

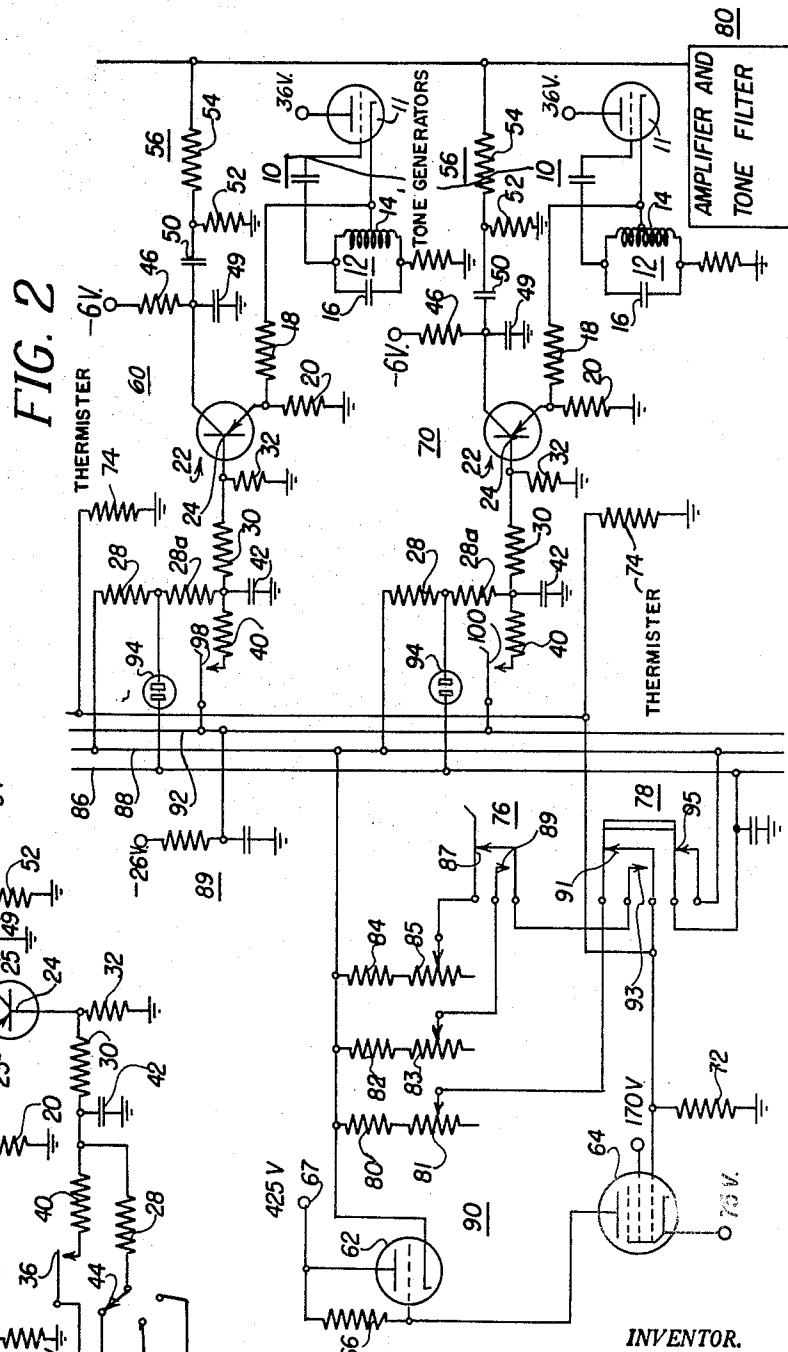
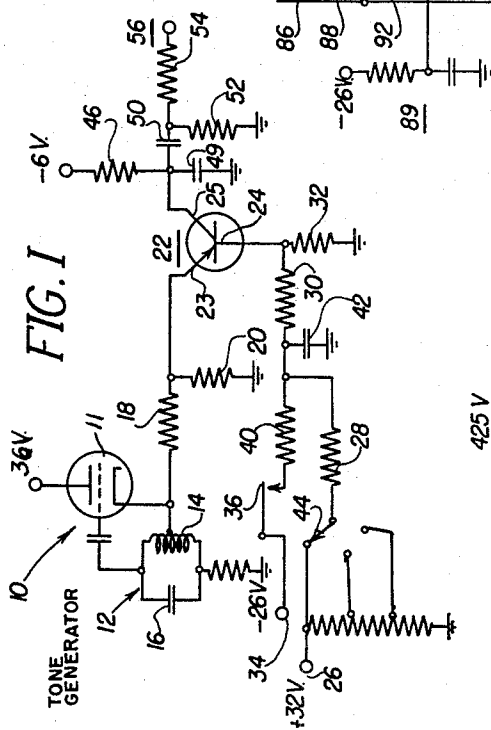
July 20, 1965

