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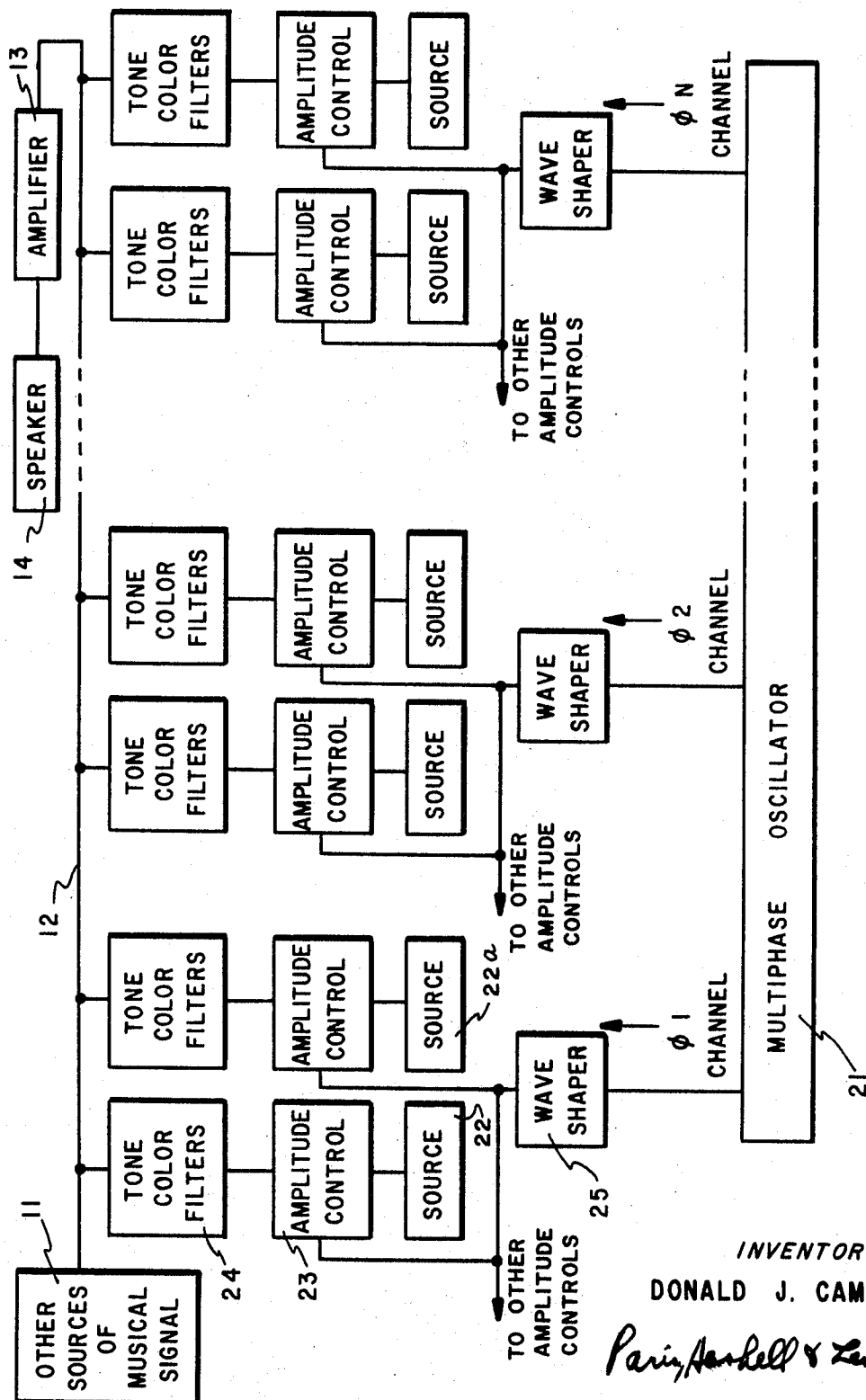
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REITERATION, PERCUSSION AND SPEAKING TONE EFFECTS IN
ELECTRONIC MUSIC GENERATION

