT

Original Filed July 9, 1962

3 Sheets--Sheet 1

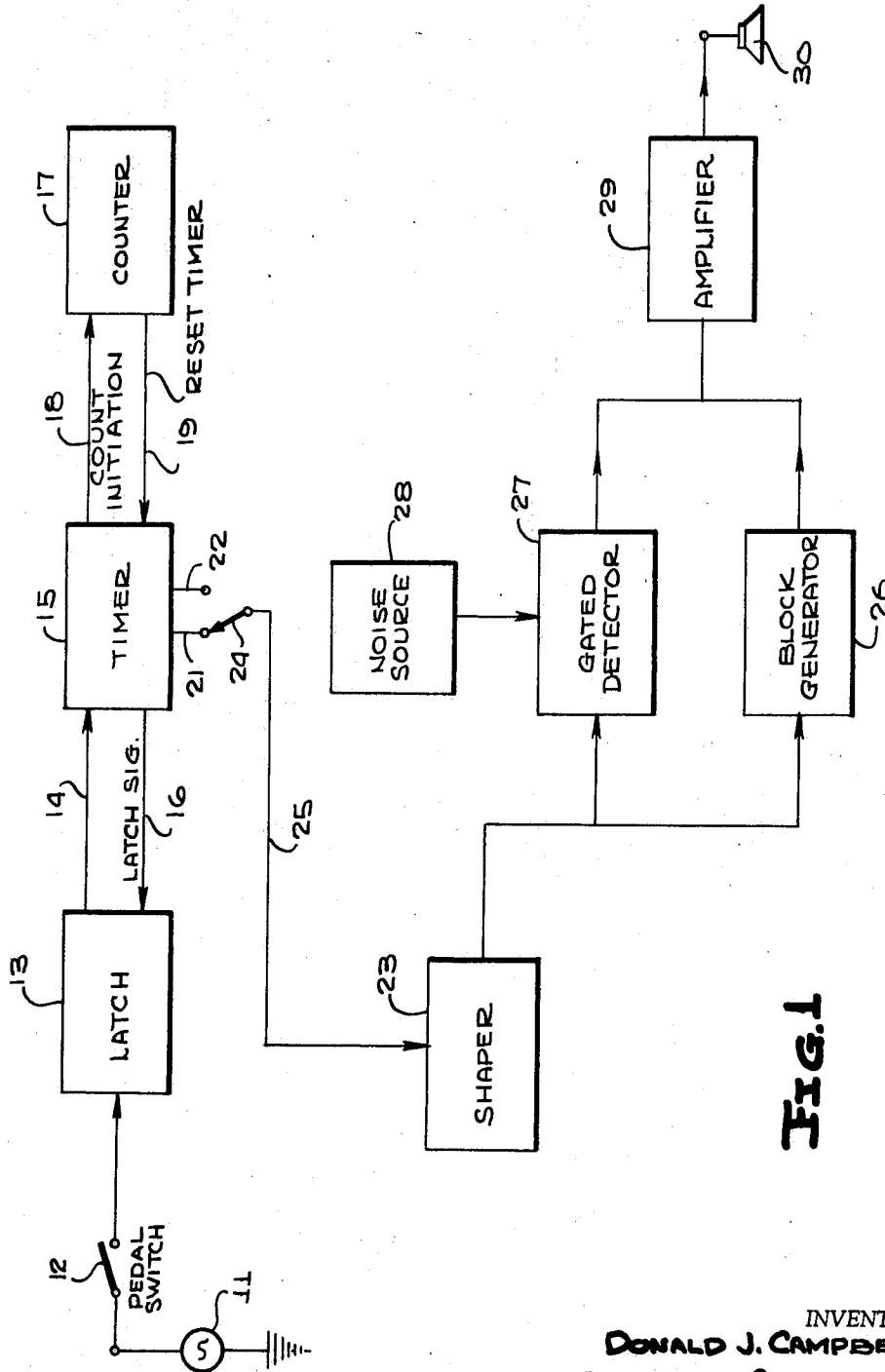


FIG. 1

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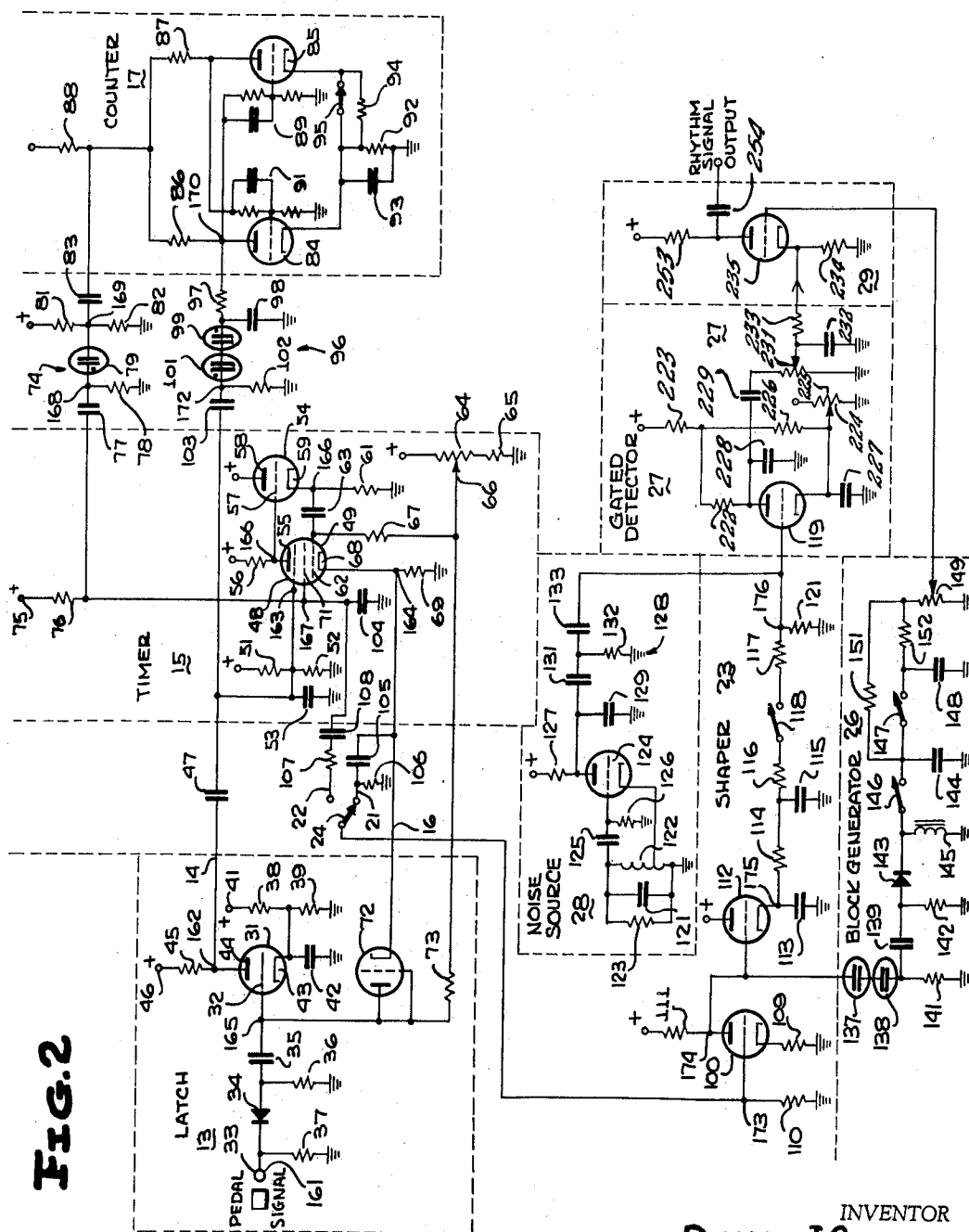
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SEMI-AUTOMATIC RHYTHM ACCOMPANIMENT

