

Oct. 4, 1949.

T. J. GEORGE

2,483,823

ELECTRONIC KEYING MEANS

Filed April 7, 1947

2 Sheets-Sheet 1

FIG. 1

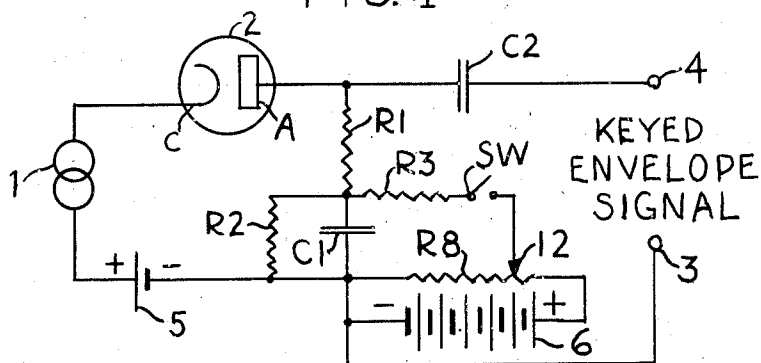


FIG. 2

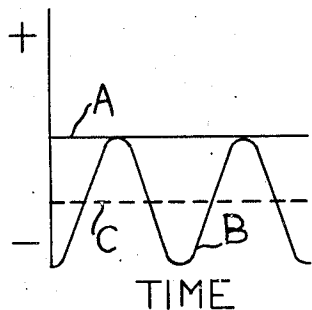


FIG. 3

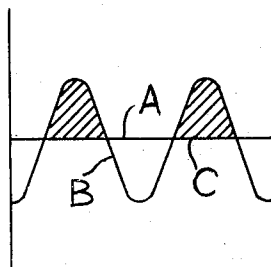


FIG. 4

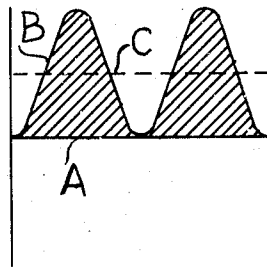
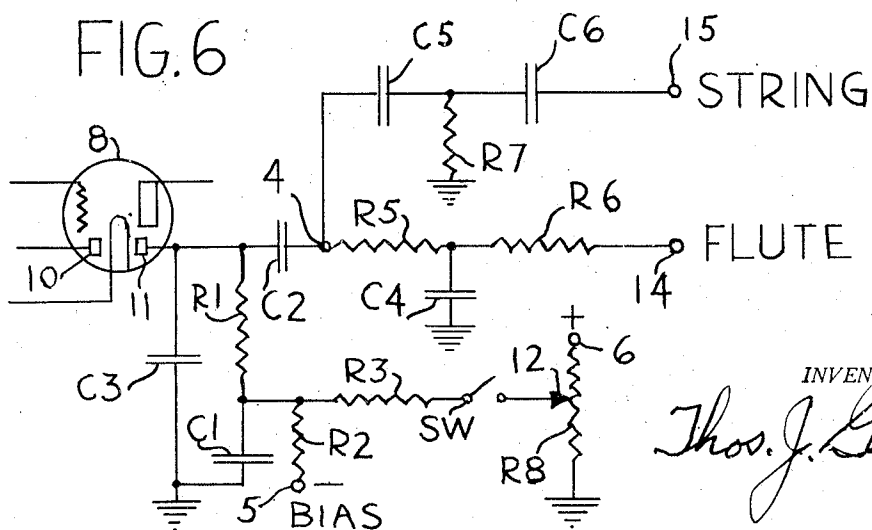