ELECTRONIC MUSIC GENERATION

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4 Sheets-Sheet 1



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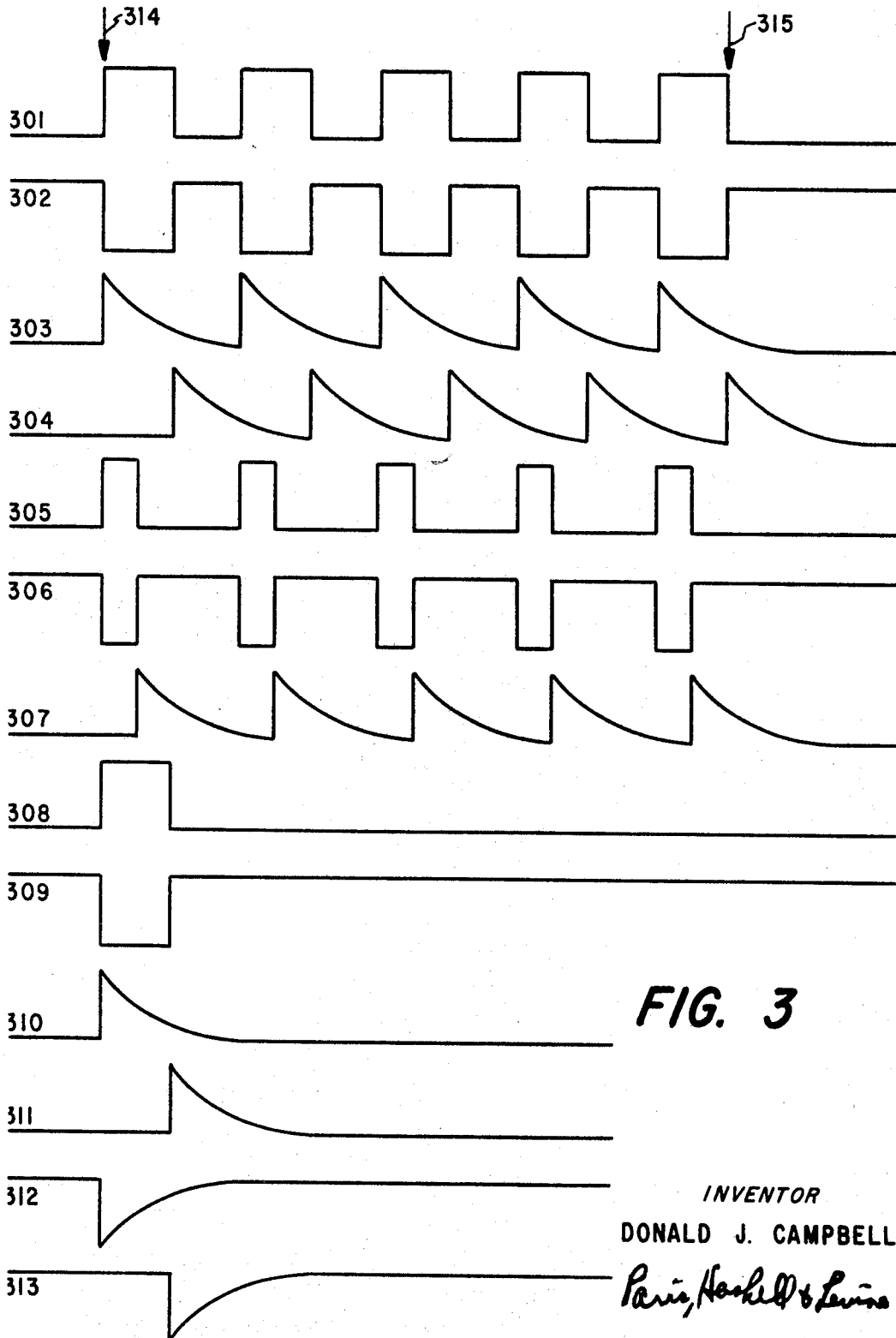