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3 Sheets-Sheet 2



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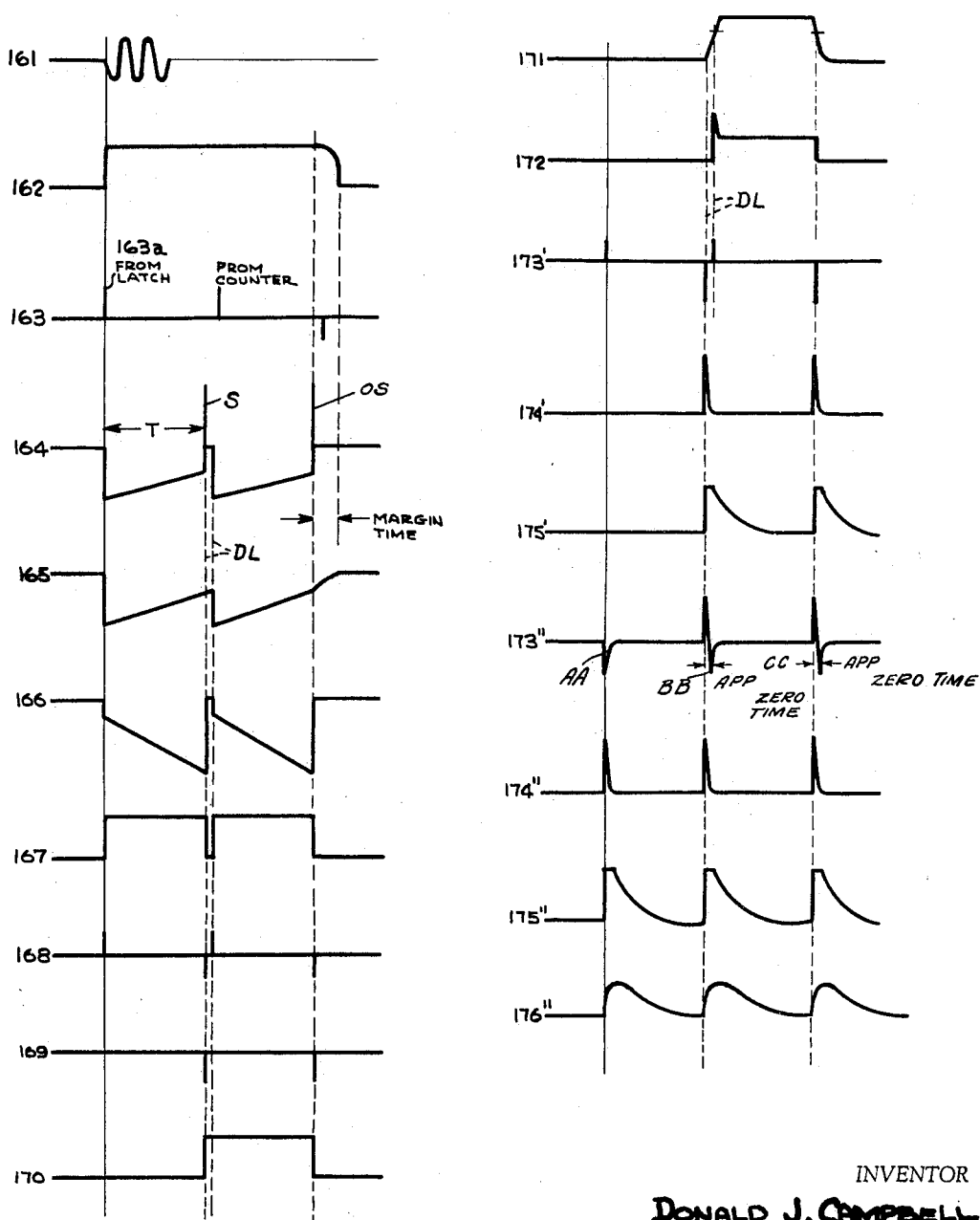
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SEMIAUTOMATIC RHYTHM ACCOMPANIMENT

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3 Sheets-Sheet 3

FIG. 3



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3,493,667

SEMI-AUTOMATIC RHYTHM ACCOMPANIMENT
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Original application July 9, 1962, Ser. No. 208,443, now Patent No. 3,247,309, dated Apr. 19, 1966. Divided and this application Feb. 17, 1966, Ser. No. 550,070

Int. Cl. G10f 1/02

U.S. Cl. 84—1.03

16 Claims

This application is a division of my application Ser. No. 208,443, filed July 9, 1962, and entitled "Semiautomatic Rhythm Accompaniment," now Patent No. 3,247,309, issued Apr. 19, 1966.

The present invention relates generally to a musical instrument for simulating percussive effects and more particularly to a system for supplementing certain notes played rhythmically on a musical instrument by interposing further musical sounds at controlled intervals following each of the notes.