FIG. 6



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FIG. 5

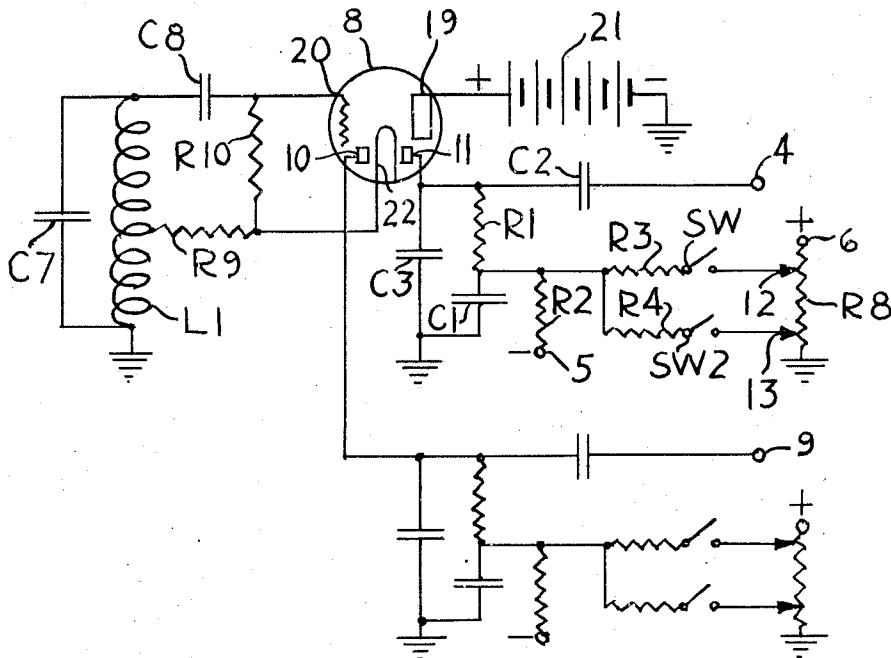
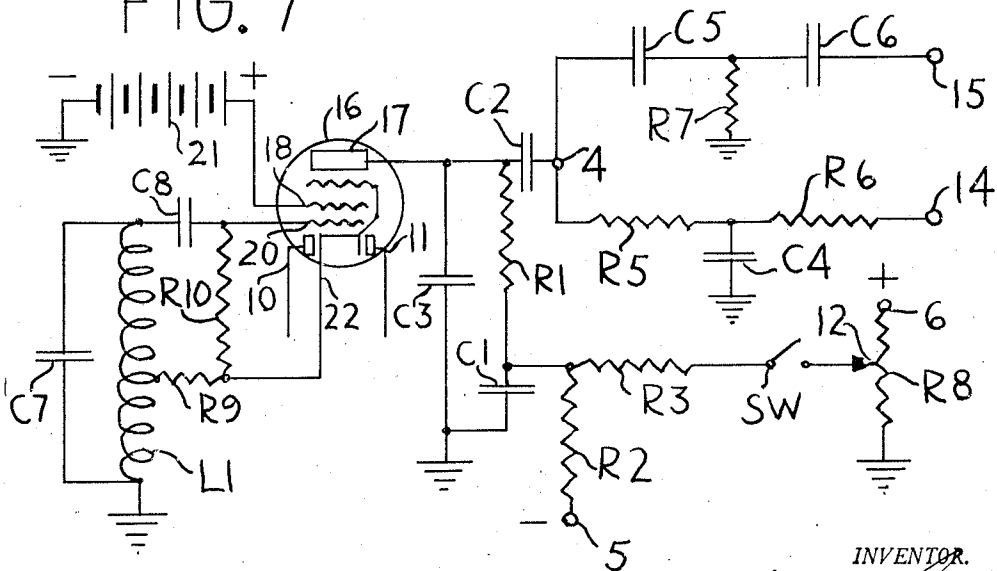


FIG. 7



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ELECTRONIC KEYING MEANS

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20 Claims. (Cl. 84—1.26)

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The present invention relates in general to electronic musical instruments and in particular to improvements in instruments of this type which employ electronic keying means to produce keyed envelope signals.

In certain forms of electronic musical instruments the signal is keyed directly thus causing the signal to start and stop instantaneously in accordance with the operation of the playing key. This produces a transient or key thump in the sound reproducing system which, particularly in electronic organs, is considered to be a very undesirable musical effect.

In accordance with the present invention it is proposed to overcome the effects of key thumps or transients by employing a keying voltage which is applied to electronic keying means through a network which produces a gradual attack and decay of the musical notes. Such network not only eliminates the key thump but provides the means for obtaining artificial reverberation, which is a very important musical effect, particularly in the playing of organ literature.