FIG. 3

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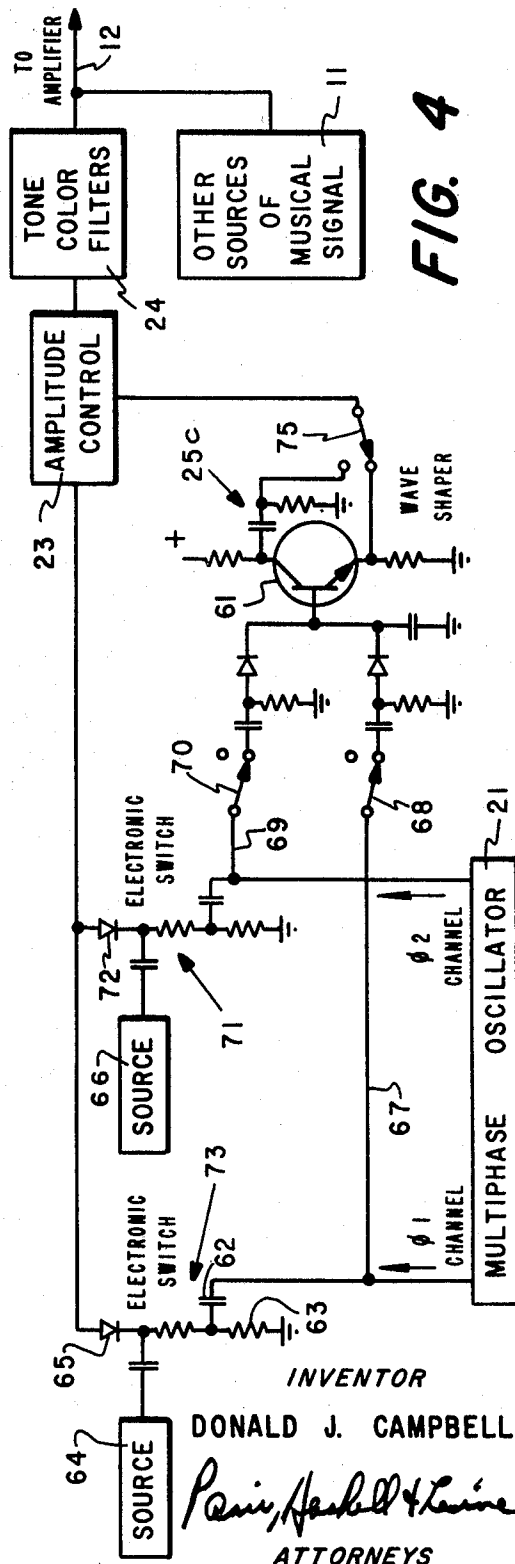
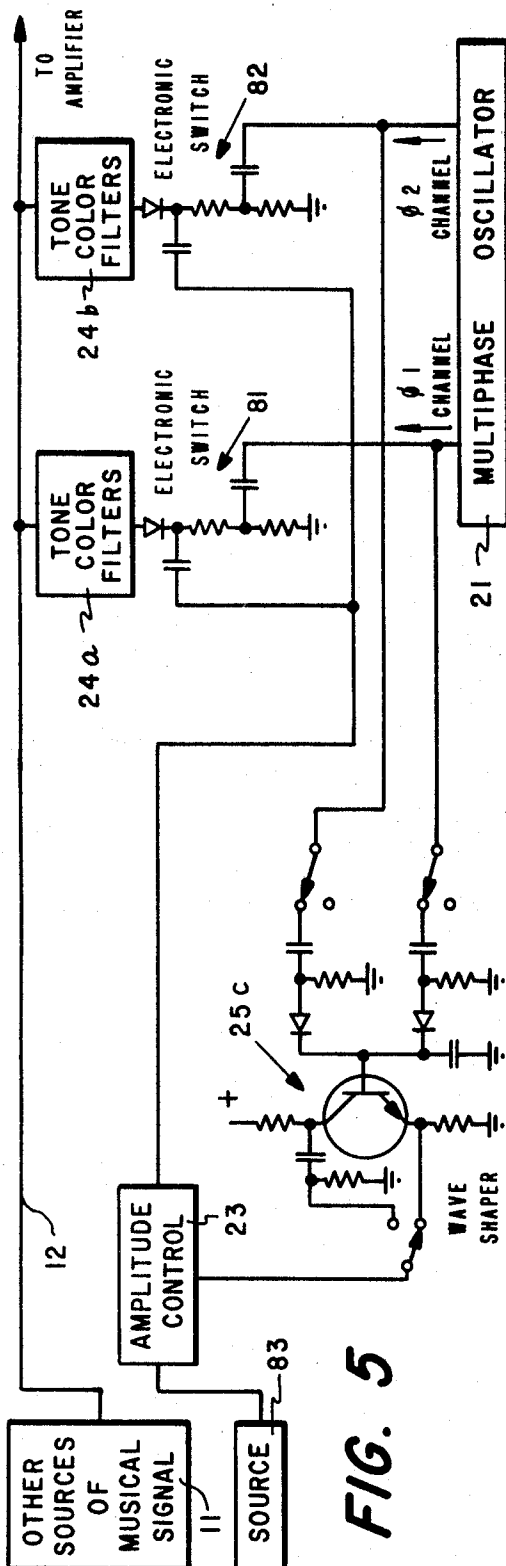
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REITERATION, PERCUSSION AND SPEAKING TONE EFFECTS IN ELECTRONIC MUSIC GENERATION