In my co-pending application for U.S. patent I have disclosed a system for interpolating percussive tones in synchronous relation to the pedal notes of an electronic organ. The system includes a computer for measuring a basic time interval between a first pair of pedal notes, establishing a next succeeding basic time interval accordingly, and sub-dividing the latter in accordance with the requirements of a desired rhythm. Control signals are generated at the termination (and/or initiation) of each sub-divided time interval, which are utilized to time interpolated percussive tones. The measurement of each basic time interval is stored, to effect control of the duration of the next succeeding basic time interval. The sub-divided time intervals in the latter are thereby controlled, in each musical measure, from the duration of the immediately preceding musical measure. Because of this characteristic of the system it is denominated "fully automatic."

In the present system, described as semiautomatic, the basic time interval, instead of being the result of a measurement, is set into the system manually. The initiation of each basic time interval is controlled by pedal actuation, but its termination is established by a manual adjustment, in contradistinction to the fully automatic system wherein initiation is controlled as in the semiautomatic system, but termination is automatically established for one measure from the timing of pedal notes in the immediately preceding measure.

In playing the electric organ with percussive accompaniment, the musician always actuates a pedal at the commencement of each musical measure. He may play in 2/4 or 3/4 time. In the former case a desired percussive tone may be an interpolation, for 2/4 time, at the commencement of a measure and an interpolated percussive tone at the half time (second beat) of the measure, or only the latter tone. For 3/4 time, similarly, a percussive tone may be desired at the commencement of each measure and an interpolated percussive tone on the second and third beats of the measure, or only on the latter two beats. It is desirable for the organist to be able to actuate pedals at times other than at the beginning of a measure without interfering with the interpolated tones. A choice of percussive sounds is also desired, i.e. brush, temple block and wood block.

In order that the first pedal note of each measure initiate a cycle of rhythmic interpolation, and that the remaining pedal notes be inoperative for this purpose, a latch is provided. The latch is an amplifier which is gated off during each measure, in response to an initial pedal tone, and which has as its purpose to initiate a cycle of operation

in response to the initial or on-beat pedal signal and to render ineffective any subsequent pedal notes played during the measure.

The first negative alternation of a pedal note signal passes through a diode, poled to apply negative control voltage to the grid of a latch amplifier. The plate of the amplifier is pulsed positive when its grid goes negative, and the positive pulse is conveyed to a grid of a phantastron, causing the cathode of the phantastron to go negative. The negative potential on the cathode charges a large capacitor through a diode, and the potential on the capacitor holds the grid of the latch amplifier negative to cut-off. The latch amplifier remains cut off until after the phantastron cathode goes positive, at the end of its cycle of operations, at which time the capacitor discharges through a large resistance. The latch amplifier does not become conductive and sensitive to further pedal note signals until the capacitor has discharged. Discharge time provides margin time to allow the organist to play pedal notes on the last after beat. Margin time is caused to increase with decreasing tempo, by associating the discharge circuit of the capacitor with a tempo control resistance.

The phantastron is conventional, of the cathode coupled type, whose time of operation is the time between beats, i.e. the reciprocal of tempo. Positive pulses from the latch applied to the suppressor grid of the phantastron tube initiates a phantastron cycle. Negative pulses derived at the end of each phantastron cycle are transmitted to a counter, which has the function of determining the number of after beats in the rhythm pattern. The counter may be an ordinary bi-stable multivibrator circuit with symmetrical input and asymmetrical output. In the case of 2/4 time the counter is disabled, and only one pulse is derived from the phantastron, as an after beat. In the case of 3/4 time the counter is operative to insert two after beat pulses, effecting phantastron cycle for each after beat pulse.

A shaper is employed to convert pulses from the phantastron into waveforms suitable for energizing a gated detector and block generator. A switch associated with the phantastron selects the desired rhythm pattern, i.e. with or without on-beat, by selecting a signal output position in the phantastron circuit. Negative pulses only are selected from the timer, and these are applied to an amplifier tube grid, causing a rise in plate voltage. The latter voltage charges a capacitor which then slowly discharges. The slow discharge provides a sawtooth gating wave form, which is delivered to a gated detector, to which is also supplied noise signal.

The gated detector creates a brushed snare drum sound by shaping the amplitude and spectrum of the noise signal. A block signal generator is also supplied, which may be selectively applied to an output terminal in place of the brushed snare drum signal.

It is, accordingly, an object of the present invention to provide a system for interpolating rhythmic beats at predetermined points in a musical selection, wherein said interpolation is controlled semiautomatically.

It is another object of the present invention to provide a system for semiautomatically adding rhythmic accompaniment to instrumental music in timed relation to the music.

Still another object of the present invention is to provide a system for semiautomatically adding rhythmic accompaniment to electronic organ music, controlling the initiation of each cycle of accompaniment in response to pedal tones of the organ.

It is a further object of the present invention to provide a novel system for generating percussive tones for use particularly in electronic organs.

Still another object of the present invention is to provide a system for generating sounds simulating a brushed snare drum, by use of an ultrasonic noise signal which feeds a detector through a variable impedance, the variable impedance varying in accordance with a predetermined exponential function.

An additional object of the present invention is to provide a novel pulse shaping circuit, utilized particularly in conjunction with a phantastron, for generating output pulses upon the completion of a phantastron cycle of operation.

It is a further object of the present invention to provide a novel wave shaping circuit, responsive to the termination of a phantastron cycle of operation, wherein a bias glow tube is supplied with negative voltage spikes from the screen grid of the phantastron tube.

The above and still further objects, features and advantages of the present invention will become apparent upon consideration of the following detailed description of one specific embodiment thereof, especially when taken in conjunction with the accompanying drawings, wherein:

FIGURE 1 is a block diagram of a rhythmic interpolator according to the present invention;

FIGURE 2 is the circuit diagram of a preferred embodiment of FIGURE 1; and

FIGURE 3 illustrates wave forms arising in the circuit of FIGURE 2.

Reference is now made to FIGURE 1 of the drawings, which discloses a source 11 of oscillations, coupled through an electronic organ pedal switch 12 to a latch circuit 13. When pedal 12 is closed, the first oscillation causes latch circuit 13 to supply a signal via 14 to manually controlled timer circuit 15. In response to the signal on lead 14, timer 15 initiates a sawtooth signal having a duration dependent upon a control setting. A blocking signal is fed back from timer 15 to latch 13, via lead 16, for the duration of the timing signal to prevent the further actuation by signals from source 11.