It is an object of the present invention to provide an improved system for electronic musical instruments whereby keyed envelope signals may be employed without the introduction of undesirable transient effects.

It is another object of the present invention to provide an improved keying means for electronic musical instruments, whereby a gradual attack and decay of musical notes can be obtained.

Another object is to provide in an electronic musical instrument means whereby artificial reverberation can be introduced into the music being produced by the instrument.

A still further object of the present invention is to provide in an electronic organ, means for obtaining a keyed envelope attack in conjunction with any of the conventional signal sources.

Another object is to provide means, toward the end of economy, in an electronic organ, whereby a conventional multipurpose vacuum tube may be employed to provide the signal source and a plurality of electronic keying means in one tube.

Another object of this invention is to provide means of obtaining more than one type of tone quality from each source of keyed envelope signal.

Other objects will appear from the following description, reference being had to the accompanying drawings, in which:

Figure 1 shows a fundamental form of the invention, in which a diode is used to obtain a keyed envelope signal.

Figures 2, 3, and 4, show three different voltage operation conditions of a diode, used as electronic keying means.

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Figure 5 shows a form of the invention in which a triode twin diode is used to provide an electronic signal generating means, with two electronic keying means each providing a separate source of keyed envelope signal.

Figure 6 illustrates one means for obtaining two different types of tone quality from one keyed envelope signal source.

Figure 7 shows how a pentode twin diode tube may be used to provide an electronic signal generating means, and three separate electronic keying means, each providing a keyed envelope signal, and each such signal available in two contrasting tone qualities.

In the present invention a direct voltage is used to supply plate current to the anode of a control tube, rectifier, or diode, which serves as electronic keying means for connecting the signal source to the tone modifying and audio reproducing system of the instrument. This keying voltage is applied to the electronic keying means through a resistance capacitance network, which permits a gradual attack and decay of the musical note.

Figure 1 shows one form of the invention in which an alternating current generator 1, is connected in series with a diode 2, a resistor R1, a resistor R2, and a negative bias source 5. Resistor R2 is shunted by capacitor C1. Resistor R3 is an attack resistor which permits capacitor C1 to charge slowly when the adjustable contact 12 of a voltage divider R8 across the positive keying potential 6 is connected thereto upon closure of switch SW.

Normally the anode A of diode 2 is biased negatively through resistors R1 and R2 to such an extent that even on the most positive peaks of voltage from the alternating current generator, the anode does not become positive with respect to the cathode C. Normally therefore there is no current flowing through the diode.

Resistors R1, R2, and R3 are all large compared to the forward internal impedance of the diode. R2 is larger than R3, and R3 is larger than R1.

When switch SW is closed the positive keying potential from the voltage divider R8 is applied to capacitor C1, and to the anode of the diode through resistor R1. During those periods when the instantaneous sum of the positive keying potential, and the positive peaks of the alternating voltage from the generator becomes greater than the negative bias voltage at the anode, the diode will conduct current. At those times the anode is at a positive potential with respect to the cathode. A pulsating direct current will therefore flow through the diode and resistor R1. Resistor R1 and capacitor C2 serve as coupling

means and an alternating voltage appears across the output terminals 3 and 4.

Although the circuit of Figure 1 shows a diode, it should be understood that a rectifier of any type would serve, within the limits of the invention, and although the bias polarity is shown as negative and the keying potential polarity as positive, these polarities may be reversed providing the connections to the cathode and anode are interchanged.

In Figures 2, 3, and 4 are shown three voltage conditions of operation of the diode of the circuit of Figure 1. Time is plotted horizontally in the three figures, and voltage conditions vertically. The reference for each curve is the cathode potential, represented by the line A. Voltages above this line are positive with respect to the cathode, and those below the line are negative. Curve B represents two cycles of voltage waveform delivered by generator 1. Straight dashed line C represents the direct potential present at the anode of the diode. This potential is the resultant of the negative bias potential added to the positive keying potential. Since the alternating voltage B is superimposed upon the direct voltage C, its position with respect to the cathode line A is determined by the magnitude and polarity (location) of direct voltage line C.