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15 Claims

ABSTRACT OF THE DISCLOSURE

A circuit for any musical instrument having different electronic signal sources by which the envelope of the tone-signal is shaped, according to predetermined patterns. Such shaping affects attack and decay, and is effected by use of a multiphase oscillator connected to control amplitude of tone signals. By this device, any rate of attack, any rate of decay, any amplitude, and any number of signal sources having any waveform can be combined in any sequence and rate to produce an infinite number of single event or repetitive tonal and/or percussion effects.

The present invention relates to the field of electronic music generation, and particularly to the production of certain effects or characteristics involving reiteration, percussion, and speaking tones.

In the art of electronic music generation, it is known to produce music by the generation of audio oscillations from a plurality of sources, each source for example producing a different frequency, and to pass the signals of these sources selectively and appropriately through tone color filters to produce musical tones of a desired character. In accordance with the present invention, the audio oscillations are further modified to produce reiteration, percussion, and speaking tone effects by the use of a multiphase, or N-phase oscillator to modify up to N signals in selected relationship. Although it is expected that a two phase oscillator, such as a multivibrator, would be the most common and useful type of multiphase oscillator, and is therefore described herein in the specific examples of the invention, it is not intended thereby to exclude multiphase oscillators of more than two phases or stages, such as three phase and four phase ring oscillators, which will also be found to be useful for certain purposes in practicing the principles of the present invention.

By using a multiphase oscillator in the manner herein suggested, one is enabled to obtain not only the well known functions of single event percussion, reiteration of a one tone color-pitch combination, reiteration having pitch alternation, and single event speaking tones, e.g. chaff, but also the additional functions of reiteration having tone color sequence, reiteration having a sequence of entirely independent tone color-pitch combinations, N-event speaking tones such as double and triple tonguing effects, and rhythm patterns in which the beats are marked by emphasizing or de-emphasizing the tone signal, as will be appreciated from the detailed description of the invention hereinafter provided.

It is accordingly an object of the present invention to provide electronic music generation with reiteration, percussion and speaking tone effects, and particularly such effects as above suggested. And it is a further object of the present invention to provide such effects by utilization of a multiphase oscillator, wherein the different phases of the oscillator are utilized to modify different channels of audio signals, and particularly wherein the modification of different channel signals is effected in an inter-

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related manner through the relationship of the several output phases of the oscillator.

Other objects and advantages of the present invention will become apparent to those skilled in the art from a consideration of the following detailed description of one illustrative embodiment of the invention, had in conjunction with the accompanying drawings, wherein like numerals refer to like or corresponding parts, and wherein:

FIG. 1 is a block diagram of an electronic music generation system incorporating one embodiment of the invention;

FIG. 2 is a schematic drawing of a portion of the system shown in FIG. 1;

FIG. 3 is a waveform chart illustrating the waveforms produced in accordance with the present invention, and their relationship;

FIG. 4 is a partial schematic circuit diagram of a modified embodiment of the invention; and

FIG. 5 is a partial circuit schematic and partial block diagram of still another modification of the present invention.

A basic approach utilized in practicing the present invention is illustrated in the block diagram of FIG. 1. Conventional sources of musical signal are for convenience broadly designated by means of a block 11, and they are shown feeding into an output line 12 which includes an output amplifier 13 and an output signal transducer designated as a loud speaker 14. In addition, the system includes a multiphase oscillator 21 having a plurality of output phases $\phi 1, \phi 2 \dots \phi N$, each controlling a respective channel. Thus the phase $\phi 1$ output of oscillator 21 controls the $\phi 1$ channel, the phase $\phi 2$ output controls the $\phi 2$ channel, etc. Since each phase channel is identical, the description of one will suffice for all.

