

July 7, 1964

D. J. CAMPBELL

3,140,336

RHYTHMIC INTERPOLATOR

Filed Aug. 30, 1959

3 Sheets-Sheet 1

FIG. 2

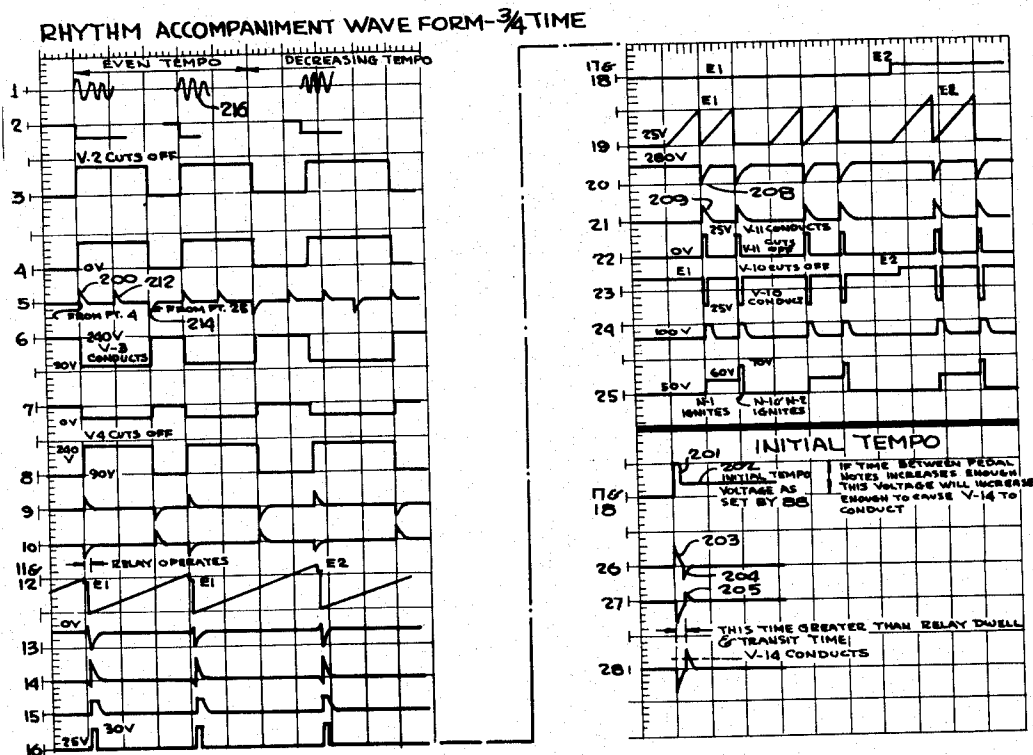
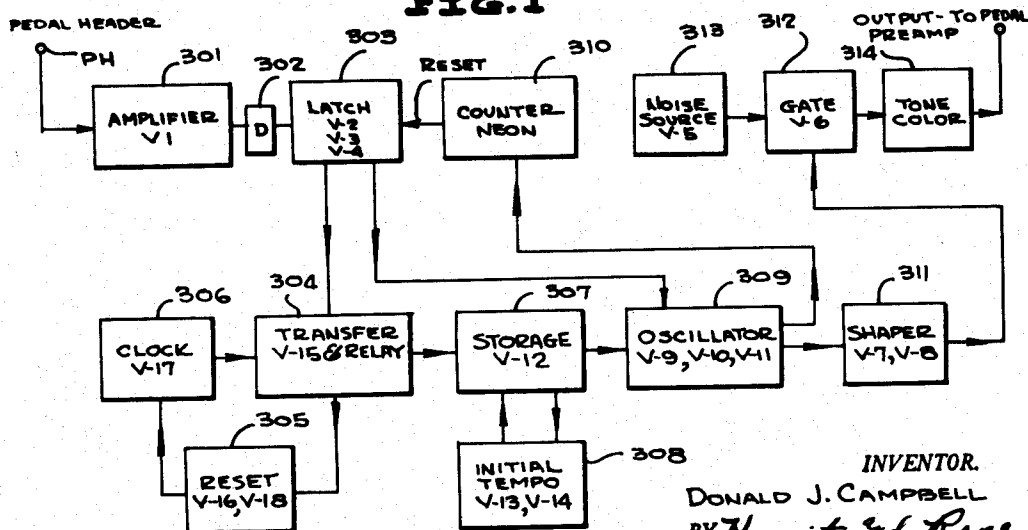


FIG. 1



INVENTOR.
DONALD J. CAMPBELL
BY *Hurwitz and Rose*
ATTORNEYS
William H. Breunig
AGENT