Upon the completion of the time interval for which timer 15 has been preset, a signal is transmitted to counter 17 via lead 18, from timer 15. The signal on lead 18 causes counter 17 to switch states. This results in the application of a control signal to timer 15 via lead 19 from counter 17, which re-instigates the timing cycle of timer 15. When the timer cycle is re-instigated, latch 13 is again blocked via lead 16, and cannot respond to closure of pedal switch 12. When timer 15 has completed its cycle in response to the signal applied to it via lead 19, a further pulse is applied to counter circuit 17 via lead 18. This further pulse resets counter circuit 17 to its original state. Accordingly, timer 15 is cycled through two predetermined time period cycles in response to closure of switch 12. For 2/4 tempo, counter 17 is disabled and generates no output pulses in response to transitions in the timer cycle, whereby the timer goes through only one cycle in response to a closure of switch 12.

The duration of each of the cycles is determined manually in accordance with a manually controlled tempo setting. The tempo setting may cause beats to be produced at a rate of between 60 to 300 per minute. In response to the initiation and end of each timing cycle, a pulse is generated on lead 21, while pulses are derived on lead 22 only in response to the end of each timing cycle.

The signals on leads 21 and 22 are selectively applied to shaper 23 via switch 24 and lead 25. Shaper 23 transforms the sharp pulses on lead 25 into slowly decaying wave forms, which have decayed completely in a time period equal to the periodicity of timer 15. The output of shaper 23 is applied in parallel to block generator 26 and gated detector 27. Block generator 26 supplies, in response to the leading edge of the output from shaper 23, a shock excited, highly damped sinusoidal wave. The frequency of the wave derived from block generator 26 is commensurate with that produced by a temple or wood block. Detector 27, in addition to being supplied with the damped exponen-

tial output of shaper 23, is response to a noise source 28. Shaper 23 controls the detection of the noise provided by noise source 28 as it is fed through detector 27. The noise components, which include wide band audio-frequency amplitude and frequency modulated noise, when amplitude modulated by the exponential wave of shaper 23, and detector by detector 27, approximate the spectrum and wave envelope of a brushed snare drum. The output of block generator 26 together with the output of gated detector 27, is applied to amplifier 29, which drives a suitable power amplifier in the instrument.

Reference is now made to FIGURE 2 of the drawings, wherein is illustrated a circuit diagram of a preferred form of the system of FIGURE 1. Latch circuit 13 includes a first triode 31 having its grid electrode 32 responsive to the negative input signal applied to input terminal 33 via diode 34 and bias capacitor 35. The junction between the anode of diode 34 and one plate of capacitor 35 is coupled to load resistor 36, for diode 34. The junction between input terminal 33 and the cathode of diode 34 is connected to signal load resistor 37 at one of its terminals, the other terminal of resistor 37 being connected to ground. Tube 31 is normally maintained in the conducting state by the cathode biasing circuit, which includes resistors 38 and 39 connected in series as a voltage divider for positive DC potential connected to terminal 41. The junction between resistors 38 and 39 is connected to bypass capacitor 42 and the cathode 43 of triode 31. The plate 44 of triode 31 is connected through plate load resistor 45 to B+ terminal 46.

The output signal of the triode 31 is coupled via blocking capacitor 47 to the suppressor grid 48 of pentode 49, connected in a phantastron configuration. Suppressor grid 48 is normally maintained at cutoff by a biasing circuit which includes voltage dividing resistors 51 and 52, which are connected between ground and a positive source of DC biasing voltage. Connected in parallel with resistor 52 and to the suppressor grid 48 is capacitor 53, which maintains the proper suppressor bias and prevents the application of excess currents to the suppressor.

Pentode 49 is the essential element of a phantastron circuit, which includes cathode follower circuit 54. Plate 55 of pentode 49, in addition to being connected to the B+ source via plate load resistor 56, is connected to the grid 57 of cathode follower triode 54. Anode 58 of triode 54 is connected directly to a source of B+. Cathode electrode 59 is connected to load resistor 61 and to the control grid 62 of pentode 49 via integrating capacitor 63.

Control grid 62 is normally maintained above cutoff by the biasing potentiometer 64, which is series connected to voltage limiting resistor 65. One end of potentiometer 64 is connected to a positive voltage terminal so that the slider 66 thereof couples a positive DC voltage to the control grid 62 via current limiting resistor 67 which is connected to the slider 66. Cathode 68 of pentode 49 is connected to ground by a cathode load resistor 69. When the suppressor grid 48 of tube 49 is maintained at cut-off, a current path exists between cathode 68 and control grid 62 and screen grid 71. This current is of appreciable value so that when the phantastron plate current is cut off there is a positive DC voltage across resistor 69.

The voltage across resistor 69 is coupled to the grid 32 of triode 31 via diode 72. Cathode resistor 69 is connected to the cathode of diode 72, the anode thereof being connected to the junction between capacitor 35 and grid 32. Slider 66 of potentiometer 64 normally couples a positive DC biasing voltage to the control grid 32 via a large current limiting resistor 73.

The timer circuit 15, including pentode 49 and triode 54, is connected as a normal phantastron circuit, the triode being included to insure rapid flyback after bottoming has occurred in pentode 49.

The negative output derived at the screen grid 71 of pentode 49 at the end of each timer cycle is applied to a shaping circuit 74. The screen grid 71 is maintained at a

positive bias by the DC voltage connected to terminal 75 and screen load resistor 76.

Clipping circuit 74 includes a differentiator comprising capacitor 77 and resistor 78, the former being connected directly to the screen grid and the latter to ground. The junction between capacitor 77 and resistor 78 is connected to one terminal of neon glow tube 79, the other terminal of which is connected to a biasing circuit which includes voltage divider resistors 81 and 82. Voltage divider resistors 81 and 82 are connected in series between a positive voltage source which is of insufficient voltage to ignite tube 79.

The clipping circuit output is coupled to the input of counter 17 via coupling capacitor 83. Counter 17 comprises a standard plate fed flip-flop or frequency dividing circuit. Flip-flop 17 includes a set of dual triodes 84 and 85 which have their plate resistors 86 and 87 connected to capacitor 83 and a common load resistance 88 which is DC coupled to a source of B+. Counter 17 is a standard bistable multivibrator circuit including cross-coupling circuits 89 and 91 connected between the anodes and grids of the respective tubes.