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3,196,201

TRANSISTOR KEYS

Filed April 26, 1961



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TRANSISTOR KEYS

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Filed Apr. 26, 1961, Ser. No. 105,697
11 Claims. (Cl. 84-1.26)

This invention relates to electronic musical instruments and more particularly to a keyer circuit for an electronic organ.

It is desired to achieve tones from an electronic organ which simulate tones from a pipe organ, including tones which start and stop slowly. In providing a flute note for example, it is advantageous to have some means of controlling the build up and decay of the electronic signal reaching the output circuit of the organ. It will be understood that if the electronic signal is controlled by a simple on-off switch, the signal in the circuit following the switch changes from zero, or a relatively small value, to its maximum in an abrupt manner when the switch is closed. The signal would similarly return to zero in an abrupt manner and very often, particularly with flute notes, would produce an undesirable transient or "pop" at the start and stop of the tone.

It is therefore an object of the present invention to provide an electronic organ keyer adapted to control the manner in which a tone starts and stops, and to minimize undesired transients in the tone signal.

Another object of the present invention is to provide a transistorized keyer adapted to generate long sustain notes from an electronic organ.

A further object of the present invention is to provide an electronic organ having a plurality of individual keyers which are isolated from each other, and in addition provide a simple and inexpensive means for selecting one or more sustain intervals.

A feature of the present invention is the provision of an organ keyer circuit including a transistor device and time constant bias circuit to control the build up and decay of an oscillator signal passed by the keyer circuit.

Another feature of the invention is the provision of a transistorized keyer circuit including a capacitor to retain and decrease the bias applied to a transistor device gradually with time. Different blocking voltages and impedances are selectively connected to the capacitor to afford different graduations of sustain time.

A further feature of this invention is the provision of a keyer circuit including twelve transistorized keyers for one octave, having their respective collector electrodes connected together and supplied with a direct current operating voltage through one resistor.

Another feature of the present invention is the provision of a transistorized keyer circuit adapted to aid in accomplishing long sustained sounds from an electronic organ and including neon lamps to provide isolation between keyers controlled by a single voltage to allow the keyers to operate independently of one another.

A further feature of this invention is the provision of an organ keyer including a plurality of thermistors positioned about the transistor keyer to offset variation in transistor operation occurring because of changes in room temperature and/or internal temperature of an electronic organ.

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In the accompanying drawing:

FIG. 1 is a schematic diagram of a simplified transistor keyer circuit of the present invention; and

FIG. 2 is a schematic diagram of a circuit including a plurality of keyer circuits of the present invention.

In accordance with the present invention, a transistorized signal keyer is provided for an electronic organ which controls the magnitude of a signal applied from a tone generator to the output circuit of the organ. The keyer therefore acts as a variable gain amplifier whose gain may be controlled by application of the proper biasing current to the control electrode of the transistor. A blocking voltage of one polarity is provided to the control electrode to prevent conduction between the input and output electrodes. A key may be actuated to provide a voltage of the opposite polarity to override the blocking voltage and cause the transistor to conduct. The transistor valve can be biased to permit very little or no signal to pass through the keyer, the actual ratio of maximum-to-minimum signal output being about 70 decibels. The bias current which increases or decreases the keyer output may be controlled so that it increases or decreases gradually with time, and therefore the magnitude of the oscillator signal at the keyer output circuits varies with time in a generally similar manner to the controlled bias current. Sustain tones or intervals are provided by decreasing the transistor bias current very slowly by means of a capacitor coupled in the circuit, which may be governed in its operation by a switch actuated variable impedance circuit path. When several keyers are connected together, a neon lamp is connected in the circuit to provide isolation between individual keyers coupled to a single blocking voltage source, allowing them to operate independently from one another, and at the same time permit a simple, inexpensive means of selecting one or more sustain intervals. In addition a thermistor, which has a negative temperature coefficient, may be connected to the circuit to offset variations of transistor operation occasioned by changes in temperature.

