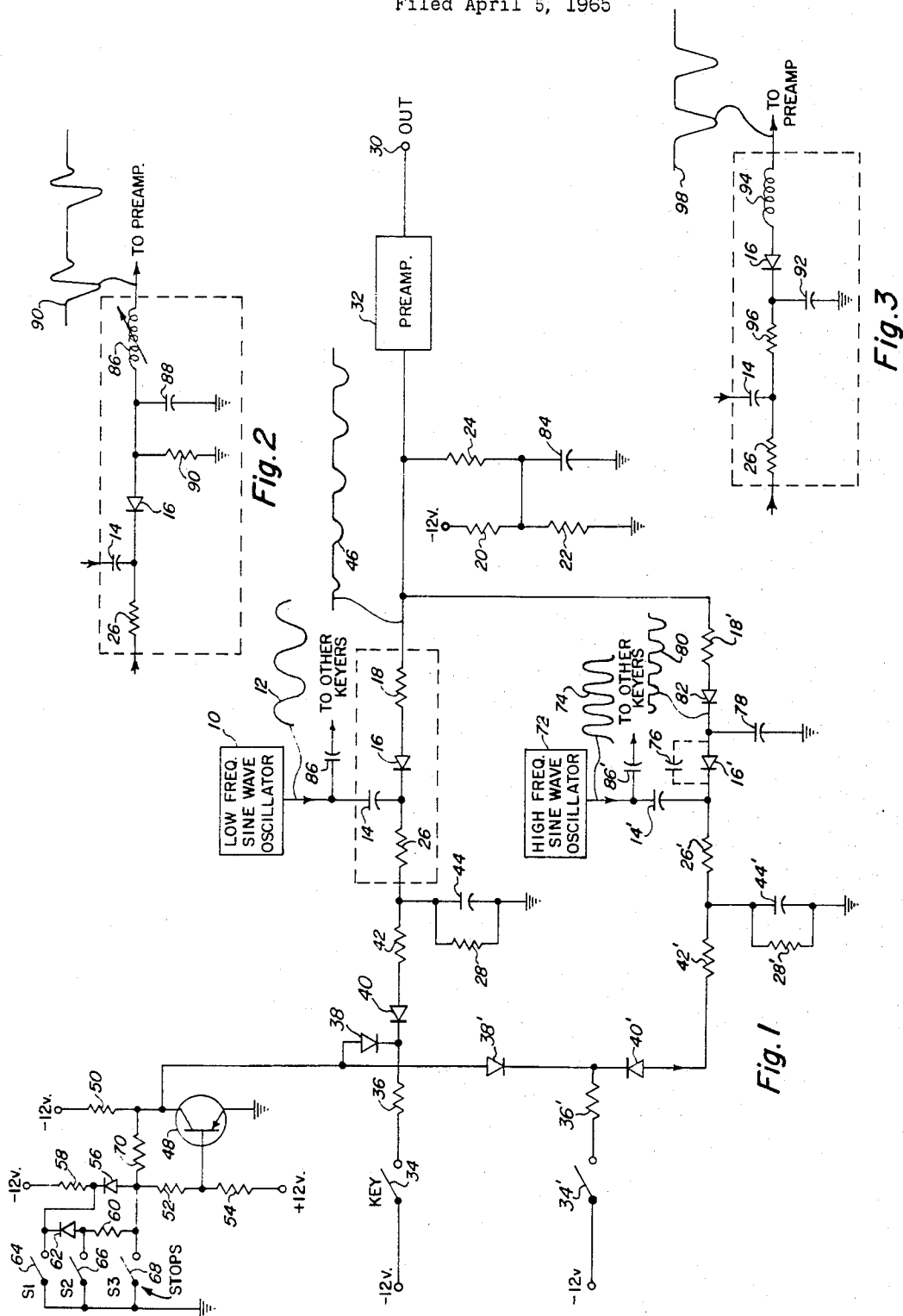


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KEYING AND WAVE-SHAPING CIRCUIT FOR ELECTRONIC
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FREDERICK B. TINKER
INVENTOR

BY *BUCKHORN, BLORE, KLARQUIST & SPARKMAN*
ATTORNEYS

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KEYING AND WAVE-SHAPING CIRCUIT FOR ELECTRONIC MUSICAL INSTRUMENT

Frederick B. Tinker, Beaverton, Oreg., assignor to Rodgers Organ Company, Hillsboro, Oreg., a corporation of Oregon