A cathode biasing circuit for tubes 84 and 85 is provided so that tube 84 is normally maintained in the conducting state. The biasing circuit includes the parallel combination of resistor 92 and capacitor 93, connected between the cathodes of tubes 84 and 85 and ground and resistor 94, the latter being shunted by switch 95.

When the circuit of the present invention is utilized for 3/4 time, switch 95 is closed so that normal flip-flop operation occurs. For 2/4 time, switch 95 is open to disable the counter. Disabling occurs because of the high value of resistor 94 compared to resistor 92.

The output of counter 17 is derived from the plate of triode 84 and applied to delay circuit 96. Delay circuit 96 includes an integrating circuit consisting of resistor 97, connected to the counter output, and capacitor 98. A pair of neon glow tubes 99 and 101 are series connected between the integrator output and the input to a differentiator which includes resistor 102 and capacitor 103. The output of delay circuit 96 taken across the differentiator is applied to the suppressor grid 48, of the phantastron pentode.

The output of phantastron tube 49 is selectively derived across the cathode load resistor 69 or the screen grid shunting capacitor 104 by control of switch 24. Cathode load resistor 69 is connected to one contact of switch 24 and lead 21 by way of a differentiating circuit which include capacitor 105 and resistor 106, the latter being connected to ground. The screen grid output is obtained by positioning switch 24 so that it contacts resistor 107 which is series connected to screen grid 71 by way of capacitor 108. With switch 24 engaging lead 21 and cathode 68, an output pulse is derived from the timer circuit in response to the initial application of a signal to terminal 33 and the occurrence of the trailing edge of the waves generated by the timer. In contrast, no signal is derived from lead 22 when an input is applied initially to terminal 33, an output being derived at lead 22 only in response to the termination of timing waves.

The signal at switch 24 is applied to the control grid of triode 100 which is included in shaper 23. The control grid is connected to a grid leak resistor 110, the other end of which is connected to ground. Connected to the cathode of triode 100 is a cathode biasing resistor 109. Connected to the anode of this tube is plate load resistor 111 which is coupled to the triode source of B+.

The output at the plate of triode 100 is DC coupled to the grid of cathode follower triode 112. The anode of triode 112 is connected to B+ and the cathode thereof is connected to a shaping circuit which is essentially a low pass filter. The shaping or filter circuit includes capacitor 113, connected between the cathode of tube 112 and ground, resistor 114, and shunting capacitor 115. The shaping circuit output is coupled via a pair of current

limiting and voltage attenuating resistors 116 and 117 and brush control switch 118 to the control grid of tube 119, included in gated detector 27. The input signal for triode 119 is generated across grid leak resistor 121 which is responsive to the output of the shaper and noise source 28.

Noise source 28 includes a conventional Hartley oscillator, having a resonant frequency of about 500 kc. The oscillator includes a tank circuit including capacitor 121 connected in parallel with tapped inductance 122 and resistor 123. The tap of inductor 122 is connected to the cathode of triode 124, the grid of which is connected to one end of coil 122 via a quenching circuit which includes capacitor 125 and resistor 126. Capacitor 125 is series connected between one end of inductance 122 and the control grid of triode 124 while the resistance 126 is connected between the control grid and ground. The output of the Hartley oscillator is derived at its plate which is connected to a B+ source via load resistance 127.

The oscillations at the anode of triode 124 have three separate components, a high amplitude 25 kc. sawtooth wave which is amplitude and frequency modulated with wide band audio noise; the 500 kc. oscillations set up by the Hartley oscillator and a low amplitude wide band thermal and tube noise signal. The 25 kc. sawtooth oscillations are established by the quench circuit, including resistor 126 and capacitor 125, which alternately gates tube 124 on and off in a known manner similar to super-regenerative oscillator operation.

The output of tube 124 is applied to the control grid of triode 119 via a band pass filter 128. Filter 128 includes an RF bypass capacitor 129 which is directly connected in shunt with the anode of triode 124 and a high pass filter which includes a pair of cascaded capacitance resistance sections. The first section includes capacitor 131, directly connected to the anode of tube 124 and resistor 132, connected to the other side of capacitor 131 and ground. The second section of the cascaded filter includes capacitor 133 which is connected between resistor 132 and the grid of tube 119 and resistance 121.

Thus, the outputs of shaper 23 and noise source 28 are combined in gated detector 27. The amplitude of the signal applied to the gated detector 27 from shaper 23 varies the impedance of triode 119 to effect a variable detection of the noise source output.

The plate of detector 119 is connected to B+ source via series connected resistances 122 and 123 the junction of which is connected to the slider 124 of potentiometer 125 via dropping resistor 126. Triode 119 is normally maintained at cutoff by the cathode biasing circuit including capacitor 127 which is connected to slider 124, since one end of potentiometer 125 is connected to a positive voltage source. Connected in shunt with the anode of triode 119 is detecting capacitor 128 and a shaping circuit which includes the series combination of capacitor 129 and potentiometer 131.

The slider of potentiometer 131 is connected to a control circuit which includes capacitor 132 and resistance 133 which is coupled to the cathode input resistor 134 of triode 135 which serves as the output amplifier of the rhythmic interpolator circuit. The grid of triode 135 is supplied with signals from block generator circuit 26 which is also fed by the output of triode 100.

The plate output of tube 100 is coupled through a pair of series connected neon glow tubes 137 and 138 to a shaping circuit which includes capacitor 139 and resistors 141 and 142. The shaping circuit output is applied to a highly damped shock excited generator by diode 143.

The shock excited generator includes the parallel combination of capacitor 144 and coil 145 which are tuned to a suitable frequency for simulating the tone of a wood block being struck with a drum stick. Connected between coil 145 and capacitor 144 is switch 146 which is closed when it is desired to simulate the block sound.

A further switch 147 is connected to capacitor 144 so that capacitor 148 is selectively connected in parallel with

the capacitor 144. When switch 147 is closed and capacitor 148 is connected in parallel with capacitor 144 the resonant frequency of the shock excited circuit is decreased so that tones simulating a temple block are simulated. Closure of switch 147 also results in an amplitude compensation of the shock excited oscillations which are applied across potentiometer 149 by resistor 151 when switch 147 is open. Resistor 152, having a smaller value than resistance 151, couples the shock excited wave to the potentiometer with switch 147 closed. The selection of resistors 151 and 152 is dependent upon the decrease in amplitude of the shock excited wave when capacitor 148 is included in the circuit.