Thus it will be seen in Figure 2, that at no time does curve B cross line A, indicating that the anode of the diode never becomes positive with respect to the cathode. The distance from line A down to dashed line C represents the magnitude of the negative bias voltage 5 in Figure 1. The peak voltage of generator 1 (curve B) is equal to or slightly less than the bias voltage. Figure 2 shows the voltage condition existing when switch SW in Figure 1 is open.

Figure 3 shows the voltage condition existing when switch SW is closed and a moderate keying potential just sufficient to bring the resultant direct voltage at the anode of the diode to zero potential, is applied. Under this condition line C coincides with line A, and the positive excursions of curve B rise above line A. When the curve rises above line A the anode of the diode is positive with respect to the cathode, and the diode conducts current during the periods indicated by the shaded areas under the curve. These shaded areas also indicate the approximate waveform of the pulsating current through the diode, and also the output waveform at terminals 3 and 4 of Fig. 1.

Figure 4 indicates the voltage condition existing at the anode when a higher keying potential is applied to the anode, switch SW of course being closed. Under this condition the direct potential line C appears above line A, the distance above the line indicating the magnitude of the direct potential at the anode. This magnitude in Figure 4 is just equal to the peak voltage of the alternating current generator, and the shaded areas under the curve B indicate the periods when the diode is conducting current. The approximate waveform and magnitude of the output voltage is also indicated as before. It will be seen that any further increase in the keying potential will not result in any increase in output voltage, but only a greater current through the diode. Figure 4 therefore indicates the condition of maximum output from the circuit of Figure 1.

Other keying potentials between the extremes given above will result in output voltages of corresponding magnitude.

In the quiescent condition shown in Figure 2

there is no output signal. When switch SW in Figure 1 is closed the keying potential charges capacitor C1 through resistor R3 relatively slowly, causing the output voltage to rise gradually from zero to a value determined by the magnitude of the keying potential. Thus a signal of the same frequency as that of generator 1 is caused to appear across the output terminals 3 and 4, without a key thump, and a smooth pleasing attack.

When the switch SW is opened the charge on capacitor C1 is dissipated through resistor R1 and the diode, and also through resistor R2, causing the output signal to decay gradually to zero. If the capacitor and the resistors are relatively large the period of discharge can be made long enough so that a pleasing effect of reverberation may be obtained in an electronic musical instrument using this circuit.

Figure 5 shows an embodiment of the invention in which the triode section of a triode twin diode tube 8 such as the 6R7, is connected in a conventional triode oscillator circuit. This oscillator is adjusted to the frequency of one of the musical notes to be played by the instrument. Each of the diodes 10 and 11 of the tube is utilized as the electronic keying means used in the manner of Figure 1.

Inductance L1 and capacitor C7 comprise the tuned tank circuit, and R10 and C8 are the grid resistor and capacitor respectively, connecting to grid 20 of the triode 8. Plate 19 connects to source of positive plate potential 21. Cathode 22 connects to a tap on L1 through a load resistor R9.

Diode 11 is shown connected to a keying circuit which is identical in all but two respects to that shown in Figure 1, and similar reference characters indicate components serving similar functions in all of the figures. The first difference is the addition of a capacitor C3, whose function will now be explained.

Consideration of Figures 3 and 4 will indicate that distortion takes place during the keying operation with low levels of keying voltage. While Figure 4 shows no distortion since the tube is conducting during the entire cycle, Figure 3 indicates that the negative half cycles are clipped, resulting in distortion. This effect is musically undesirable since the harmonic structure of the keyed tone changes with different keying potentials. Thus the sustained level or maximum intensity of the tone is duller (having fewer harmonics) than the decay period of the tone. It is during this later period that the most distortion occurs, since increased clipping takes place as the charge on capacitor C1 is dissipated, with the consequent lowering of the direct potential at the anode of the diode.

To prevent this change in waveform with change in keying potential, a suitable capacitor is connected from anode to ground. This arrangement provides an output voltage having a sawtooth waveform, and this waveform is produced with any useful keying voltage. Thus from maximum to minimum keying potential there is practically no change in tone quality, and only a change in intensity, since the amplitude of the sawtooth wave is dependent upon the magnitude of the keying potential. This capacitor is shown as C3 in Figure 5.

The second difference between the keying circuits of Figures 1 and 5 is that in the latter, another keying switch SW2, having its own attack resistor R4, and its own variable keying potential terminal 13, has been added.