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ABSTRACT OF THE DISCLOSURE

A keying and wave-shaping circuit for an electronic organ is described in which the output of a free running sine wave oscillator is gated by a normally nonconducting gating diode. Different keying voltages are applied to the gating diode to enable it to be rendered conducting by the sine wave to vary the width of the transmitted sine wave pulses and therefore the harmonic content of the output signal of such circuit. The keying voltages are produced by charging and discharging a keying capacitance connected to the gating diode from a D.C. voltage source when a key switch is closed and opened to provide gradual attack and decay effects in such output signal. The different steady state keying voltages are produced by a voltage clamping diode connected to the keying capacitance and having means including a plurality of stop switches for selectively applying different D.C. reference voltages to the clamping diode to reverse bias such diode until the voltage on the keying capacitance exceeds the selected reference voltage and renders the diode conducting to limit further charging of the keying capacitance.

The subject matter of the present invention relates generally to electronic musical instruments and in particular to a keying and wave-shaping circuit including a gating diode for transmitting a repetitive periodic signal from a continuously running oscillator through such circuit when such gating diode is rendered conducting. The present keying and wave-shaping circuit modifies an oscillator signal by applying different keying voltages to the gating diode to change the harmonic content or quality of the output signal of the circuit. Also by gradually increasing the keying voltage at the beginning of a keying operation and gradually decreasing such keying voltage at the end of a keying operation "attack" and "decay" effects, respectively, are produced in the output signal with harmonic contents which vary during such effects. The result is a pleasing musical sound and in many cases this type of keying more realistically reproduces the sound of a musical instrument being simulated than prior electronic circuits.

The keying and wave-shaping circuit of the present invention is especially useful in electronic organs. Such electronic organs require a large number of such circuits to produce all the musical tones required. A plurality of such keying and wave-shaping circuits may be connected to the output of a continuously running sine wave oscillator to enable one oscillator to simultaneously produce a plurality of output signals of different musical tone, quality or effect. By employing a sine wave oscillator, the quality of "voice" or musical tone may be changed in a simple and inexpensive manner merely by clipping off the peak portion of the sine wave signal at different amplitudes with the gating diode, and transmitting such clipped peak portions as the output signal. This is possible because the width of a sine wave changes continuously so that output signals including portions clipped from the sine wave half cycle at different distances from its axis contain different amounts of harmonics. Thus an output signal made up of the narrower clipped portions taken from the extreme peak of the sine wave half cycles have

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a greater harmonic content than an output signal made up of the wider portions clipped nearer to the axis of the sine wave. The ratio of the pulse width of the clipped output signal to the length of one cycle of such signal is one factor which determines the harmonic content of the output signal both as to the number of harmonics and their amplitudes. In general the smaller this ratio is the greater is the harmonic content of the output signal. Similarly, a sawtooth signal also has a width which changes with different distances from the axis of such signal so that it can also be clipped in a similar manner and the clipped peak portions transmitted to change the tone quality of the resulting output signal. It is apparent that a square wave signal cannot be clipped in this manner to vary the harmonic content of the output signal because the width of such square wave signals is constant.

Another advantage of the circuit of the present invention is that it employs a single diode to perform both the keying and wave-shaping functions and, as a result, is simpler and less expensive than previous circuits of this type. The present circuit also employs a simple voltage regulator circuit including a single transistor for applying a plurality of different D.C. keying voltages to the gating diode in order to clip the sine wave signal at different levels to change the quality of the output signal. This, together with the fact that a plurality of different keying and wave-shaping circuits can be connected to the output of the same sine wave oscillator provides an extremely versatile system which can produce a great number of different musical signals by means of a relatively small number of components. In addition a stable sine wave oscillator is less expensive to build than a square wave oscillator and it is also much easier to produce a good diapason signal from a sine wave than it is from a square wave.

It is therefore one object of the present invention to provide an improved keying and wave-shaping circuit for an electronic musical instrument which is simpler, less expensive and more versatile.

Another object of the invention is to provide an improved keying and wave-shaping circuit for an electronic musical instrument in which both of these functions are performed by a single gating diode.