Each phase channel includes one or more sources of electrical audio tone signals, and two have been specifically indicated as 22 and 22a in the $\phi 1$ channel. Each of these sources may be conventional electronic single pitch tone generators. The output of source 22 is fed to an amplitude control circuit 23, then to the usual tone color filters 24, thence to the output line 12. Appropriate amplitude control circuits are well known in the art, however, a particularly desirable amplitude control circuit for practicing the present invention is shown in detail in my copending application Ser. No. 493,773, filed Oct. 7, 1965, and entitled "Conversion of Tonal Character of Aural Signals." As indicated, the $\phi 1$ channel may include any number of tone sources, each feeding its respective amplitude control circuit and tone color filter.

The phase output P1 of multiphase oscillator 21 is coupled through a wave shaper 25 to each of the amplitude control circuits 23 of the $\phi 1$ channel; and it is the function of the wave shaper 25 to provide a desired or selected waveform, effecting through the amplitude control circuits 23 a corresponding amplitude envelope for a number of cycles of the outputs from sources 22. The wave shaper 25 preferably provides a sawtooth envelope.

Considering two possible modes of operation of oscillator 21, it could be keyed on to run for a period of time, or it could be triggered into one cycle of operation. In the former mode, the several oscillator outputs $\phi 1, \phi 2 \dots \phi N$ are produced in a selected phase relationship, and the oscillator continues to cycle with this output phase relationship for the period that the oscillator is keyed on. Each phase channel is operated in synchronism with the phase of its respective oscillator output. I.e. the activated source or sources 22 in the $\phi 1$ channel are presented in the output line 12 in synchronism with the $\phi 1$ phase of the oscillator, while the activated sources in the $\phi 2$ channel are presented in the output line 12 in

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synchronism with the $\phi 2$ phase of the oscillator, etc. This mode of operation produces reiteration effects.

In the single cycle mode of operation for the oscillator 21, it is apparent that each phase channel is again activated in synchronism with its respective output phase from the oscillator in the same manner as above-described, except in this instance each channel is activated only for one oscillator cycle for each triggering of the oscillator. This mode of operation provides percussion and speaking tone effects.

Operation of the present system will be more fully understood from a consideration of FIG. 2, which is a schematic circuit diagram of a specific embodiment of the multiphase oscillator and wave shaper portions of the system, utilizing a two phase oscillator, feeding two phase channels and their corresponding two wave shaper circuits. The multiphase oscillator 21 in FIG. 2 is a multivibrator comprising transistors 31 and 32, and is designed to be free running when switch 33 is closed to position 33a. When running, the oscillator 21 produces a repetitive rectangular wave of phase $\phi 1$ at the collector of transistor 32, which is the input to the $\phi 1$ channel and to its wave shaper circuit 25a. Simultaneously, the oscillator produces a second rectangular wave output $\phi 2$, 180° out of phase with the $\phi 1$ output, at the collector of transistor 31. The oscillator $\phi 2$ output is the input to the $\phi 2$ channel and to its wave shaper circuit 25b.

With switch 34 closed to position 34a and switch 35 closed to position 35a, the base of transistor 31 is coupled to the collector of transistor 36. The stable state of transistor 36 is set to be conducting, by the current source applied through resistor 37, thereby clamping the base of transistor 31 to ground and holding this transistor cut off with transistor 32 conducting. This quiescent state of the oscillator 21 is maintained until an audio signal, as may be derived from a tone source or a key controlled oscillator, is applied to the input 38. The audio input signal is differentiated by resistance-capacitance network 39, 40, 41, and the negative pulses are passed by diode 42 to capacitor 43 and to the base of transistor 36. The pulses collected by capacitor 43 drive the base of transistor 36 negative to cut off this transistor and hold it in that state for the duration of the application of the audio signal to input 38, causing the multivibrator 21 to oscillate for this period. At the end of the audio input signal, transistor 36 returns to its conducting state, and the multivibrator reverts to its quiescent state, with transistor 31 cut off and transistor 32 conducting.

Alternatively to controlling the oscillator 21 by an audio signal, it may be controlled by a simple switch connection to ground. If switch 34 is simply opened, the multivibrator will oscillate. Therefore, for simple switch control of the oscillator, switch 34 is closed to its contact 34b, connecting the base of transistor 31 to the alternate input 44. Input 44 is intended to be connected to ground through a switch (not shown) suitably located on the keyboard of the instrument in which the invention is incorporated. Thus, when input 44 is connected to ground the multivibrator is quiescent, as above described, and when the ground connection is opened, the multivibrator oscillates.