July 7, 1964

D. J. CAMPBELL

3,140,336

RHYTHMIC INTERPOLATOR

Filed Aug. 30, 1959

3 Sheets-Sheet 2

FIG. 3

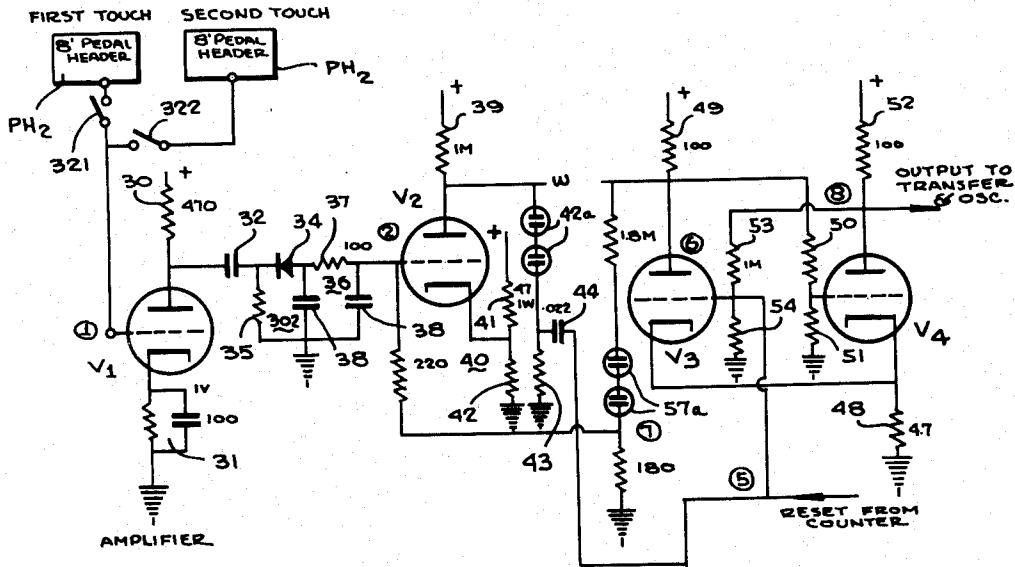
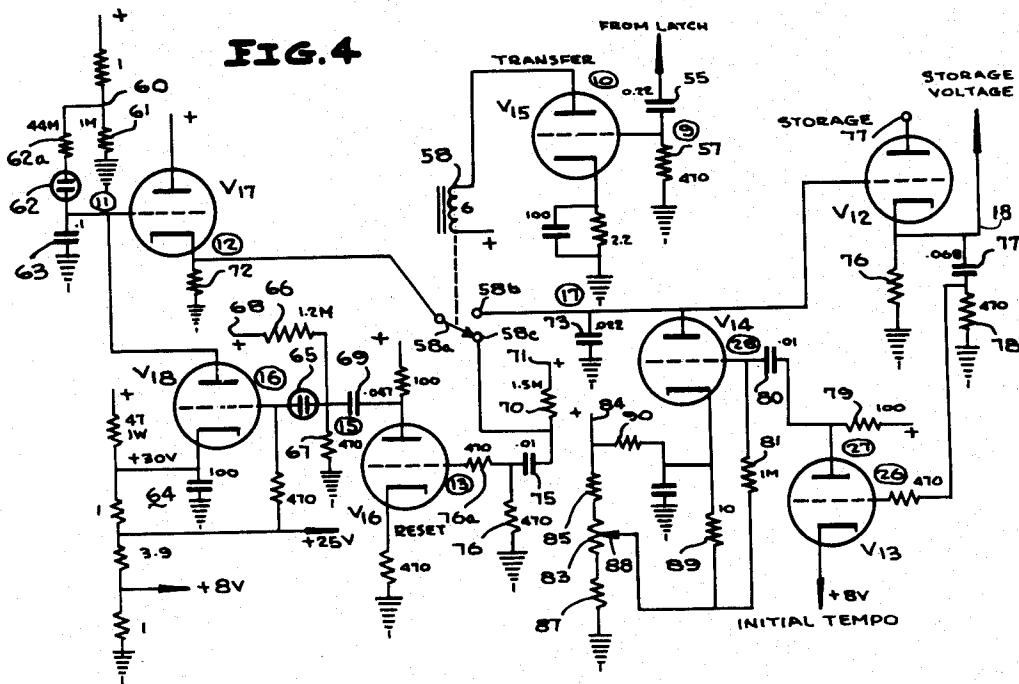


FIG. 4



INVENTOR.
DONALD J. CAMPBELL
BY *Nurnitz & Rose*
ATTORNEYS
William H. Breunig
AGENT

1

3,140,336

RHYTHMIC INTERPOLATOR

Donald J. Campbell, Cincinnati, Ohio, assignor to D. H. Baldwin Company, a corporation of Ohio
Filed Aug. 30, 1960, Ser. No. 52,827
20 Claims. (Cl. 84-1.03)

The present invention relates generally to musical instruments, and more particularly to systems for supplementing certain notes played rhythmically on a musical instrument by interposing further musical sounds at spaced intervals between pairs of the former notes.

Keyboard musical instruments usually are employed where one instrument is to be played alone. This is due to the more complete musical nature of these instruments as compared with monophonic musical instruments. However, still more complete music can be produced by the addition of other instruments to the keyboard instrument.

When playing popular music the first instrument usually added to a piano is the bass viol, where the bass player usually plays only the accented beats. This combination is more or less rhythmically equivalent to the organ, where the organist plays the accented beats on the pedals.

The first instrument usually added to the organ (or to the piano-bass combination) is the percussionist's drums and traps, used mainly to play the unaccented or after beats. A large portion of the percussionist's playing usually consists of more or less mechanically produced unaccented beats timed from the accented beats. Since in playing popular music the organ pedal notes occur on the accented beats, it is possible to construct a machine which will compute a rhythm accompaniment from the organ pedal signal.

This rhythm accompaniment consists of the various percussion sounds usually produced by the percussionist and its addition to an organ provides musically useful sounds not heretofore available to the organist playing alone. In addition one allows the organist greater freedom since he is no longer required to play unaccented beats. A simple device of this character cannot deal with subjective beats, but these seldom occur in popular music. The invention is, therefore, most readily adapted to that class of popular music in which there is normally a steady rhythm produced by the bass viol player and the percussionist against which any rhythmical aberrations are played on the keyboard instrument.