A further object of the invention is to provide an improved system for an electronic organ including a continuously running sine wave oscillator having its output connected to a plurality of different keying and wave-shaping circuits in which the sine wave signal may be clipped at different levels merely by changing the keying voltage of such circuit in order to produce different musical tone qualities.

An additional object of the present invention is to provide an improved keying and wave-shaping circuit for keying the output of a continuously running oscillator in which the attack and decay portions of the musical tone signal transmitted from the circuit are produced by gradually varying the bias voltage on a gating diode in such circuit.

Still another object of the present invention is to provide an improved keying and wave-shaping circuit for an electronic organ in which a gating diode and a resonant circuit are employed to produce a musical signal of the desired waveform in a simple and inexpensive manner.

Other objects and advantages of the present invention will be apparent from the following detailed description of preferred embodiments thereof as shown in the attached drawing, of which:

FIG. 1 is a schematic diagram of a signal generating system for an electronic organ, employing the keying and wave-shaping circuit of the present invention;

FIG. 2 is a schematic diagram of another embodiment of the portion of the keying and wave-shaping circuit in the system of FIG. 1 surrounded by a dashed line; and

FIG. 3 is a schematic diagram of a third embodiment of the dashed line portion of the keying and wave-shaping circuit of FIG. 1.

As shown in FIG. 1, a signal generating system in accordance with the present invention for use in an electronic organ includes a free-running sine wave oscillator 10, which continuously generates a sine wave signal 12 having a peak-to-peak voltage of about 1.5 volts and a low frequency on the order of 440 cycles per second. The output of oscillator 10 is connected through a coupling capacitor 14 of 0.1 microfarad to the cathode of a gating diode 16. The anode of a gating diode 16 is connected through a coupling resistor 18 of 8.2 kilohms to a load impedance including a voltage divider formed by a pair of series-connected resistors 20 and 22 of 1.8 kilohms and 220 ohms, respectively, connected between a negative D.C. voltage source of -12 volts and ground. The common terminal of the voltage divider resistors 20 and 22 is held at a negative D.C. voltage of about -1.2 volts, which is applied to one terminal of a load resistor 24 of 150 ohms whose other terminal is connected to the anode of the gating diode 16. The voltage drop across resistor 24 causes a negative D.C. bias voltage of about -1.0 volt to be applied to the anode of the gating diode which quiescently reverse biases such diode nonconducting since its cathode is connected to ground through a pair of series-connected resistors 26 and 28 of 470 kilohms and 330 kilohms, respectively. Thus, the gating diode 16 normally prevents the sine wave signal 12 produced by the oscillator 10 from being transmitted to the output terminal 30 of a preamplifier 32 connected to the anode of such gating diode through resistor 18.

a normally open key switch 34, having one terminal connected to a negative D.C. voltage source of -12 volts and its other terminal connected through a coupling resistor 36 of 68 kilohms to the common connection of the cathodes of a pair of coupling diodes 38 and 40, is closed to reduce the reverse bias voltage on the gating diode 16 and enable such diode to be rendered conducting by negative portions of the sine wave signal 12. The anode of coupling diode 40 is connected through a charging resistor 42 of 220 kilohms to one terminal of a bias capacitor 44 of 0.1 microfarad whose other terminal is grounded. Thus, when the key switch 34 is closed, current flows from the -12 volts source through coupling diode 40 and charging resistor 42 to charge the bias capacitor 44 and coupling capacitor 14 gradually at a rate determined by the RC time constant of such bias capacitor and resistors 36 and 42 and the RC time constant of coupling capacitor 14 and resistors 36, 42 and 26. The voltage produced on the bias capacitor 44 and the coupling capacitor 14 which together form the keying capacitance is applied to the cathode of the gating diode 16 through coupling resistor 26 and acts as a keying voltage to gradually reduce the reverse bias voltage on such gating diode so that it is rendered conducting by the negative half cycles of the sine wave 12.

As the negative keying voltage on the bias capacitor 44 increases the gating diode is rendered conducting during a greater portion of the sine wave for each successive cycle. As a result, the sine wave rectified or clipped and transmitted through the gating diode as an output signal 46 is in the form of negative pulses, which gradually increase in amplitude and width with each successive pulse until a steady state maximum amplitude is reached corresponding to the maximum value of the keying voltage produced on the bias capacitor 44. This gradual increase in the keying voltage provides an "attack" effect at the beginning of the output signal which simulates the operation of a pipe organ. Similarly, the keying voltage gradually decreases from its steady state value to zero after the key switch 34 is reopened as the voltage on the

capacitor 44 discharges through the shunt resistor 28 connected across such capacitor. This produces a gradual "decay" effect at the end of the output signal.