When multivibrator 21 oscillates in free running fashion, it provides two outputs as above described. One is the $\phi 1$ output at the collector of transistor 32, and indicated in the waveform chart FIG. 3 as the square waveform 301. The other is the $\phi 2$ output, 180° out of phase with $\phi 1$ output, appearing at the collector of transistor 31, and indicated in FIG. 3 as square waveform 302. In FIG. 3, instant 314 is taken as the beginning of a period of oscillation of multivibrator 21, and instant 315 as the end of that oscillation period. Waveforms 301 and 302 are symmetrical in time; however, it may of course be desired to obtain non-symmetrical rectangular waveform outputs from the oscillator 21, such as indicated by waveforms 305 for phase $\phi 1$ and 306 for

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phase $\phi 2$. This is obtained by varying the tap on resistor 45. Likewise, it is of course important to be able to vary the frequency of the oscillator, and that is provided for by variable resistor 46.

In addition to the above described free running mode of operation, oscillator 21 can also run as a one-shot or monostable multivibrator. This is accomplished by closing switch 33 to contact 33b and switch 35 to contact 35b, causing a quiescent condition of transistor 32 conducting and transistor 31 cut off. Transistor 36 now functions as an amplifier stage with resistor 47 its load and capacitor 48 coupling it to the base of transistor 31. An audio signal at input 38 cuts off transistor 36 as above-described, and the resulting positive pulse in its collector circuit causes the multivibrator 21 to go through one cycle of operation. This action produces waveform 308 in the $\phi 1$ channel, and waveform 309 in the $\phi 2$ channel. In this mode of operation, both resistors 45 and 46 control the length or duration of the pulses forming waveforms 308 and 309.

Referring now to the wave shaper circuits, when waveform 301 is present in the $\phi 1$ channel, it is applied to wave shaper circuit 25a. This waveform is first differentiated by the resistance-capacitance network 51, 52, and the positive pulses are passed by diode 53 to capacitor 54. The resultant rapid charging and gradual discharging of this capacitor produces the sawtooth waveform 303. Transistor 55 is a phase inverter, and reproduces waveform 303 at a desired low impedance at output 56, as well as an inverted version of waveform 303 at output 57.

Since the wave shaper circuit 25b is identical to circuit 25a, it need not be further described, except to point out that the waveform 302 in the $\phi 2$ channel appears at the output 58 as sawtooth waveform 304, and an inverted form of this signal appears at output 59.

Similarly, it will be readily understood that where non-symmetrical waveforms 305 and 306 are present in the $\phi 1$ channel and $\phi 2$ channel respectively, the outputs of the wave shaper circuits are represented respectively by the sawtooth waveforms 303 and 307. It may be observed that the non-symmetrical relationship between waveforms 303 and 307 produces a loping quality to reiteration when utilized for that purpose.

When the monostable mode of operation of the multivibrator is employed, the wave shaper circuits 25a and 25b function in the same manner as above described. Consequently, the presence of rectangular waveforms 308 and 309 in the $\phi 1$ and $\phi 2$ channels respectively, produces the sawtooth outputs 310, 311, 312 and 313 respectively at the outputs 56, 58, 57, and 59.

Of course the outputs of the wave shaper circuits 25a and 25b are coupled to amplitude control circuits of their respective phase channels by means of appropriate selector switches, not shown. Thus for example, any one or more of the tone signals from sources 22 in the $\phi 1$ channel (FIG. 1) may be modified in amplitude by the wave shaper circuit output waveforms represented by 303, 310, or 312; while the signals from sources in the $\phi 2$ channel are modified by the waveforms represented by 304, 307, 311 or 313, to provide the signals with amplitude envelopes corresponding to these waveforms. By simply using the output 303 (or 304), ordinary reiteration of one tone color at one pitch is obtained. By using outputs 303 and 304 together (or non-symmetrical outputs 303 and 307), the following effects can be obtained: reiteration having the same tone color but alternating pitch; reiteration having the same pitch but alternating tone color—a tone color vibrato; and reiteration alternating between one tone color at one pitch and a second tone color at a different pitch. It has been further observed that when using the non-symmetrical waveforms 303 and 307, the loping character of the reiteration can provide a speaking tone effect. Speaking tone and percussion effects are provided by obtaining a first tone color at a first pitch modified by an amplitude envelope represented by one of the