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Keying potential terminals 12 and 13, on voltage divider R8 are, as indicated, individually variable. This permits switch SW to apply a higher or lower keying potential than that provided by switch SW2. Since the intensity of the tone produced is dependent upon the intensity of the keying potential, one or the other of the two switches may be made to produce a louder or softer tone than the other, depending upon the relative adjustments of the keying potential terminals 12 and 13.

In a complete electronic organ having multiple contacts operable by each playing key, switch SW might represent the so called "unison" contact on a certain key, while switch SW2 might be the "octave" contact on the key one octave lower. Similarly any number of switches could be associated with each playing key to obtain various other organ "coupler" effects.

The playing keys associated with diode 11 could all be located on the upper manual of the instrument. The output terminal 4 would therefore be associated with the tone control, voicing, or formant circuits of the upper manual.

Diode 10 is connected to a keying circuit which is identical to that just described, and its output terminal 9 as well as all keying switches, keying potential terminals, and playing keys could be associated with the lower manual of the instrument.

In operation the triode oscillator is in continuous oscillation, and in the quiescent state no signal appears at either output terminal. When keying potential is applied to either diode as previously described, the corresponding musical tone is heard from the reproducing system of the instrument.

In this way a single tube can provide an electronic signal generating means and two separate electronic keying means, and one such tube and associated circuit, would be provided for each musical frequency to be produced, in a two manual electronic organ of this type. By methods disclosed in the prior art either two or three tubes were required to accomplish equivalent results. In an instrument of this type, which may be required to produce eighty or ninety different musical frequencies, this invention provides a very real economy in the reduction of tubes which are required in the complete instrument.

In order that the feeling of multiple tone sources shall be preserved in this kind of instrument it is necessary that the closure of two key switches, such as SW and SW2 in Figure 5, shall produce a tone of more intensity than the closure of one only of such switches. In order for this requirement to be met it is necessary for resistors R3 and R4 to be larger than resistor R1. Thus the larger resistors become the current limiting factors, so that when two switches are closed, more current flows through the two parallel resistors, to R1 and the diode, than flows through either resistor alone. If resistor R1 were larger than the attack resistors R3 and R4 it would become the current limiting factor, and the closure of two switches would produce no perceptible increase in signal intensity.

As a means of obtaining different tonal effects in an electronic organ, the conventional radio tone control is very undesirable. Although the harmonic content may be varied to some extent by this method, it is undesirable because voicing of the scale is badly unbalanced through its use. Thus when the tone control is adjusted to reduce the harmonic content of the tones, it also reduces

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the overall intensity of the upper octaves of the instrument with consequent unbalancing of the scale, and the bass becomes relatively too loud for the treble. As a means of overcoming this difficulty, and also to provide a greater range of tonal variation, the voicing circuit of Figure 6 is used. The output coupling condenser C2 connects to terminal 4 as in Figures 1 and 5. Two branch circuits connect to terminal 4, one being a high pass filter, and the other being a low pass filter. Resistors R5 and R6, and capacitor C4 provide the low pass filter, connecting common output terminal 4 to flute tone output terminal 14. Capacitors C5 and C6, and resistor R7 are the high pass filter, and connect terminal 4 with the string tone output terminal 15.

It was previously mentioned that the waveform of the output voltage at terminal 4 is essentially a sawtooth wave. This wave is rich in natural harmonics. The high pass filter is adjusted to emphasize the higher harmonics relative to the fundamental, thus producing a bright tone, similar to a reed or string.

The low pass filter attenuates the higher harmonics thus emphasizing the fundamental and low order harmonics, and producing a dull tone which is flute-like in quality.

Therefore each note may be independently voiced relative to the other notes of the instrument, both as to tone quality and intensity, through choice of the constants of the low pass and high pass filters.

Each signal source of the instrument has a flute tone terminal 14 and a string tone terminal 15. All like terminals for all notes of one manual are connected together, and to their own controlling means. Thus all terminals 14 connect together and to a means for controlling the flute tone intensity of one manual of the instrument. Likewise all terminals 15 connect together and to a means for controlling the string tone intensity of the same manual of the instrument.