The system of the present invention, in one specific embodiment thereof, briefly described, provides rhythm accompaniment by equally dividing the time between selected pedal notes of an electronic organ, interposing the sound of a snare drum at the division points. For this purpose, a computer is provided which measures the duration of the latest measure completed, in terms of time between pedal notes as a base, and divides this time by a factor appropriate to the rhythm of the music. This division factor may be three (3) for example. If the organist changes tempo the computer senses this fact, and changes the time between beats accordingly. The computer is always one measure behind the organist; but this causes little difficulty unless a very rapid change in tempo occurs during the transition between tempi.

Various tempi may be provided for, as 2/4, 3/4, 4/4 by employing a corresponding time division ratio, and in such case devices according to the invention produce approximately the same rhythm accompaniment as an unrehearsed human percussionist playing "straight" or evenly with no rhythmic aberrations.

On commencing to play, the computer has no reference time. This difficulty may be overcome by omitting percussion until a tempo is established, or, preferably, by

2

providing for insertion of a manually selected rhythm period into the computer in response to the initial pedal note.

It is, accordingly, a broad object of the invention to provide a system for automatically interpolating rhythmic beats at predetermined points in a musical selection.

It is a further object of the invention to provide a system for interpolating a predetermined number of equally spaced pulses between pairs of pulses of variable time spacing.

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

Still another object of the invention resides in the provision of a system for adding rhythmic accompaniment to electronic organ music, controlling the tempo of the accompaniment in response to pedal tones of the organ.

It is still another object of the invention to provide a novel system for generating percussion tones in electronic organs.

Another object of the invention is to provide a system for generating sounds simulating the snare drum, from a broad band noise spectrum, by shaping the noise amplitude as a function of time and simultaneously filtering the noise spectrum.

It is still a further object of the invention to provide a system for converting variable time intervals into stored voltage levels, sensing each time interval as it occurs and generating each voltage in accordance therewith.

It is another object of the invention to provide a novel frequency controllable oscillator, capable of generating voltage pulses having frequencies which are a function of a control voltage level.

Another object of the present invention resides in the provision of a counter of simple circuit configuration, arranged to transmit a control pulse on completion of a predetermined count.

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 functional block diagram of a system according to the invention;

FIGURE 2 is a wave form diagram showing wave forms at selected points of the schematic diagrams of FIGURES 3, 4 and 5;

FIGURE 3 is a schematic circuit diagram of an amplifier and latch portion of FIGURE 1;

FIGURE 4 is a schematic circuit diagram of a reset, clock, transfer, storage and initial tempo portion of FIGURE 1.

FIGURE 5 is a schematic circuit diagram of an oscillator and counter components included in FIGURE 1; and

FIGURE 6 is a schematic circuit diagram of shaper, noise source, gate and tone color components of FIGURE 1.

A specific embodiment of the invention is briefly described by reference to the functional block diagram of FIGURE 1, identifying the blocks in terms of the triodes employed therein in the corresponding schematic circuit diagram of FIGURES 3, 4, 5 and 6.

The signal provided by the pedal header of a conventional electronic organ is available at terminal PH. That signal is amplified in an amplifier V1 and detected in rectifier D. The output of detector D operates a latch circuit V2, V3, V4, each onset of pedal signal transferring the latch circuit to its latched condition. When the latch circuit latches it supplies a control pulse to a transfer circuit V15, which drives a relay. The relay operates a

3

reset circuit V16, V18 which resets a clock circuit V17. The latter generates a sawtooth wave which starts in response to reset, and builds up to a level determined by the intervals between resets. The latter is in turn determined by the time between latch and release of latch V2, V3, V4.

Before the transfer circuit V15 operates the reset circuit V16, V18 it transfers the voltage level attained by the clock sawtooth since the last reset to a storage device V12. The latter in turn controls the period of an interpolation oscillator V9, V10, V11. The oscillations generated by the latter are at the frequency of the rhythmic accompaniment which it is desired to generate. The oscillations are initiated by the latch V2, V3, V4 and are counted by a pre-set counter 310, which resets the latch V2, V3, V4 after a desired count has been attained. The desired count equals the number of beats it is desired to interpolate between pedal bursts.

The oscillator V9, V10, V11 supplies control pulses to a pulse shaper V7, V8, which generates pulse envelopes suitable to the specific accompaniment desired. These are used to control a gate V6, which passes noise signals supplied by noise source V5, to tone color filters TC, and then to an output terminal.

To provide a specific example, if the period of a measure of a musical composition were one second, and the rhythm were $\frac{3}{4}$, it would be desired to interpolate two beats between each pedal burst, the beats occurring at intervals of $\frac{1}{4}$ second from each other and from the pedal burst. Should the tempo increase or decrease, the timing of the beats should increase or decrease in proportion.

The one second time intervals are then established by the musician's manipulation of the pedals of the organ. The clock V17 is arranged to attain a voltage level E1 following operation of latch V2, V3, V4 by a pedal burst, and this level stored in storage V12 and applied as a control to oscillator V9, V10, V11, establishes a period for that oscillator equal to $\frac{1}{3}$ second.

The counter 310 counts two beats following the pedal beat, following the pedal burst, and then resets the latch V2, V3, V4 in readiness for a following pedal burst.

Any change in the tempo of the pedal bursts is reflected as a variation of timing, and hence output voltage of clock V17, which in turn varies the period of oscillator V9, V10, V11.

Any pedal bursts occurring during the time the latch V2, V3, V4 is latched have no effect. This allows the organist to play rhythmic embellishments on the pedals during this period.

Initial tempo, i.e., tempo antecedent to establishment of a tempo pattern to govern clock V17 is set by V13, V14, which establishes a manually selective voltage for storage V12.

In the following detailed description of a specific embodiment of the invention, important circuit points are identified by encircled numerals, and wave forms for these circuit points indicated in FIGURE 2 of the drawings in correspondingly numbered lines.