The maximum steady state keying voltage produced on the bias capacitor 44 is determined by the value of the negative D.C. reference voltage applied to the anode of coupling diode 38, since such diode acts as a voltage comparator device or clamp to prevent its cathode voltage from exceeding a corresponding value slightly more negative than its anode voltage. Thus diode 38 clamps the maximum voltage on capacitor 44 to the D.C. reference voltage applied to such diode by a transistor 48. The anode of clamping diode 38 is connected to the collector of transistor 48 of a PNP type whose emitter is grounded and whose collector is connected to a source of negative D.C. supply voltage of -12 volts through a load resistor 50 of 1.2 kilohms. The base of transistor 48 is connected to the common terminal of a pair of series-connected resistors 52 and 54 of 1.5 kilohms and 27 kilohms, respectively, which form a voltage divider along with a diode 56 whose anode is connected to resistor 52 and whose cathode is connected to a resistor 58 of 4.7 kilohms. The end terminals of the voltage divider network at resistors 54 and 58 are connected respectively to D.C. voltage sources of +12 volts and -12 volts. In addition, a resistor 60 of 1.5 kilohms and a diode 62 are connected in series across the diode 56 in the voltage divider string.

Three normally open stop switches 64, 66 and 68 labelled S1, S2 and S3, are respectively connected between ground and the cathode of diode 56, between ground and common terminal of resistor 60 and the anode of diode 62, and between ground and the anode of diode 56. When all of the stop switches 64, 66 and 68 are opened, the voltage produced on the collector of transistor 48 is about -0.1 volt, which means that the clamping diode 38 is rendered conducting immediately after the key switch 34 is closed, so that only a very small negative charge is produced on the bias capacitor 44 which is insufficient to enable the gating diode 16 to be rendered conducting by the sine wave signal. However, when stop switch 64 is closed, a collector voltage of about -2.5 volts is produced on the collector of transistor 48 by current flowing from load resistor 50 to the base of such transistor through a shunt resistor 70 connected between such collector and resistor 52. As a result a negative bias voltage is applied to the base of transistor 48 and to the anodes of diodes 56 and 62 to render such transistor conducting and such diodes nonconducting. This negative collector voltage means that the clamping diode 38 is reverse biased, so that such diode is not rendered conducting when the key switch 34 is closed until after the bias capacitor is charged to a steady state voltage of a value which is sufficient to enable the gating diode 16 to be rendered conducting by the peak portions of the negative half cycles of the sine wave signal 12. When stop switch 66 is closed, diode 62 is rendered conducting and diode 56 nonconducting, so a reference voltage of -4.6 volts is produced on the collector of transistor 48. When stop switch 68 is closed, diodes 56 and 62 are both rendered conducting and the transistor is rendered nonconducting because its base is positive with respect to its emitter, which causes a reference voltage of about -6.6 volts to be produced on the collector of such transistor.

As a result of the more negative collector voltage when stop switch 66 is closed, the bias capacitor 44 is charged to a greater negative D.C. voltage before clamping diode 38 conducts than when stop switch 64 is closed. Also when stop switch 68 is closed, the bias capacitor 44 charges to an even higher negative D.C. keying voltage than when either of the other stop switches is closed. The greater negative voltage produced on the bias capacitor causes the gating diode 16 to conduct a greater portion of the negative half cycle of the sine wave 12 and produces a more string-like tone. Thus, when stop switch 68 is closed

to provide a collector voltage of -6.6 volts, closing of the key switch 34 causes the gating diode 16 to transmit a substantially complete negative half cycle of the sine wave after charging of the bias capacitor 44 to produce the initial "attack" effect. This output signal is employed as a diapason organ tone, since the power of its harmonics is a lower percentage of the fundamental frequency power than the harmonics in the output signals produced by the closing of the other two stop switches. The transistor 48 acts as a voltage regulator, which maintains its collector voltage substantially constant even after the key switch 39 is closed. The shunt resistor 70 provides negative voltage feedback which assists in maintaining the collector voltage substantially constant.