By mixing the amounts of string tone and flute tone in controlled proportions the overall tone quality of the instrument may be changed without producing the unbalance of the conventional tone control.

When the flute tone and the string tone are adjusted in proper relative proportions, and used together, a very pleasing diapason tone may be obtained. These three are probably the most important organ tone qualities in common use. Pleasing solo qualities may be obtained by using combinations of these three qualities in conjunction with formant circuits, and organ coupling means previously described.

Representative values for the circuit of Figure 6 are as follows:

Note—Middle C frequency 261.27 cycles

Keying potential 100 volts

Peak signal voltage at cathode—8 volts

Bias voltage 8 or 9 volts

C1—.25 mfd.

C2—.01

C3—.01

C4—.006

C5—.002

C6—.002

R1—50,000 ohms

R2—3 megohms

R3—1.5 megohms

R5—100,000 ohms

R6—100,000 ohms

R7—250,000 ohms

In Figure 6 the leads of the triode which are now shown connected to any circuit, may be connected to one or more signal generating sources including any type of oscillator circuit, such as feed-back, multi-vibrator, parallel T R.-C., or phase shift oscillators, as well as any type of tone wheel generator, frequency divider, or frequency multiplier, which permits the cathode to be above ground potential for the signal voltage. A plurality of signal sources may be used to produce ensemble effects, or various tone color effects.

Diode plate 10 may be connected to a keying circuit identical in every respect to that connected to diode plate 11, the output of diode 11 being associated with the circuits of the upper manual, and the output of diode 10 being associated with the circuits of the upper manual, and the output of diode 10 being associated with those of the lower manual.

In an electronic organ a third source of keyed envelope signal is sometimes desirable, either for a third manual, if it is a larger instrument, or for solo purposes, or to provide the pedal notes of the organ. It is possible to make a third source serve as both solo and pedal source because of the fact that pedal notes are confined to the lower end of the musical scale, while the solo notes generally are more useful in the middle and upper registers. Therefore if all such sources generating the lower notes of the instrument are connected to pedal control circuits, and those generating the notes in the middle and higher range are connected to the solo control and formant circuits, this objective shall have been achieved.

A circuit providing three separate sources of keyed envelope signal from one vacuum tube is shown in Figure 7, in which a vacuum tube 16 of the pentode twin diode type is used. Such a tube as the type 6B8 will serve satisfactorily. The oscillating circuit of Figure 7 is similar to that of Figure 6. However the screen 18 of the pentode serves as the anode of the triode oscillator circuit, and is connected to the positive anode supply 21. This is the conventional electron coupled oscillator circuit, and the plate 17 serves to deliver the output signal by means of electron coupling to the electron stream.

In its function of serving as output electrode of the signal source, the plate 17 serves also as an electronic keying means, and for this purpose it is connected to the keying circuit shown, which is within the limits of the present invention, and whose operation has already been described in keying a diode. In Figure 7 similar reference characters indicate components of similar function and size, as those used in the foregoing figures.

The diodes 10 and 11 are not shown connected to any circuit and it is understood that they may be connected to keying circuits similar to those shown and described above. The circuit of Figure 7 thus provides an electronic signal generator and three separate sources of keyed envelope signal, using but one vacuum tube.

The bias source 5 in Figure 7 serves a somewhat different purpose from that of Figures 1, 5, and 6 in which a diode is the electronic keying means. When a diode is the keying means the alternating voltage on the anode itself serves to modulate the electron stream in the tube. The only electron accelerating potential in the tube is that on the anode itself. Consequently when the anode is at a negative potential with respect to the cathode, the electrons are not accelerated as they leave the cathode. The tendency for

spurious electrons to arrive at the anode is therefore slight.

In the case of the multi-electrode tube shown in Figure 7 however, there are other electrodes in the tube than the anode. Since these electrodes are grids, and since they are sometimes positive with respect to the cathode, they may accelerate the electrons as they leave the cathode. A small negative bias on the plate assists in preventing the arrival at this electrode of those spurious electrons which succeed in passing through the grid wires. These electrons, if allowed to arrive at the plate, cause a small audio signal to be apparent at the output terminal, and in a complete instrument, an undesirable background of sound is the result.