Amplifier and Latch

Referring now more particularly to the schematic circuit diagram of FIGURE 3 of the accompanying drawings, the triode V1 is an amplifier tube, anode loaded by a resistance 30, and having a self-bias cathode circuit 31. To the grid of triode V1, point (1) is supplied tone signal deriving from a pedal header PH of an electronic organ, which may be of conventional character per se. The output signal voltage provided at the anode of triode V1 is A.C. coupled via capacitor 32 to a rectifier or detector circuit 302. The latter consists of a diode 34, in series with capacitor 32, and having its cathode connected directly to capacitor 32, and to ground via a relatively high resistance 35. The anode circuit of diode 34 includes a low pass filter 36, consisting of a series resistance 37 and shunt capacitors 38, each connected to ground.

4

The grid of a triode V2 is directly connected to the output of filter 36, at point (2). The anode of triode V2 is resistance loaded by a high resistance 39 and the cathode is connected to an unbypassed fixed bias circuit 40, consisting of a voltage divider including two series connected resistances 41 and 42, between a positive voltage source and ground. The cathode of triode V2 is connected to the junction of resistances 41, 42, and is thus maintained slightly positive with respect to point (7) when neon lamps 57a are conducting. When neon lamps 57a not conducting the voltage at point (7) is 0 and the voltage at the cathode of V2 causes V2 to be cut off.

Connected from the anode of triode V2, point (3), and ground are, in series, two neon lamps 42a and a relatively small resistance 43. Voltage variation developed across resistance 43, point (4), is coupled via capacitor 44 to the control grid of a triode V3, in the form of pulses, made available at point (5).

In the system as described hereinabove, when a pedal of the pedal clavier is depressed, tone signal is supplied to amplifier tube V1, and transferred to rectifier circuit 302. The latter provides a negative cut-off voltage at the grid of tube V2, raising the voltage at its anode to a value adequate to cause conduction in neon lamps 42a, which are normally not conducting, and the consequent development of a positive voltage across resistance 43. The latter action supplies either a zero voltage or a fixed positive voltage across resistance 43, depending on whether neon lamps 42 are conducting or not conducting. However, the coupling capacitor 44 assures the transfer of variation voltages only, so that a positively going pulse is supplied to the grid of triode V3 in response to each depression of a pedal, or in response to initiation of each pedal tone signal present in the pedal header PH.

Triodes V3 and V4 are connected in bi-stable configuration, i.e., as a flip-flop having a common small cathode resistance 48, and having anodes back-coupled to grids via resistive networks. The anode of triode V3, point (6), is resistance loaded by a small resistance 49, and is coupled to the grid of triode V4 through a voltage divider comprised of series resistances 50, 51. Similarly, the anode of triode V4, point (8), is resistance loaded by a small resistance 52, and is coupled to the grid of triode V3 through a voltage divider consisting of series connected resistances 53, 54. Accordingly, when the initiation of a pedal tone causes the grid of triode V3 to go positive, its anode voltage drops, reducing the voltage on the grid of triode V4 and increasing its anode voltage. The action is regenerative, and once started the triode V4 goes to cut-off and V3 conducts. In this latched condition the voltage at point (8) is high and at point (6) is low causing neon lamps 57a to be non-conducting. Point (7) is now at ground potential and the fixed cathode potential of V2 causes V2 to be cut off so that subsequent pedal signals have no effect. The latch circuit remains in this latched condition until a negative pulse arrives at point (5) from the counter.

The negative pulse at point (5) initiates the reverse of the above regenerative action which leaves the latch circuit in the unlatched condition, i.e. V4 conducting, V3 cut off, neon lamps 57a conducting, V2 conducting and neon lamps 42a non-conducting. In this unlatched condition the latch circuit is sensitive to and will accept the next pedal signal.

The operation of the latch circuit may be summarized as follows: the initiation of a pedal signal at point (1) results in the two valued voltage at point (8) being raised to its higher value and remaining there (latched condition), further pedal signals having no effect until after a negative pulse is applied to point (5) at which time the voltage at point (8) falls (unlatched condition) and the latch circuit will respond to the next pedal signal.

Clock, Transfer and Storage

Referring to FIGURE 4 the voltage across resistance 57, i.e., at point (9), is applied to the grid of a self-biased triode amplifier V15, having in its anode circuit a relay coil 58, which, when energized, actuates a movable armature 58a selectively to move between fixed contacts 58b and 58c. Each positive pulse developed at point (9) energizes relay coil 58 momentarily, pulling up armature 58a momentarily. Negative pulses at point (9), occurring when the latch is reset, have no effect on the relay.

A fixed voltage source is provided at point 60, having the same voltage and source impedance as point (8), FIGURE 5. Across resistance 61 is connected a neon lamp 62 in series with a clock capacitor 63. The ungrounded terminal of clock capacitor 63 is connected to the anode of a triode V18, the cathode and grid of which are connected to a voltage divider 64, arranged to bias the grid negatively of the cathode by a fixed amount, i.e., five volts, the cathode itself being maintained at 30 v. Triode V18 is normally cut-off by this bias. The ungrounded terminal of clock capacitor 63 is also connected to the grid of triode V17 which operates as a cathode follower having its anode connected directly to B+ and a cathode load 72 across which, at point (12), appears the clock voltage having substantially the same magnitude as the voltage across clock capacitor 63, point (11), but having much lower impedance due to the cathode follower action of V17.