The present system may also employ another sine wave oscillator 72, which continuously generates a high frequency sine wave 74 of, for example, 1319 cycles per second. The output of oscillator 72 is connected through a coupling capacitor 14' to the cathode of a gating diode 16' which is operated by a key 34' in a similar manner to oscillator 10. The attack and decay wave-shaping circuit for gating diode 16' including bias capacitor 44' is similar to that described above with regard to gating diode 16, so that the same parts have been given similar reference numerals except for a prime (') notation. However, it should be noted that coupling capacitor 14' and bias capacitor 44' are .05 microfarad and coupling resistor 26' is 1.6 megohms. The coupling diode 38' which clamps the maximum voltage of the bias capacitor 44' is also connected to the collector of the same voltage regulator transistor 48 as coupling diode 38. However, it is also possible to key several oscillators from the same key switch if appropriate stop switches are provided.

It has been found that some of the high frequency sine wave signal 74 is fed through the stray leakage capacitance 76 across gating diode 16', even though such diode is reverse biased nonconducting. In order to solve this problem a high frequency bypass capacitor 78 of 120 picofarads is connected between the anode of gating diode 16' and ground to form a capacitance voltage divider with stray capacitance 76 in keying circuits connected to an oscillator with a frequency above about 1000 cycles per second. In addition an isolation diode 82 is connected between the ungrounded terminal of the bypass capacitor 78 and the coupling resistor 18'. The stray capacitance 76 of the gating diode is about .5 picofarads when such diode is reverse biased so that most of the feedthrough signal is attenuated by the bypass capacitor because of its large capacitance and low impedance and because diode 82 is also reverse biased to cause the stray leakage capacitance and shunt capacitance to ground of such diode to form a second voltage divider across capacitor 78. The shunt capacitance of diode 82 is much smaller than that of bypass capacitor 78 and prevents the resistor 18' from diverting the feedthrough signal away from such bypass capacitance due to its having an impedance lower than that of the bypass capacitance but higher than that of such shunt capacitance. However, when the gating diode 16' and isolation diode 82 are rendered conducting, their stray capacitance does not prevent the amount of signal transmitted through resistor 18' from exceeding that of the bypass capacitance 78 due to the lower impedance of such resistor. In order to provide this impedance relationship the coupling resistor 18' is increased in value to 27 kilohms.

The bias circuit including voltage divider resistors 20 and 22 is used for both of the gating diodes 16 and 16' and may be provided with a bypass capacitor 84 connected between the common terminal of such resistors and ground. Such bypass capacitor has a value of about 100 microfarads so that both output signals 46 and 80 are transmitted to ground through such capacitor, which means that resistor 24 is the load resistor for both circuits.

In order to produce other quality musical signals such

as reed or flute signals, the outputs of the sine wave oscillators 10 and 72 may be connected to other keying circuits (not shown) through coupling capacitors 86 and 86' respectively. Such other keying circuits may be provided with filters between the output of their gating diodes and the input of their preamplifiers in order to further modify the wave shape of the output signal. Alternatively, this wave-shaping can be accomplished directly in the keying circuit by employing either of the modifications shown in FIGS. 2 and 3, in place of that portion of the circuit in FIG. 1 enclosed by a dashed line. Thus, if a reed quality musical tone is desired, the coupling resistor 18 is replaced by the resonant circuit of FIG. 2, including a variable coupling inductance 86 connected between the anode of gating diode 16 and the input of the preamplifier and a shunt capacitance 88 of .1 microfarad connected between the anode of such gating diode and ground. The values of the coupling capacitor 14 and the coupling resistor 26 are changed to .22 microfarad and 2.2 megohms respectively. Normally, the resonant circuit is tuned to a harmonic of the sine wave input signal applied to the coupling capacitor 14 in order to produce a reed-like output signal 90. However, it is also possible to produce a flute voice by tuning the resonant circuit to the fundamental frequency of the sine wave input signal, since this will cause the output signal 90 to be a full sine wave signal. Of course it is also possible to forward bias gating diode 16 of FIG. 1 by charging the bias capacitor 44 to a highly negative voltage which is sufficient to enable the entire sine wave signal 12 to be transmitted through such gating diode instead of only the negative half cycles of such sine wave. However, this would cause some distortion during the attack effect discussed previously because the wave shape of the signal changes drastically due to the clipping action of the gating diode. A damping resistor 90 of 1.5 kilohms is connected across capacitor 88 in order to reduce ringing in the resonant circuit.