An organ designed and built to incorporate the details of this invention, and which are disclosed herein, is capable of producing rich and satisfying organ music, not only because it has a pleasing range of useful tone colors, and complete lack of key thump, but also because the artificial reverberation produced by the instrument, lends a realism and spaciousness to the music which is ordinarily associated only with large cathedral organs.

The simplifications and economies provided by the present invention in an electronic organ having a signal source for each note of the instrument, and electronic keying means for each playing key of the instrument, may better be appreciated by comparison with similar instruments of the prior art.

In a conventional organ having two playing manuals, and the standard 32 note pedalboard, a total of 85 musical frequency signal sources is provided. The two manuals and the pedal board of the instrument must function with complete independence of one another, both as to keying control, and also tone color control.

To meet these requirements using circuits of the prior art, and providing the advantages of gradual attack and reverberative decay, the number of tubes required would be as follows: 85 tubes for the signal sources, 85 tubes for the electronic keying circuits of the upper manual, 85 tubes for the electronic keying circuits of the lower manual, 32 tubes for the electronic keying circuits of the pedal board. This is a total of 287 tubes. By employing the economies provided by the circuits of the present invention, the same flexibility of operation is obtained using 85 multi-purpose vacuum tubes.

The equally important advantage, for which to the best of my knowledge, there is no prior art counterpart, is the simultaneous availability of contrasting tone colors from one electronic keying device.

While for the purpose of illustrating and describing the present invention, certain preferred embodiments have been shown, it will be apparent to those skilled in the art that various modifications may be made, including the use of other types of vacuum tubes and circuit arrangements, without departing from the basic principles of the invention. I therefore do not wish to be limited to the precise details set forth herein, but desire to include within the scope of the invention those modified forms by means of which similar results may be obtained in substantially the same way.

Having thus described my invention, I claim as follows:

1. In an electronic organ the combination comprising a source of alternating current, a two ele-

ment vacuum tube keying device having a cathode and an anode, a source of bias potential therefor, a load circuit for said vacuum tube including a resistor connected in series with a capacitor, a resistor connected in parallel with said capacitor, said latter resistor having a high resistance value, a source of keying potential having one terminal connected to one terminal of said capacitor, and means for selectively connecting a resistor between the juncture of said capacitor and said first mentioned resistor and the other terminal of said source of keying potential.

2. In an electronic organ, the combination comprising a source of alternating signal current, a unilaterally conductive device, having an input electrode and an output electrode and being associated with said source of current, a source of bias voltage for said unilaterally conductive device, a capacitor, a load resistor, said source of bias voltage, said capacitor, and said load resistor being serially connected between said output electrode and said source of alternating signal current, a relatively high value resistor connected in parallel to said capacitor, a source of keying voltage, and switching means for selectively connecting said source of voltage across said capacitor.

3. In an electronic organ, the combination comprising a source of alternating current, an output circuit including a resistor connected in series with a capacitor, a unidirectionally conductive device having an input electrode and an output electrode interconnecting said source of alternating current with said output circuit, a source of biasing voltage for said device, a second source of voltage of greater magnitude than said first source of voltage, and means connected to said latter source of voltage including a time delay circuit for rendering ineffective said first mentioned source of voltage.

4. In an electronic organ, the combination comprising a plurality of sources of alternating signal current, an output circuit including a resistor connected in series with a capacitor, a unilaterally conductive device, having an input electrode and an output electrode and being associated with said sources of alternating signal current, a source of biasing voltage of one polarity for rendering said device inoperative, a second source of voltage of opposite polarity and of greater magnitude than said first source of voltage, and means connected to said latter source of voltage including a time delay circuit for rendering said device operative.

5. In an electronic organ, the combination comprising a source of alternating current, a rectifier having an anode and a cathode, means for normally maintaining said anode negative with respect to said cathode, and keying means for said rectifier including a source of potential switching means, and time delay means operative upon closure of said switching means to delay the application of said potential to cause said anode to be at a positive direct current potential with respect to said cathode.