When armature 58a is pulled up to contact 58b, the ungrounded end of storage capacitor 73, point (17), is connected directly to point (12). The capacity of capacitor 73 is relatively small. During the time armature 58a dwells on contact 58b current flows into or out of storage capacitor 73 until the voltage at point (17) equals the clock voltage at point (12). No current flows from point (17) through V14 because this tube is cut off at this time as explained in the initial tempo section. Point (17) is also connected to the grid of triode V12 operated as a cathode follower, having its anode directly connected to B+ and a cathode load resistor 76 across which, point (18), appears the storage voltage. This storage voltage has substantially the same magnitude as point (17) but, due to the cathode follower action of V12, has the low impedance essential to control the oscillator as explained later.

Clock Reset

Contact 58C is normally connected to point (12) through armature 58a but during the transfer operation described above, this connection is broken. Since contact 58C is connected to B+ 71 through high resistance 70 the voltage at contact 58C approaches B+ relatively slowly by charging capacitor 75 during transfer and then rapidly falls back to the clock voltage at point (12) when the armature 58a returns to contact 58c immediately after transfer. These voltage changes, first positive at the beginning of transfer, then negative at the end of transfer, are communicated as pulses to the grid of amplifier triode V16, point (13), through differentiating network capacitor 75 and resistor 76. These pulses amplified and inverted, are transmitted to point (15) through coupling capacitor 69. Point (15) is maintained at a positive potential just under the firing potential of neon lamp 65 by voltage divider 67 and 66. Neon lamp 65 is connected between point (15) and point (16), grid of V18. The first pulse, now negative and decreased in magnitude by resistor 76a, has no effect on neon lamp 65 but the second pulse, now positive and occurring at the end of transfer, causes the neon lamp to ignite. Current through neon lamp 65 raises the voltage at point (16) causing V18 to conduct and discharge the clock capacitor 63 to 30 v., the cathode voltage of V18. This action resets the clock so it starts measuring the length of the present

measure by slowly charging capacitor 63 through neon lamp 62 and high resistance 62a from voltage point 60.

The operation of the reset, clock, transfer and storage may be summarized as follows: The transition of the latch from its unlatched state to its latched state results in the transfer inserting a new voltage in the storage. This new storage voltage closely approximates the clock voltage at this instant in time. The clock voltage is a measure of the time between successive transfers since the clock is reset immediately following transfer. The chain of events—beginning of organist's pedal note, latch transition, transfer, and reset—all take place in a few milliseconds resulting in very small error in measuring length of measure.

Initial Tempo

V14 and V13 operating with storage tube V12 provide a storage voltage for the initial measure of music. At the beginning of the initial measure the storage voltage will always rise to a much higher voltage than at any other time since the voltage in the clock represents a time very much longer than any musical measure played by the organist. This larger than normal voltage saturates the cathode follower storage tube V12 resulting in its output voltage, point (18), first increasing but then, a short time later, decreasing. This decrease is arranged to occur after relay armature 58a leaves contact 58b and is communicated to the grid of V14, point (28), as a positive pulse via coupling capacitor 80, via conventional amplifier triode V13, via coupling capacitor 77 from point (18). The grid and cathode of V14 are returned to a voltage divider network comprised of resistors 85, 87, 89 and 90 and variable resistor 83. This network maintains V14 always cut off except at the beginning of the initial measure when a positive pulse arrives from V13. Yet the cathode voltage is variable by adjusting the slider 88 of resistor 83. The positive pulse from V13 causes V14 to conduct, which discharges the storage capacitor 73 to the cathode voltage of V14 which was pre-set by adjusting slider 88. The initial tempo circuit is inoperative at all times except the beginning of the initial measure at which time it injects into the storage an arbitrary, manually selected tempo for use during the first measure only.

Oscillator

The voltage at point (21), FIGURE 5, is too low to permit neon lamps 121 to conduct to point (22), the grid of V11, is at 0 potential and V11 is cut off since its cathode is held at +25 v. Timing capacitor 112 has been left with 25 v. at point (19), the grid of V10, by the last oscillation cycle. The cathode of V10, point (23), is connected to point (18), storage circuit FIGURE 4, through dropping resistor 113. Since V11 is cut off, no current flows through dropping resistor 113 and the cathode of V10 is at storage voltage E which is always greater than 25 v., resulting in V10 being cut off.

Point (19) is also connected to point (8), latch circuit FIGURE 3, through timing resistor 110 and neon lamp 111 which is non-conducting until the latch latches in response to a pedal note. At this time the voltage at point (8) rises, neon lamp 111 conducts, and timing capacitor 112 gradually charges at a rate determined by timing resistor 110 until point (14), the grid of V10 reaches a value equal to the cathode voltage of V10 which is being held at the storage potential E. At this point V10 conducts and the voltage at point (20), the plate of V10, rapidly decreases since resistor 115 is of very high value. This decrease in voltage is communicated to the grid of V9 by capacitor 116 causing the plate of V9, point (21), to increase. This in turn causes neon lamps 121 to conduct, raising the potential at point (22), the grid of V11, from 0 to a value sufficient to cause V11 to conduct which drops point (23) from stor-

age potential E to 25 v. Since dropping resistor 113 has a value much higher than the impedance of point (18), point (18) is not disturbed by this dropping of point (23). Point (23), the cathode of V10 is now much lower than its grid, point (14), which is at storage potential E. This causes timing capacitor 112 to be rapidly discharged to 25 v. by current flowing from grid to cathode in V10 and plate to cathode in V11.

During the discharge of timing capacitor 112, V10 conducts heavily but when this capacitor is discharged to 25 v., V10 conducts less current resulting in an increase in voltage at its plate, point (20). This increase in voltage reverses the chain of events described above. The grid of V9 rises, its plate, point (21) falls, neon lamps 121 become non-conductive, point (22) drops to 0 potential, V11 cuts off, point (23) raises to storage potential E, V10 cuts off and timing capacitor 112 starts to charge up again. This completes one cycle of oscillation, the slow charge and rapid discharge of timing capacitor 112 repeating as long as point (8) remains at its higher potential. The frequency of oscillation is determined by timing capacity 112, timing resistor 110 and storage potential E.