Another wave-shaping circuit is shown in FIG. 3 which can be employed in place of the circuit of FIG. 2 to produce a reed-like tone. In this embodiment a shunt capacitor 92 of .1 microfarad is connected between the cathode of the gating diode 16 and ground, and an inductance 94 of 100 millihenries is connected between the anode of the gating diode and the input of the preamplifier in order to provide a resonant circuit when such gating diode is rendered conducting. In addition, a coupling resistor 96 of 10 kilohms is connected between the coupling capacitor 14 and the cathode of gating diode 16. In this example the coupling capacitor 14 is also .22 microfarad while the coupling resistor 26 is 470 kilohms. It can be seen that the output signal 98 of the circuit of FIG. 3 is in the form of negative peaks which produce a different sounding reed tone than the complex output signal 90 of the circuit of FIG. 2.

It is apparent that the oscillators 10 and 72 may form part of a set of oscillators of which there is one oscillator for each note of an equal tempered chromatic scale and that there will be a key such as a key 34 or 34' for each oscillator of the set. Thus the oscillator 10 may, for example, produce the tone of A above middle C and the oscillator 72 may produce the tone of E two octaves above middle C. The frequency below which keying circuits of the type shown associated with oscillator 10 are employed and above which keying circuits of the type shown associated with the oscillator 72 are employed may, for example, be just below the tone of C two octaves above middle C, or approximately 1000 cycles per second.

It will also be apparent that with appropriate organ stop switching circuits the key switches such as switches 34 and 34' may be employed to simultaneously or separately key other sets of tone generators such as, for example, a higher or lower pitch set of constantly running oscillators of the type shown in FIG. 1 or a set of oscillators to which direct current power is supplied to cause

one of the oscillators to oscillate only when a corresponding key is depressed.

It will be obvious to one having ordinary skill in the art that various changes may be made in the details of the above described preferred embodiments of the present invention without departing from the spirit of the invention. For example, input signals other than sine waves can be employed, although they are preferable due to the fact that they can produce a diapason signal most easily. Therefore the scope of the present invention should only be determined by the following claims.

I claim:

1. A keying and wave-shaping circuit for an electronic musical instrument, comprising:

a gating diode connected between the signal input terminal and the signal output terminal of said circuit; bias means for applying a reverse bias voltage to said gating diode to quiescently bias said gating diode nonconducting to prevent an input signal applied to said input terminal from being transmitted through said diode to said output terminal;

keying means including a capacitor connected to said diode, a source of forward bias voltage and a switch connected between said capacitor and said source of forward bias voltage, for gradually decreasing the reverse bias voltage on the gating diode from an initial quiescent voltage to a steady state keying voltage in one position of said switch in order to cause said gating diode to be rendered conducting by the input signal so that portions of said input signal are transmitted to said output terminal as an output signal whose amplitude gradually increases with successive cycles until a maximum amplitude is reached, and for gradually returning the bias voltage on said gating diode from said steady state keying voltage back to said quiescent voltage in another position of said switch so that the amplitude of the output signal gradually decreases with successive cycles until said output signal terminates; and

clamping means for limiting the maximum voltage to which the capacitor can be charged, including a voltage comparator device connected to said capacitor and means for applying a D.C. reference voltage to said comparator device to bias it nonconducting until the voltage on said capacitor renders said comparator device conducting.

2. A keying and wave-shaping circuit for an electronic musical instrument, comprising:

a free running oscillator continuously generating a signal; a gating device connected between the output of said oscillator and the output terminal of said circuit; bias means for applying a reverse bias voltage to said gating device to quiescently bias said gating device nonconducting to prevent said oscillator signal from being transmitted through said device to said output terminal;

keying means including a capacitor connected to said gating device, a source of forward bias voltage and a switch connected between said capacitor and said source of forward bias voltage, for gradually decreasing the reverse bias voltage on the gating device from an initial quiescent voltage to a steady state keying voltage when said switch is closed in order to cause said gating device to be rendered conducting by the oscillator signal so that portions of said oscillator signal are transmitted to said output terminal as an output signal whose amplitude gradually increases with successive cycles until a maximum amplitude is reached, and for gradually returning the bias voltage on said gating device from said steady state keying voltage back to said quiescent voltage when said switch is opened so that the amplitude of the output signal gradually decreases

with successive cycles until said output signal terminates; and

clamping means for limiting the maximum voltage to which said capacitor can be charged, including a voltage comparator device connected to said capacitor and means for selectively applying different D.C. reference voltages to said comparator device to bias it nonconducting until the voltage on said capacitor exceeds said reference voltage and renders said comparator device conducting.