6. In an electronic organ, the combination comprising a source of alternating signal current, an output circuit including a resistor connected in series with a capacitor, a unilaterally conductive device, having an input electrode and an output electrode and being associated with said source of alternating signal current, a source of biasing voltage for said device, a second source of voltage of greater magnitude than said first

source of voltage, and means connected to said latter source of voltage including a time delay circuit for rendering said device operative, said time delay circuit including said capacitor, and a resistor, said second resistor having a greater resistance than said first resistor.

7. In an electronic organ, the combination comprising a source of alternating current, an electronic keying means connected between said source of alternating current and an output circuit, said keying means including a two element vacuum tube arranged to produce a keyed envelope signal, a source of keying potential, a load resistor connected between one electrode of the vacuum tube and said source of keying potential, and means shunting said resistor for causing said keyed envelope signal to have substantially the same wave form for any value of applied keying potential.

8. The combination set forth in claim 7 in which the means shunting the load resistor is reactive.

9. The combination set forth in claim 7 in which the means shunting the load resistor is a capacitor.

10. The combination set forth in claim 7 in which the keyed envelope signal is of sawtooth waveform.

11. In an electronic musical instrument, the combination comprising a source of alternating current, an electronic vacuum tube keying means having an output electrode, a load circuit for said vacuum tube, a pair of output terminals, and a network interconnecting said terminals with said load circuit for delivering a keyed envelope signal having a simpler harmonic conformation than the signal appearing across said load circuit, a second pair of output terminals, a second network interconnecting said latter terminals with said load circuit for delivering a keyed envelope signal having a more complex harmonic conformation than the signal appearing across said load circuit.

12. The combination set forth in claim 11, wherein the first mentioned network includes a series resistor and a shunt capacitor, and the second mentioned network includes a series capacitor and a shunt resistor.

13. In an electronic musical instrument, the combination comprising a triode connected in an oscillator circuit, an electronic keying means including a diode, an output circuit, said keying means interconnecting the cathode of said triode and said output circuit, means for selectively rendering said keying means operable to deliver a keyed envelope signal across said output circuit.

14. The combination set forth in claim 13 wherein said triode and said diode are contained within the same evacuated envelope.

15. In an electronic musical instrument, the combination comprising a pentode connected in an oscillator circuit, the screen of said pentode serving as oscillator anode, an output circuit, the plate of said pentode serving as electronic keying means interconnecting said oscillator and said output circuit, a second electronic keying means including a diode, a second output circuit, said second keying means interconnecting the cathode of said pentode and said second output circuit, means for selectively rendering said first or said second electronic keying means operable.

16. The combination set forth in claim 15 wherein said pentode and said diode are contained within the same evacuated envelope.

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17. In an electronic musical instrument, the combination comprising a signal generator circuit including a triode, an electronic keying means including a diode, an output circuit, said keying means interconnecting the cathode of said triode and said output circuit, means including a time delay circuit for selectively rendering said keying means operable to deliver a keyed envelope signal to said output circuit.

18. The combination set forth in claim 17 wherein said triode and said diode are contained within the same evacuated envelope.

19. In an electronic musical instrument, the combination comprising a signal generator circuit including a pentode, an output circuit, the plate of said pentode serving as electronic keying means interconnecting said signal generator and said output circuit, a second electronic keying means including a diode, a second output circuit, said second keying means interconnecting the cathode of said pentode and said second output circuit, means including a time delay circuit for selectively rendering said first keying means operable to deliver a keyed envelope signal to said first output circuit, means including a time delay circuit for selectively rendering said second keying means operable to deliver a keyed envelope signal to said second output circuit.

20. In an electronic musical instrument, the combination comprising a signal generating means including a pentode, an output circuit including a resistor, the plate of said pentode

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serving as electronic keying means interconnecting said signal generating means and said output circuit, a second electronic keying means including a diode, a second output circuit including a resistor, said second keying means interconnecting the cathode of said pentode and said second output circuit, means including a time delay circuit for selectively rendering said first keying means operable to deliver a keyed envelope signal to said first output circuit, said time delay circuit including a capacitor and a resistor, said resistor having a higher resistance than said first mentioned resistor, means including a time delay circuit for selectively rendering said second keying means operable to deliver a keyed envelope signal to said second output circuit, said time delay circuit including a capacitor and a resistor, said resistor having a higher resistance than said second mentioned resistor.

THOS. J. GEORGE.

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