Counter

The counter consists of neon lamp 131 connected in parallel with timing capacitor 133, the ungrounded end of this parallel combination being connected to point (24) through a second neon lamp 130. Point (24) is held at a potential equal to the sum of the extinguishing potentials of neon lamps 130 and 131 by voltage divider resistors 126 and 127. Point (25) has been left at the extinguishing potential of neon lamp 131 by a previous counting cycle. Thus both neon lamps 130 and 131 are not normally conducting but need only a small voltage increase to cause them to conduct. Such an increase is provided for neon lamp 130 by the oscillator output pulse which is communicated to point (24) from the oscillator by capacitor 128. Neon lamp 130 conducts during each oscillator pulse and the current pulses through this neon lamp flow into timing capacitor 133 causing the potential across it, point (25), to increase step-wise with each oscillator pulse until the conduction potential of neon lamp 131 is reached and neon lamp 131 conducts. The current through this neon lamp discharges timing capacitor 133 to the extinguishing potential of neon lamp 131 at which time this neon lamp stops conducting and leaves the counter in its original state ready to start another count. The number of current pulses through neon lamp 130 required to charge timing capacitor 133 to the conduction potential of neon lamp 131 is determined by the capacity of timing capacitor 133 and any number of pulses can be provided for by adjusting this value.

The discharge of timing capacitor 133 produces a negative output pulse at point (25) which is conveyed by capacitor 135 to point (5) of the latch circuit, FIGURE 3. This negative pulse resets the latch to its unlatched condition completing one measure of operation of the device and rendering the latch sensitive to the next pedal note. Positive pulses occurring at point (25) on each oscillation cycle have no effect on the latch in its latched condition.

It will be recalled that the oscillator frequency is determined by timing resistor 110, timing capacitor 112 and storage potential E. The latter potential varies with the tempo or speed of the organist's playing and maintains the oscillator frequency in step with the organist. Timing capacitor 112 has the same capacitance as timing capacitor 63 in the clock, FIGURE 4. The resistance of timing resistor 110 is an integral submultiple of the resistance of timing resistor 62a in the clock, FIGURE 4, according to the number of beats to be injected between accented pedal notes. For each value of timing resistor 110 there corresponds a value for timing capacitor 133 in the counter, FIGURE 5, to provide an appropriate number of

injected beats. The following table gives an example of these relationships.

Rhythm or Time	Number of Injected Beats	Clock		Oscillator		Counter 133, mfd.
		63, mfd.	62a, meg.	110, meg.	112, mfd.	
2/4	1	.1	44	22	.1	.1
3/4	2	.1	44	14.7	.1	.25
4/4	3	.1	44	11	.1	.43

Values of resistance 110 and capacitor 133 are selected by the organist before beginning to play by adjustment to 2/4, 3/4, or 4/4 according to the rhythm he intends to play.

Although capacitor 63 charges from 30 v., the potential of the cathode of V13, capacitor 112 charges from 25 v., the potential of the cathode of V11. This difference in initial voltages compensates for small errors in transfer, storage and oscillator.

Shaper

The output of the oscillator at point (22) consists of sharp rectangular pulses of short duration which vary in height and length somewhat with frequency. These pulses actuate a conventionally designed cathode coupled multivibrator, V7 and V8, FIGURE 6, which removes the variations and lengthens the pulses, the length depending on the adjustment of variable resistance 175 which is available to the organist. The design, operation and function of this circuit are well known. Resistors 190 and 191 connected in series from multivibrator output plate to ground act as a voltage divider for the shaper output, capacitor 192, connected from the junction of resistors 190 and 191 to ground provides further shaping. Resistor 193 conveys the shaper output to the gate, V6, which allows bursts of noise voltage from the noise generator to pass through it, in response to the gating wave from the shaper.

Noise Source and Gate

A noise source is provided for the system of the invention which consists essentially of a neon lamp 104, connected in series with a protective resistance 141 to a positive voltage source. The neon lamp is operated under ignited conditions, and as is well known a noise voltage is generated across the neon lamp under these operating conditions. The noise voltage is amplified in a triode V5, which is conventional per se, and is transferred through a coupling capacitor 142 to a gate triode V6.

The gate triode V6 includes a cathode which is fixed positively biased with respect to ground by means of a voltage divider 143 and includes two relatively small anode load resistances 144 and 145, connected in series to a positive voltage terminal 146. The anode of the triode V6 is A.C. coupled through a capacitor 151 and a volume control resistance 152 to an output terminal 153, which in an electric organ would be connected to a pre-amplifier in a pedal header. The junction of resistances 144 and 145 is likewise connected to the output terminal 153 via volume control resistance 152 via switch 164, via a coupling condenser 154. The common terminal of condenser 151 and volume control resistance 152 is connected to ground through cascaded filter sections comprising a group of series connected inductances 156, 157, 158 and 159. Across each of inductances 157, 158 and 159 is connected a filter capacitor, these being denominated C1, C2, C3, and across each of the inductances 156 to 159, inclusive, is connected a switch, the switches being denominated 160, 161, 162 and 163. Each of the switches effectively short circuits one of the filter sections so that various combinations of the filter sections may be inserted in shunt to the output terminal 153 and thereby tone color may be imparted to the output tones. A further switch 164 is connected in series between capacitor 154 and output terminal 153, and when opened serves

to sharpen the tone without changing the volume of the output from the gate triode V6, because capacitor 154 is considerably larger than capacitor 151, and is associated with a smaller anode load. Switches 160 to 164 inclusive control the tone color and variable resistance 175 controls the length of the simulated brushed snare drum sound produced by the action of the shaper, gate, and tone color filters on the noise voltage in response to each oscillation cycle of the oscillator. The brushed snare drum sound is exemplary only; many other rhythm accompaniment sounds are possible, e.g. gated tones to simulate temple blocks, etc.