3. A keying and wave-shaping circuit for an electronic musical instrument, comprising:

a free running sine wave oscillator continuously generating a sine wave signal;

a gating diode connected between the output of said oscillator and the output terminal of said circuit;

bias means for applying a reverse bias voltage to said gating diode to quiescently bias said gating diode nonconducting to prevent said sine wave signal from being transmitted through said diode to said output terminal;

keying means including a keying capacitor connected to said diode, a source of forward bias voltage, and a switch connected between said keying capacitor and said source of forward bias voltage, for gradually decreasing the reverse bias voltage on the gating diode from an initial quiescent voltage to a steady state keying voltage when said switch is closed in order to cause said gating diode to be rendered conducting by the sine wave signal so that portions of said sine wave signal are transmitted to said output terminal as an output signal whose amplitude gradually increases with successive cycles until a maximum amplitude is reached, and for gradually returning the bias voltage on said gating diode from said steady state keying voltage back to said quiescent voltage when said switch is opened so that the amplitude of the output signal gradually decreases with successive cycles until said output signal terminates; and

clamping means including a clamping diode connected to said keying capacitor and switch means for selectively applying several different D.C. reference voltages to reverse bias said clamping diode by different amounts so that said clamping diode is rendered conducting at different voltages on the keying capacitor in order selectively to vary the value of said steady state keying voltage to change the pulse width of the output signal and thereby vary its harmonic content.

4. A keying and wave-shaping circuit for an electronic musical instrument, comprising:

a free running oscillator continuously generating a signal;

a gating diode connected between the output of said oscillator and the output terminal of said circuit;

a resonant circuit including an inductance and a capacitance connected between said oscillator and said output terminal to produce an output signal for each oscillator signal transmitted through said gating diode;

bias means for applying a reverse bias voltage to said gating diode to quiescently bias said gating diode nonconducting to prevent said oscillator signal from being transmitted through said diode;

keying means including a capacitor connected to said gating diode, a source of forward bias voltage and a switch connected between said capacitor and said source of forward bias voltage, for gradually decreasing the reverse bias voltage on the gating diode from an initial quiescent voltage to a steady state keying voltage when said switch is closed in order to cause said gating diode to be rendered conducting by the oscillator signal so that portions of said oscillator signal are transmitted to said resonant circuit to produce an output signal whose amplitude grad-

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ually increases with successive cycles until a maximum amplitude is reached, and for gradually returning the bias voltage from said steady state voltage back to said quiescent voltage when said switch is opened so that the amplitude of the output signal gradually decreases with successive cycles until said output signal terminates; and

clamping means for varying the value of said steady state keying voltage, including a clamping diode connected to said capacitor and switch means for selectively applying different D.C. reference voltages to said clamping diode to reverse bias said clamping diode by different amounts so that the clamping diode is rendered conducting at different voltages on said capacitor.

5. A keying and wave-shaping circuit for an electronic musical instrument, comprising:

- a gating diode connected between the input and output terminals of said circuit;
- means for quiescently biasing said gating diode non-conducting;
- a bias capacitance connected to the input of said gating diode;
- a D.C. voltage source of charging current;
- a charging resistance connected between the source of charging current and said bias capacitance;
- a discharging resistance connected to said bias capacitance;
- a key switch connected between said source of charging current and said bias capacitance;
- reference voltage means for producing a substantially constant D.C. reference voltage and for varying the value of said reference voltage in predetermined steps; and
- a pair of coupling diodes each having one terminal connected to said switch, with the other terminal of one coupling diode connected to said reference voltage means and the other terminal of the other coupling diode connected to said bias capacitor, said one coupling diode being biased nonconducting by said reference voltage until the voltage on said bias capacitor reaches a keying voltage, corresponding to said reference voltage, which renders said one coupling diode conducting to maintain said keying voltage substantially constant.