The output of block generator 26, obtained at the slider of potentiometer 149, is coupled to the control grid of triode 135. If switch 118 is closed at the same time switch 146 is closed, the audio frequency signals applied to the grid and cathode of triode 135 are combined in a linear manner in a manner quite like that of combined brush and block drum beat. The oscillations applied to triode 135 are amplified in the output circuit which includes plate load resistor 153 which is connected to a suitable source of B+ and decoupling capacitor 154.

Reference is now made to FIGURES 2 and 3 for a description of the manner in which the circuit of the present invention functions. Initially the musician operating the instrument sets the various controls to the desired states. Switch 95 is open if it is desired to have a drum beat for 2/4 time music while it remains in its closed position for 3/4 time.

Potentiometer slider 66 of potentiometer 64 is rotated to the appropriate tempo at which the music is to be played. For fast tempo when the phantastron timing period must be maintained at a short duration, slider 66 is positioned so that a large positive voltage is applied to the grid 62 of pentode 49 so that bottoming of the phantastron cycle will occur fairly soon after initial suppressor activation. For slower tempos, slider 66 is moved towards the lower end of potentiometer 64 and the period of the phantastron is increased.

If it is desired to produce a percussion sound with the initial closure of the pedal switch, switch 24 is coupled to lead 21 so that an output is derived across the cathode load resistor 69 of pentode 49. If to the contrary, no percussion sound is desired at initial pedal activation, termed no on-beat, switch 24 is rotated to engage lead 22 and an output is derived from the screen grid of pentode 49.

For brush simulated sounds, switch 118 is closed so triode 119 may be periodically rendered in a conductive state by the output of shaper 23. To provide drum beats similar to a wood block, switch 146 only is closed while both switches 146 and 147 are closed for simulation of a temple block sound. To control the volume of the sounds which are derived from the unit, the sliders of potentiometers 131 and 149 are rotated to an appropriate position for the desired loudness of the brush and block sounds, respectively.

Upon closure of the pedal switch which generally occurs at least once every measure in popular or jazz music, wave form 161, FIGURE 3, is applied to the cathode of diode 34. In response to a negative excursion of wave form 161, a negative voltage is applied through diode 34 to grid 32 of tube 31, causing plate 44 of tube 31 to go positive.

The sudden increase of plate voltage of tube 31 is applied through capacitor 47 as pulse 163a, wave form 163, to the suppressor grid 48 of pentode 49. This results in a sudden flow of plate current in pentode 49 with a corresponding sudden decrease at the grid 62 because of the voltage drop through capacitor 63. The voltage drop at grid 62 results in a decrease in the cathode current and a correspondingly negative swing across cathode load resistance 69, as indicated by wave form 164.

The negative swing across cathode load resistance 69 is applied through diode 72 to charge capacitor 35. The

grid 32 of triode 31 is held negative by the charge on capacitor 35 to latch the triode into a cutoff state, so that further application of wave forms 161 to terminal 33 does not effect tube 31. The negative voltage applied through diode 72 is stored in capacitor 35 to positively prevent the positive sinusoidal swing of wave form 161 from reaching the grid of triode 31.

In accordance with the well-known operation of a phantastron circuit, the plate voltage of pentode 49 and the cathode voltage of triode 54 decrease linearly, as indicated in wave form 166. When plate current saturation occurs, and capacitor 63 stops discharging, a sudden regenerative termination of plate current occurs resulting in a sharp increase of plate voltage.

Prior to the occurrence of pulse 163a on suppressor grid 48 of pentode 49, considerable current flows through screen grid 71 causing the screen to be maintained at a relatively low potential. Upon the occurrence of pulse 163a and the ensuing flow of plate current in pentode 49, the screen current decreases suddenly causing an increase screen voltage, as indicated by wave form 167. In response to plate current cutoff in pentode 49, the screen grid voltage suddenly decreases to its former value.

The positive and negative going wave forms derived at the screen grid 71 are applied to differentiator circuit which includes capacitor 77 and resistor 78. The differentiator output consists of positive and negative going spikes, as indicated by wave form 168. The positive going spike has no effect on neon glow tube 79 and accordingly is not passed to the voltage divider which includes resistors 181 and 182. However, the negative going spike in wave form 168 instantaneously fires neon glow tube 79. Thereby a negative spike, as indicated by wave form 169, is derived at the junction between resistors 81 and 82 in response to cutoff of plate current in pentode 49.

The negative going pulse, indicated by wave form 169, is applied to the flip-flop or counter stage 17 which includes tubes 84 and 85. Tube 84, normally maintained in the conducting state, is cutoff in response to the negative pulse, thus rendering tube 85 conductive. In response to cut-off of tube 84, a sudden increase of its plate voltage occurs, as indicated by wave form 170.

The step voltage derived from the plate of triode 84, is applied to an integrating circuit which includes resistor 97 and capacitor 98. The integrator smoothes the sudden plate voltage increase so that wave form 171 is applied to series connected neon glow tubes 99 and 101. Accordingly, glow tubes 99 and 101 do not fire until a predetermined time interval after the occurrence of a negative going spike in wave form 169.

When the voltage across integrator capacitor 98 has reached the necessary level to fire neon glow tubes 99 and 101, a positive pulse is derived at the junction between resistor 102 and capacitor 103, as indicated by wave form 172. The sudden increase in voltage at the junction between resistor 102 and capacitor 103 results in the application of another positive pulse to the suppressor grid 48 of pentode 49. This reinitiates the cycle which has just previously been completed so that triode 31 is again cut off and a positive voltage is applied to the differentiator which consists of capacitors 77 and resistors 78. It will be seen that the inclusion of the delay circuit 96 is necessary to insure a sufficient time delay between the cutoff of pentode 49 and the beginning of a second cycle.