Operation

The operation of the various sections of the apparatus have been described in conjunction with the foregoing detailed description and it is, therefore, necessary at this time merely to give a brief resume of the manner in which the apparatus is used and operates.

Prior to commencing to play, the organist adjusts a rhythm switch for the type of rhythm he intends to play, e.g., 2/4, 3/4, or 4/4. This switch selects timing resistor 110 in the oscillator and timing capacitor 133 in the counter. The organist has an initial tempo in mind which he imparts to the apparatus by adjusting slider 88 in the initial tempo circuit.

The organist now commences to play, his first pedal note occurring on the first accented beat of the music. This initial pedal signal is communicated through amplifier 301, FIGURE 1, and detector 302 to latch 303 where it causes the latch to assume the latched condition.

The latch's transition actuates the transfer 304 to first transfer the clock voltage from the clock 306 to the storage 307 and, secondly, to reset the clock by actuating reset 305. The clock now starts measuring the length of the first measure.

The initial clock voltage which now is the storage voltage is greater than subsequent clock voltages which measure the length of subsequent measures since the time prior to the first measure is very long. This larger than normal storage voltage actuates the initial tempo 308 which inserts the initial tempo voltage, previously set by the organist, into storage 307.

At the same time the latch actuates the transfer. It also activates the oscillator 309 synchronizing the oscillator to the organist's playing. The frequency of the oscillator is determined by the storage voltage. Each oscillation is counted by the counter 310 which, after the number of oscillations appropriate to the type of rhythm being played, resets the latch to its unlatched condition completing the first cycle of operation which also corresponds to the first measure being played. Returning the latch to the unlatched condition turns off the oscillator, has no effect on the transfer, but renders the latch sensitive to the next pedal note which will be the accented note at the beginning of the next measure.

Pulses from the oscillator are suitably shaped by the shaper 311 and then conveyed to gate 312. The gate creates shaped pulses of noise from noise source 313 in response to the pulses from the shaper. Gate output is conveyed to organ preamplifier through tone color filters 314. By these means each oscillator pulse creates an output signal pulse simulating a brushed snare drum.

At the beginning of the second measure the organist plays a pedal note. The latch, transfer, reset and storage are activated as at the beginning of the first measure except the clock voltage transferred to the storage has a value dependent on the length of the first measure rather than the high value transferred before. The initial tempo 308 is not actuated by this lower voltage and is not normally actuated for the remainder of the composition being played. All other sections of the apparatus function as during the first measure. In all measures except the first, the tempo of the organist's playing, as measured by the

clock voltage transferred to storage, controls the tempo of the rhythm accompaniment created by the apparatus.

When playing some types of music it is desirable to have a more complicated rhythm accompaniment than that produced by the apparatus described above. Closing the on-beat switch 180, FIGURE 6, creates an output pulse on the accented or first beat of each measure in addition to the unaccented output pulses described above. On-beat, switch 180, communicates the positive pulse on the plate of latch triode V2, FIGURE 3, via level adjusting resistor 181, via coupling capacitor 182 to the grid or V8, the input of the shaper. The shaper, gate, and tone color filters act on the one-beat pulse from V2 in the same manner as the after beat pulses from point (22) in the oscillator, the only difference being the time at which the pulses occur.

More complicated rhythms such as rumba, cha cha, etc. can easily be produced by suitable modifications of the oscillator and counter.

At the end of a musical rendition it is frequently desirable to eliminate the last group of after beats. This is readily accomplished by providing a laterally operated cut off switch 320 attached to the expression pedal of the organ. This cut off switch can operate at the output point 153, FIGURE 6, or at some intermediate point.

It is possible to achieve greater flexibility in control of the rhythm accompaniment apparatus by providing the pedal clavier of the organ with second touch PH2, wherein a lower than normal position of each pedal is arrived at by the organist's exerting greater than normal pressure on the pedal being played. Second touch is well known in the art. The rhythm accompaniment apparatus is connected selectively by switches 321 and 322 to headers PH1 or PH2, the latter actuated only by the lower pedal position, allowing the organist to play pedal notes selectively, some initiating rhythm accompaniment, some having no effect on the rhythm accompaniment apparatus.

The sounds of claves, temple blocks, wood blocks, etc. are produced by the substitution of a suitable tone source for the noise source 313, FIGURE 1. The substitution of an electromechanical filter for the electrical filter 314 provides improved tone color for some rhythm accompaniment sounds.

Although all sections except transfer of the above description operate by electronic means, it is obvious that any or all sections could operate by mechanical, electromechanical, or other means without departing from the underlying principles of the invention.

What I claim is:

1. An electrical musical instrument having the usual pedal clavier operatively associated with a source of rhythmic impulses, an actuating circuit operatively connected to said source, a timing circuit operatively connected to said actuating circuit, at least one source of rhythmic interpolation signals operatively connected to said timing circuit, said timing circuit including means for electing the number of rhythmic interpolation signals to be interpolated between pairs of rhythmic impulses, whereby when selected rhythmic impulses are generated in response to operation of said pedal clavier the source of interpolation signals will be actuated rhythmically to interpolate the elected number of interpolation signals.