6. A keying and wave-shaping circuit for an electronic musical instrument, comprising:

- a gating diode connected between the input and output terminals of said circuit;
- means for quiescently biasing said gating diode non-conducting;
- a coupling capacitance connected between the input of said gating diode and said input terminal;
- a coupling resistance having one terminal connected to the input of said gating diode;
- a bias capacitance connected between the other terminal of said coupling resistance and ground;
- a D.C. voltage source of charging current;
- a charging resistance connected between the source of charging current and said bias capacitance;
- a discharging resistance connected across said bias capacitance;
- a key switch connected between said source of charging current and said bias capacitance;
- voltage regulator means including a transistor, for producing a substantially constant D.C. reference voltage and for varying the value of said reference voltage in predetermined steps; and
- a pair of coupling diodes each having one terminal connected to said switch with the other terminal of one coupling diode connected to said voltage regulator means and the other terminal of the other coupling diode connected to said bias capacitor, said one coupling diode being biased nonconducting by said reference voltage until the voltage on said bias

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capacitor reaches a keying voltage which renders said one coupling diode conducting to maintain said keying voltage substantially constant.

7. A keying and wave-shaping circuit for an electronic organ, comprising:

- a free running sine wave oscillator continuously generating a sine wave signal;
- a gating diode connected between the output of said oscillator and the output terminal of said circuit;
- means for quiescently biasing said gating diode non-conducting;
- a coupling capacitance connected between the input of said gating diode and the output of said oscillator;
- a bias capacitance connected between the input of said gating diode and ground;
- a D.C. voltage source of charging current;
- a charging resistance connected between the source of charging current and said bias capacitance;
- a discharging resistance connected across said bias capacitance;
- a key switch connected between said source of charging current and said bias capacitance to charge said bias capacitor to a keying voltage which causes said gating diode to transmit at least a portion of said sine wave;
- voltage regulator means including a transistor, for producing a substantially constant D.C. reference voltage and for varying the value of said reference voltage in predetermined steps; and
- a pair of coupling diodes each having one terminal connected to said switch, with the other terminal of one coupling diode connected to said voltage regulator means and the other terminal of the other coupling diode connected to said bias capacitor, said one coupling diode being biased nonconducting by said reference voltage until the voltage on said bias capacitor reaches a keying voltage, corresponding to said reference voltage, which renders said one coupling diode conducting to maintain the keying voltage substantially constant.

8. A keying and wave-shaping circuit for an electronic organ, comprising:

- a free running sine wave oscillator continuously generating a sine wave signal;
- a gating diode connected between the output of said oscillator and the output terminal of said circuit;
- means for quiescently biasing said gating diode non-conducting;
- a coupling capacitance connected between the input of said gating diode and the output of said oscillator;
- a coupling resistance having one terminal connected to the input of said gating diode;
- a bias capacitance connected between the other terminal of said coupling resistance and ground;
- a D.C. voltage source of charging current;
- a charging resistance connected between the source of charging current and said bias capacitance;
- a discharging resistance connected across said bias capacitance;
- a key switch connected between said source of charging current and said bias capacitance to charge said bias capacitor to a keying voltage when said key switch is closed, which causes said gating diode to transmit at least a portion of said sine wave;
- reference voltage means for producing a substantially constant D.C. reference voltage including stop switches for varying the value of said reference voltage in predetermined steps;
- a pair of coupling diodes each having one terminal connected to said switch, with the other terminal of one coupling diode connected to said reference voltage means and the other terminal of the other coupling diode connected to said bias capacitor, said one coupling diode being biased nonconducting by said reference voltage until the voltage on said bias capacitor reaches a keying voltage which renders said one

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coupling diode conducting to maintain the keying voltage constant until said key switch is opened;
 an output coupling resistance connected between the output of said gating diode and the output terminal of the circuit;
 a bypass capacitor connected between the output of said gating diode and ground to compensate for the stray leakage capacitance across said gating diode; and
 an isolation diode connected between said output terminal and the common terminal of said bypass capacitor and said gating diode, said isolation diode being quiescently reverse biased and having a stray shunt capacitance of lower value than said bypass

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capacitor so that the impedance of said output coupling resistance is higher than the impedance of said shunt capacitance and lower than the impedance of said bypass capacitor at the frequency of said sine wave signal.

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