When phantastron plate current ceases to flow during the second timing cycle, another negative voltage is applied to the plates of triodes 84 and 85 of counter 17 so that triode 84 is rendered conductive. Thereby, the plate voltage wave form 170 decreases to its former value and gas tubes 101 and 99 are extinguished. This results in a sudden decrease in voltage to the terminal between capacitor 103 and resistor 102. The negative voltage has no effect on the phantastron operation, however, since the suppressor grid 48 is normally biased to cut-

and means connected to said screen grid for deriving a signal only in response to a sudden decrease in voltage of said screen grid, wherein said means for deriving includes a differentiator connected to said screen grid, and a biased glow tube responsive to the differentiator.

2. In an electrical background musical instrument of the automatic rhythmic type used to accompany an instrument under player control,

a source of variable DC voltage level,
means automatically adjusting said DC voltage level to a value representative of the tempo of said instrument under player control, and

means for regulating the tempo of said musical instrument of the automatic rhythmic type in response to said DC voltage level.

3. The combination according to claim 2 wherein is further provided an alternative source of further DC voltage,

means for manually adjusting the level of said further DC voltage, and

means responsive to said further DC voltage for regulating the tempo of said musical instrument.

4. In an electrical background musical instrument of the automatic rhythmic type,

a source of variable DC voltage level,
means for adjusting said DC voltage level in accordance with a desired tempo of said musical instrument, and

means responsive to said DC voltage level for automatically controlling said tempo in accordance with said DC voltage level as adjusted by said means for adjusting.

5. The combination according to claim 4 wherein said means for adjusting is manually adjustable.

6. The combination according to claim 4 wherein is further provided:

an instrument under player control,
said instrument under player control comprising:

means for generating a series of impulses corresponding to the player's tempo, and
means responsive to said series of impulses for generating said DC voltage level.

7. In an electrical background instrument of the automatic repetitive rhythm type used to accompany an instrument under player control,

electrical means responsive to the player's tempo for establishing a tempo control signal for said background musical instrument, and

means responsive to said control signal means for automatically altering the tempo of the repetitive rhythm instrument in the direction which will reduce the difference between the player's tempo and the tempo of the repetitive rhythm instrument.

8. In an electrical background instrument of the automatic repetitive rhythm type,

a recycling counter,
means including said counter for generating repetitive rhythmic sounds at times corresponding with discrete counts of said counter, and

means for manually adjusting the recycling times of said counter to provide a desired tempo of said electrical background instrument.

9. In an electrical background instrument of the automatic repetitive rhythm type used to accompany an instrument under player control,

a recycling counter,
means including said recycling counter for generating repetitive rhythmic sounds at times corresponding with discrete counts of said counter, and

means for automatically adjusting the cycling times of said counter in response to the tempo of said instrument under player control to attain synchronism of said cycling times and said tempo.

10. In an electronic rhythm instrument having foot operated means for establishing the accented beat and automatic means for generating the unaccented beat, a nor-

mally inactive voltage pulse generating circuit comprising an electron discharge device, a voltage supply source, a switch, manually adjustable time delay means including a capacitor and a resistor serially connected between two terminals of said source, said time delay means coupled to said discharge device and to said switch, means controlled by said foot operated means for actuating said switch for rendering said pulse generating circuit active to generate a first pulse and a delayed pulse.

11. In an electronic rhythm instrument, an amplifier and speaker, a foot operated pedal, a control switch adapted to be operated by said pedal, a normally quiescent pulse circuit including an electron discharge device for generating delayed electrical rhythm pulses, a source of supply voltage coupled to said discharge device to energize said device, manually adjustable time delay means comprising resistance and capacitance coupled to said discharge device and to said source, control circuit means for starting said pulse circuit including said switch, circuit means including a formant circuit interconnecting said pulse circuit and said amplifier for transmitting to said speaker at least one delayed rhythm pulse upon the operation of said pedal.

12. In an electronic rhythm instrument having a pedal keyboard and a control circuit adapted to be operated by any key of said keyboard, means for generating rhythmic voltage pulses comprising a low frequency relaxation oscillator, said oscillator being normally in a quiescent state; a voltage source having terminals coupled to said oscillator, time delay means connected to said oscillator comprising a capacitor and an adjustable resistor serially connected between said terminals, circuit means including said control circuit for holding said oscillator quiescent when said switch is nonoperated and for starting said oscillator upon the operation of any key of said keyboard.

13. In an electronic rhythm instrument for generating automatically timed voltage pulses and having a foot operated pedal for establishing the accented beat, switching means adapted to be controlled by said pedal, a generator of timed voltage pulses comprising an electron conductive device coupled to a capacitance-resistance timing interconnecting said source and said generator for rendering said generator inactive when said switching means is nonoperated and active when said switching means is operated to generate automatic rhythm pulses, and manually selective circuit means intercoupling said generator and said source to select the time interval between the operation of said pedal and the first voltage pulse.

14. In an electric rhythm instrument wherein the downbeat tempo is established by a player operated key and the upbeat tempo is timed automatically, a playing key operated electric control unit, an audio output means, a first circuit interconnecting said control unit and said output means comprising an electrical pulse device for generating and transmitting a downbeat pulse to said output means immediately upon operation of said playing key, and means interconnecting said control unit and said output means comprising a manually adjustable delayed voltage pulse generator for transmitting an automatically timed upbeat pulse to said audio output means following operation of said playing key.

15. In an electric rhythm instrument for producing a player controlled downbeat and a manually controlled time delayed upbeat, a player operated control means, an audio output system, circuit means interconnecting said control means and said output system, said circuit means comprising a pulse generating element for transmitting a downbeat pulse to said audio output system immediately upon operation of said control means, means interconnecting said control means and said audio output system, said last mentioned means comprising a manually adjustable delayed pulse electric generating device for transmitting an automatically time delayed upbeat pulse to

off. The negative voltage only has the effect of further driving grid 48 momentarily beyond cutoff.

Upon completion of the second cycle, the voltage across cathode resistor 69 increases suddenly. This sudden increase in voltage at the cathode of pentode 49 causes diode 72 to cut off, resulting in a subsequent discharge of capacitor 35 through resistor 73, as indicated by wave form 165. Triode 31 is then ready to be reactivated in response to a negative input to terminal 33 to reinitiate the cycle of operation.

With switch 24 engaging lead 22, the wave form 167 at the screen grid 71 of pentode 49 is applied through the shaping network, which includes resistor 107 and capacitor 108, to the grid of triode 100. In response to the positive and negative going wave forms 167, positive and negative going spikes, respectively, are derived, as indicated by wave form 173'. The positive going spikes derived in response to the initiation of a phantastron cycle have no effect on triode 100 since it is normally maintained in a fully conducting state. However the negative going spikes are simplified by the circuitry of triode 100 so that the pulse indicated by wave form 174' are derived at the plate of triode 100. A pulse is derived at the end of each phantastron cycle when switch 24 engages lead 22.