2. The combination according to claim 1 wherein said rhythmic impulses are pedal tones of an electronic organ.

3. The combination according to claim 1 wherein said interpolation signals are tones simulating percussive sounds.

4. The combination according to claim 3 wherein said source of interpolation signals includes a source of random noise signal, a gate connected with said source of random noise signal, a source of amplitude modulated pulse signal, means applying said amplitude modulated pulse signal in gating relation to said gate and an adjustable filter means connected to said gate.

5. The combination according to claim 4 wherein said

11

gate includes an amplifier having an output electrode, first and second resistance loads connected in series with said output electrode, a relatively large capacitor coupling the junction of said first and second resistances to said filter section, and a switch connected in series with said relatively large capacitor.

6. The combination according to claim 1 wherein said timing circuit is a circuit for measuring time intervals between rhythmic impulses and for subdividing said time according to the elected number of interpolation signals.

7. An electrical musical instrument including a clavier operatively associated with a source of rhythmic impulses generated in response to manipulation of said clavier, an actuating circuit operatively connected to said source, a timing circuit operatively connected to said actuating circuit, a source of rhythmic interpolation signals operatively connected to said timing circuit, said timing circuit including means for adjusting the time positions of the interpolation signals with respect to the rhythmic impulses, whereby when selected rhythmic impulses are generated in response to operation of said clavier the source of interpolation signals will be actuated rhythmically to interpolate the elected interpolation signals.

8. The combination according to claim 7 wherein said interpolation signals are percussive tones.

9. An electrical musical instrument having a source of rhythmic impulses, an actuating circuit responsive to said impulses, a timing circuit operatively connected to said actuating circuit, at least one source of rhythmic interpolation signals operatively connected to said timing circuit, said timing circuit including means for electing the pattern of rhythmic interpolation signals to be interpolated between pairs of rhythmic impulses, whereby when selected rhythmic impulses are generated the source of interpolation signals will be actuated rhythmically to interpolate the elected pattern of interpolation signals.

10. An electrical musical instrument having a source of rhythmic impulses, an actuating circuit responsive to said impulses, a timing circuit operatively connected to said actuating circuit, at least one source of rhythmic interpolation signals operatively connected to said timing circuit, said timing circuit including means for electing the pattern of rhythmic interpolation signals to be interpolated between pairs of rhythmic impulses, whereby when selected rhythmic impulses are generated the source of interpolation signals will be actuated rhythmically to interpolate the elected pattern of interpolation signals, wherein said interpolation signals correspond to tones simulating percussive sounds.

11. An electrical musical instrument having the usual pedal clavier operatively associated with a source of rhythmic impulses, an actuating circuit operatively connected to said source, a timing circuit operatively connected to said actuating circuit, at least one source of rhythmic interpolation signals operatively connected to said timing circuit, said timing circuit including means for electing the pattern of rhythmic interpolation signals to be interpolated between pairs of rhythmic impulses, whereby when selected rhythmic impulses are generated in response to operation of said pedal clavier the source of interpolation signals will be actuated rhythmically to interpolate the elected pattern of interpolation signals.

12. An electrical musical instrument capable of generating rhythmic impulses, an actuating circuit responsive to said impulses, a timing circuit operatively con-

12

nected to said actuating circuit, at least one source of rhythmic interpolation signals operatively connected to said timing circuit, said timing circuit including means for electing the number of rhythmic interpolation signals to be interpolated between pairs of rhythmic impulses, whereby when selected rhythmic impulses are generated the source of interpolation signals will be actuated rhythmically to interpolate the elected number of signals.

13. An electrical musical instrument having the usual pedal clavier operatively associated with its related sources of rhythmic impulses, an actuating circuit operatively connected to at least one of said sources, a timing circuit operatively connected to said actuating circuit, at least one source of interpolation signals operatively connected to said actuating circuit, and at least one means for determining the number of interpolation signals, said means connected to said actuating circuit, whereby when rhythmic impulses have been initiated, the source of interpolation signals will be actuated to produce the elected number of signals.

14. In a music system, a source of recurrent signals having a spacing selective at will, a source of spaced interpolation signals occurring in predetermined rhythm, said interpolation signals simulating percussive sounds, means for manually presetting the spacing of said interpolation signals, and means responsive to at least one of said recurrent signals for controlling said interpolation signals.

15. The combination according to claim 14 wherein said interpolation signals are rhythmically derived in response to each of said recurrent signals.

16. The combination according to claim 14 wherein said interpolation signals are percussive.

17. In a music system, a source of recurrent musical signals having a spacing selective at will, a normally inoperative source of interpolation signals having musical character, means responsive to said recurrent musical signals for initiating operation of said source of interpolation signals, and means for manually adjusting the timing of said interpolation signals with respect to said recurrent signals.

18. The combination according to claim 17 further including means for at will varying the number of said interpolation signals, said interpolation signals being successively generated when said number is greater than one.

19. The combination of claim 17 including means for simulating a plurality of different percussive sounds, and means for at will selecting at least one of said sounds.

20. The combination according to claim 17 wherein said interpolation signals are discrete noise-like signals.

References Cited in the file of this patent

UNITED STATES PATENTS

2,471,138	Bartelink	May 24, 1949
2,605,422	Frederick	July 29, 1952
2,767,315	Kosten	Oct. 16, 1956
2,783,672	Hanert	Mar. 5, 1957
2,832,044	Bliss	Apr. 22, 1958
2,835,807	Lubkin	May 20, 1958
2,855,816	Olson	Oct. 14, 1958
2,863,049	Lee	Dec. 2, 1958
2,974,291	Colletti	Mar. 17, 1961

FOREIGN PATENTS

1,221,114	France	Jan. 11, 1960
-----------	--------	---------------