output waveforms 310, 311, 312, or 313, and obtaining the same or a second tone color at the same or a second pitch modified by an amplitude envelope represented by a different one of these four waveforms. Waveforms 310 and 311 produce ordinary or positive beats by causing an abrupt start and gradual decay of a tone. Conversely, waveforms 312 and 313 produce negative beats by causing an abrupt stop and gradual return of a steady tone. The abrupt stopping of a tone is perceived by the ear as an ictus just as it the abrupt starting of a tone, yet the over-all tonal effect of the two types of beats is entirely different. Utilizing the waveforms 310, 311, 312, and 313 singly or in pairs, and both with and without a steady signal from conventional sources 11, numerous effects are possible. A few of the effects are as follows: ordinary percussion using waveform 310; delayed percussion using waveform 311; double percussion of double tonguing staccato effects using waveforms 310 and 311 in various tone color and pitch combinations; a speaking tone effect using waveform 312; a double tonguing effect obtained by using only waveform 313; speaking tone effects using waveforms 312 and 313 (first, 313 controlled tone only, second, 312 controlled tone only, and third, both tones together, providing a two layer, three event effect); speaking tone effects using waveforms 310 and 312 (note begins with 310 controlled tone, then changes to 312 controlled tone, providing a one lay, two event effect); speaking tone effect using waveforms 311 and 313 (note begins with 313 controlled tone, suddenly switches to 311 controlled tone, then fades back to 313 controlled tone); speaking tone effects using waveforms 310 and 313 (note begins with 310 and 313 controlled tones together, abruptly stops, and then 313 controlled tone starts and continues); speaking tone effect using waveforms 311 and 312 and a steady tone from conventional source 11 (first, tone from 11 alone, followed by both 311 and 312 controlled tones together with the tone from 11, and followed by 312 controlled tone continuing along with the tone from 11, providing a three layer, three event effect).

A modified embodiment of the invention is illustrated in FIG. 4, again utilizing as the N-phase oscillator 21, a two phase oscillator or multivibrator providing the two outputs in the $\phi 1$ channel and the $\phi 2$ channel corresponding in all respects to the $\phi 1$ and $\phi 2$ outputs in the previous embodiment. Thus, waveforms 301, 305, or 308 will be present in the $\phi 1$ channel, and waveforms 302, 306, or 309 will be present in the $\phi 2$ channel.

The $\phi 1$ output of oscillator 21 is applied through the coupling network 62 and 63 to an electronic switch 73 comprising the diode 65, rendering it alternately conductive and non-conductive. When conductive, diode 65 couples the output of electrical tone source 64 to the amplitude control circuit 23. Similarly, the $\phi 2$ output of oscillator 21 controls the electronic switch 71, to couple the output of tone source 66 to amplitude control 23 when diode 72 is conducting.

At the same time, the $\phi 1$ and $\phi 2$ outputs are coupled through lines 67 and 69 and the respective selector switches 68 and 70 to the wave shaper circuit 25c. Operation of wave shaper circuit 25c is substantially identical to wave shaper circuits 25a and 25b, and need not be further described. Thus, depending upon the mode of operation of oscillator 21 and the condition of selector switches 68 and 70, through the wave shaper circuit 25c one obtains at the emitter of transistor 61 the waveforms 303, 304, 307, 310, and 311, and the inverse of these waveforms at the collector of transistor 61. Switch 75 selectively couples these outputs to the amplitude control circuit 23, where they effect the desired amplitude envelope for the tone signals as passed by the switches 73 and 71. The output of the amplitude control circuit 23 is passed through appropriate tone color filters 24 to the audio output line 12, where it may be combined with signals from other sources, generally indicated by the numeral 11.

The operation of the embodiment of the invention shown in FIG. 4 will be apparent in view of the previous discussion of operation of the embodiment of FIGS. 1 and 2. It will be observed, however, that the present embodiment is not as flexible as the first described embodiment, since only one tone color filter system is provided for all sources controlled by the oscillator 21. Thus, the same tone color will reside throughout a given effect, and only pitch changes can be accomplished through the cycling of oscillator 21.

In still another embodiment of the invention, as illustrated in FIG. 5, the output of the N-phase oscillator 21 is utilized to control the application of an electric tone signal to selected tone color filters. Again, a two phase oscillator is used for purposes of illustration, and its two outputs $\phi 1$ and $\phi 2$ are coupled through their respective channels to electronic switches 81 and 82, corresponding in operation to switches 73 and 71 in FIG. 4. Simultaneously, the $\phi 1$ and $\phi 2$ outputs are coupled to a wave shaper 25c identical to the wave shaper in FIG. 4. A signal from electronic tone source 83 is provided with an amplitude envelope by amplitude control 23 in accordance with the waveform obtained from the output of wave shaper 25c; and the resultant signal is selectively coupled through the switches 81 and 82 to the two tone color filter circuits 24a and 24b. The outputs of the two tone color filters are combined in audio output line 12, together with other tone signals generally designated by the box 11.