When switch 24 engages lead 21 and the cathode voltage of pentode 49 is applied to the grid of triode 100, a negative spike, as indicated by wave form 173'', is applied to the triode in response to the beginning and completion of each phantastron cycle, the spikes being derived due to the differentiating action of capacitor 105 and resistor 106. These negative spikes result in a pulse being derived at the plate of triode 100 in response to both the initiating pedal switch closure and to the end of each phantastron cycle.

The plate voltage of triode 100 is applied to the grid of triode 112 and the block generator circuit 26. In response to each of the pulses from triode 100, triode 112, operating as a cathode follower, charges capacitor 113 to the supply voltage on the anode of triode 112. Waveform 175'' is generated at the cathode of triode 112 as capacitor 113 is rapidly charged by triode 112 and is slowly discharged through resistors 114, 116, 117, and 121.

Wave form 175'', is attenuated by the voltage divider made up of resistors 114, 116, 117, and 121 and slightly smoothed by relatively small capacitor 115 to produce wave form 176''. This wave form is applied to the grid of normally cutoff triode 119 in the gated detector 27. When the grid voltage achieves a sufficiently high level, tube 119 is rendered conductive thereby passing varying segments of the output of noise source 28. Tube 119 therefore acts as a rectifier to pass only portions of the noise source above varying levels which depend on the amplitude of the shaper output. As described supra, noise source 28 generates an output having three components, the most predominant of which is a 25 kc. sawtooth which is A.M. and F.M. modulated with wide band audio noise. The ultrasonic output of noise source 28 is applied to the grid of triode 119 and its envelope is detected by capacitor 228. The resistance of tube 119 is varied in response to the exponential wave form 176'' so that the driving impedance of detector capacity 128 is amplitude modulated in a preselected manner by wave form 176''. The amplitude modulations from noise source 28 on the ultrasonic carrier, when subjected to the amplitude modulation and variable detection introduced from shaper 23, results in a signal at the output of the detector which closely simulates the sound of a brushed snare drum, because its frequency spectrum and amplitude vary in a desirable manner in response to the gating wave form 176''. The brush signal is applied to the cathode of triode 235 so that an amplified output signal is derived at the plate resistance 253.

In response to positive pulses at the plate of triode 100, neon glow tubes 137 and 138 are fired instantaneously so

that a positive spike is passed through capacitor 139 and diode 143 to the shock excited tank circuit which comprises capacitor 144 and inductance 145. This highly damped shock excited wave simulates the sound of a wood block beat when switch 147 is open. Upon closure of switch 147 capacitor 148 is added in the tank circuit thereby reducing its natural resonance frequency so that a wave corresponding with a temple block beat occurs. This wave is also damped to a great extent due to resistance 152 and potentiometer 149. The damped sinusoidal oscillations applied to the grid of triode 235 are suitably amplified so that a volt age simulating block beat is derived at the system output terminal.

The preceding description of the functioning of the present device was based upon the assumption that switch 95 was closed so that 3/4 time percussion sounds are derived. With 2/4 time, switch 95 is open and no output pulses are derived from counter 17. Accordingly, the second cycle of phantastron operation does not occur and the number of pulses at the plate of triode 100 is reduced by one for each closure of the pedal switch.

Downbeat pulses occur at the beginning of a measure, and upbeat pulses occur internally of a measure. In 2/4 time the upbeat pulse occurs midway of each measure, and in 3/4 time at the 1/3 and 2/3 points of the measure. In the present system only upbeat pulses occur on line 22 and both upbeat and downbeat pulses on line 21.

In a cathode coupled phantastron timing circuit, an overshoot occurs at the cathode. These are illustrated at OS in waveform 164. The separation between dashed lines DL in FIGURE 3 is grossly exaggerated, as are the separation between adjacent positive and negative going pulses in waveform 173''. In fact these times are not draftable on the time scale of the plot and are shown well separated for purpose of clarity.

A satisfactory explanation of the cathode coupled phantastron times is provided at pages 226 and 227 of Pulse Digital Circuits Millman and Taub, published by McGraw-Hill 1956 ed. The present phantastron does not employ a clamping diode, used in the Millman, and Taub circuit for minimizing overshoot, because this overshoot is essential to applicant's system.

The positive spikes OS have negative going portion, i.e. they rise and then fall. The falls are reflected in waveform 173'', as the second and third negative going pulses. In terms of true times, on the time scale of the plotted waveforms, the adjacent positive and negative going pulses should be collinear,

While the negative going pulses in waveform 173'' are all shown to be the same, they in fact are all different, but the differences are of no moment. The first pulse AA is derived from the first cycle of waveform 164. The second pulse BB is derived from the fall of the first overshoot spike OS, and the negative going beginning of the second timing cycle, which are, although shown spaced for clarity, in fact essentially continuous. The third spike CC, is derived solely from the negative going portion of the second overshoot OS.

Triode 100 converts these negative going pulses, which are not truly of the same amplitudes, to equal amplitude positive pulses.

While I have described and illustrated one specific embodiment of my invention, it will be clear that variations of the details of construction which are specifically illustrated and described may be resorted to without departing from the true spirit and scope of the invention as defined in the appended claims.

I claim:

1. A circuit for generating a signal a predetermined time period after the occurrence of an event, indicated by an impulse, comprising a phantastron network responsive to said impulse, said network including a tube having an anode, screen grid and control grid and a capacitor connected in circuit between said anode and control grid,

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said audio output system upon operation of said control means.

16. In an electric rhythm instrument for producing a player controlled downbeat and an automatically time delayed upbeat, a player operated control means, an audio output system, circuit means interconnecting said control means and said output system, said circuit means comprising a pulse generating element for transmitting a downbeat pulse to said audio output system immediately upon operation of said control means followed by an automatically time delayed upbeat pulse, said circuit means comprising a delayed pulse electric generating device for causing transmission of said automatically time delayed upbeat pulse to said audio output system following said operation of said control means, means for manually ad-

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justing the delay time of said automatically time delayed upbeat pulse, and means for at will deleting said downbeat pulse.

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