It will be readily appreciated that the present system will provide many of the effects above described, in connection with the preceding embodiments, but the effects will be at a single pitch, and only tone color changes are caused by the operation of the oscillator 21.

It will thus be appreciated that the foregoing embodiments of the invention provide for certain effects in the electronic production of music, involving reiteration, percussion, and speaking tones. These embodiments are presented only as exemplary of the invention and to enable a complete understanding thereof. Accordingly, various other modifications and variations will be apparent to those skilled in the art; and such modifications and variations as are embraced by the spirit and scope of the appended claims are considered to be within the ambit of the present invention.

What is claimed is:

1. In an electronic music generation system, N channels for generating N signals of different tone characteristics, and an N-phase oscillator for actuating each of said channels by controlling the amplitude of said signals at a rate no higher than the lowest frequency of any of said signals in a predetermined time phase relationship, N being an integer greater than one, said system including tone color filter means.

2. In an electronic music generation system as set forth in claim 1, wave shaping circuit means for forming each phase output of said oscillator into a sawtooth waveform, and means responsive to said circuit means for providing a corresponding amplitude envelope for the signal in each said channel.

3. In an electronic music generation system: two tone signals generating channels; each channel including a tone signal source, an amplitude control circuit for said source, and a tone color filter circuit for said source; an oscillator having two outputs providing two signals of different phase and having a frequency no higher than the lowest frequency of either of the tone signal sources; means coupling one oscillator output to the amplitude control circuit of one channel; and means coupling the other oscillator output to the amplitude control circuit of the other channel; whereby said two channels are actuated in response to the two signals of different phase.

4. In an electronic music generation system as set forth in claim 3, each said coupling means including means

for shaping the respective oscillator output signal into a desired waveform.

5. In an electronic music generation system as set forth in claim 4, said shaping means being a sawtooth waveform source.

6. In an electronic music generation system as set forth in claim 3, said oscillator being a rectangular wave generator, and said shaping means being a sawtooth waveform source.

7. In an electronic music generation system as set forth in claim 6, said oscillator being a multivibrator and including means for causing it to operate selectively in both the astable and monostable modes.

8. In an electronic music generation system as set forth in claim 7, means for keying said multivibrator on and off.

9. In an electronic music generation system as set forth in claim 8, said multivibrator including means for selectively varying the frequency and phase relationship of its output signals.

10. In an electronic music generation system: two tone signal generating channels; each channel including a tone signal source, and a control circuit therefor; an oscillator having two outputs providing two signals of different phase and having a frequency no higher than the lowest frequency of either of the tone signal sources, means coupling one output to the control circuit of one channel; and means coupling the other oscillator output to the control circuit of the other channel; whereby said two channels are actuated in response to the two signals of different phase.

11. In an electronic music generation system as set forth in claim 10, an amplitude control circuit for controlling the output amplitude of said two channels.

12. In an electronic music generation system as set forth in claim 11, a sawtooth waveform generator responsive to the two oscillator output signals, and means coupling the generator output to the amplitude control

circuit for providing corresponding amplitude envelopes for the outputs of said two channels.

13. In an electronic music generation system, a tone signal source, two tone signal channels fed by said source, each said channel including a tone color circuit and an electronic switch circuit for selectively coupling and decoupling said source to said tone color circuit, an oscillator having two outputs providing two signals of different phase and having a frequency no higher than the frequency of said tone signal source, means coupling one oscillator output to the electronic switch circuit of one channel to control that switch circuit, and means coupling the other oscillator output to the electronic switch circuit of the other channel to control that switch circuit, whereby said two channels are actuated in response to the two signals of different phase.

14. In an electronic music generation system as set forth in claim 13, an amplitude control circuit for controlling the output amplitude of said tone signal source.

15. In an electronic music generation system as set forth in claim 14, a sawtooth waveform generator responsive to the two oscillator output signals, and means coupling the generator output to the amplitude control circuit for providing corresponding amplitude envelopes for the output of said signal source.

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