Referring now particularly to FIG. 1, the transistor keyer circuit of the present invention is used to control the application of input signal voltage from a tone generator, generally indicated at the reference number 10, to an output circuit. The tone generator 10 includes tube 11 connected to an oscillator tank circuit 12 comprising an inductor 14 and a capacitor 16. The tube 11 is energized by a positive potential of 36 volts. Signals from the tone generator 10 are applied through resistor 18 and across resistor 20 to the emitter electrode 23 of transistor 22. Such signals are applied through the transistor 22 to the collector electrode 25 and to the output circuit connected thereto when the transistor 22 conducts.

The transistor 22 is of the PNP type and is controlled by the voltage applied to the base electrode 24 thereof. The collector electrode of transistor 22 is connected to a -6 volt supply by resistor 46. The transistor is normally non-conducting as a positive blocking voltage is developed across resistor 32 from source 26 through resistors 28 and 30, to provide a sufficient base to emitter positive bias voltage to hold transistor 22 non-conducting. A source of negative keying voltage 34 is connected to one terminal of key 36, and when the key is closed this potential is applied through resistors 40 and 30 across base resistor 32 to provide a negative voltage on the

base of transistor 22 to cause the transistor to conduct. This condition continues as long as key 36 is closed, and a charge is stored on capacitor 42 when the key 36 is closed to hold the transistor 22 in conduction after the key is released. Capacitor 42 discharges through resistors 30 and 32 and through resistor 28, to reduce the negative voltage at the base 24 of transistor 22, and the capacitor charges in a positive direction from the positive source 26. The voltage from source 26 is effective to discharge the negative voltage across capacitor 42 and to provide a positive charge thereacross to hold the transistor 22 cut off.

It may be desired to control the period after which key 36 is open that the tone continues to provide what is known as sustain action. This may be accomplished through action of switch 44 which controls the positive blocking voltage applied to the base of transistor 22. When the switch 41 applies a smaller positive voltage, it will require a longer time for the negative voltage on capacitor 30 to be neutralized to cut off transistor 20. This will provide a longer sustain action.

In operation, when the key 36 is open, a positive voltage is applied to the base of transistor 22 and the emitter current of the transistor is essentially zero. With the key in this position, blocking voltage source 26 supplies a current through resistors 28, 30 and 32 which provides a positive voltage at the base of transistor 22 which holds the same cut off.

With the key 36 open, the polarity of the ungrounded terminal of the capacitor 42 is positive. When the key 36 is closed, the polarity of the charge on capacitor 42 reverses and acts to change the base bias current. The negative charge on capacitor 42 controls the base bias current, and consequently the degree to which the keyer is turned on. Resistor 40 governs the rate at which the charge builds up across the capacitor 42 and this controls the signal build-up in the keyer output circuit. It will be understood that the transistor collector current is a function of the base bias current over the collector current range. When the collector current reaches a saturation value, all but a few tenths of the collector supply voltage is developed across the collector direct current load resistor 46. After the collector current reaches saturation, it is essentially unchanged as the base bias current continues to increase.

In the output circuit 56 of the keyer transistor 22, the capacitor 49 is used to reduce the "short duration" components of the transient signal that appears in the collector circuit due to the collector current changing when the keyer is turned on. A second capacitor 50 and resistor 52 form a filter section which reduces the "long duration" transient, which might be considered a low frequency component of the transient. Resistor 54 isolates the keyer from other circuits connected together to provide the complete organ output.

The relatively high dynamic resistance of the transistor collector compared to the collector load resistance 46 permits combining several keyers (FIG. 2) in a single circuit with relatively slight attenuation of any signal. The plurality of keyers may be connected together and supplied with a D.C. operating voltage through one resistor. When the collector currents of all the open keyers are substantially below saturation, the collector current of the one transistor is essentially independent of the collector current of any other open or closed keyer. Therefore, the total current flowing through resistor 46 will be proportional to the number of keyers that are simultaneously open. This assumes all transistors in a particular octave are alike.

FIG. 2 shows a circuit including a plurality of keyers 60 and 70, generally like the keyer of FIG. 1, connected together. Like components are identified by like numerals. The outputs of the keyers 60 and 70 are shown fed to an amplifier and tone filter 80. The sustain or blocking voltage is controlled by a voltage regulating

circuit indicated at 90 which performs a function comparable to that of switch 44 of FIG. 1 in that it regulates the blocking voltage to the keyers, individually and severally.

Voltage regulating circuit 90 which supplies the voltage to control the sustain action of the keyers 60 and 70 includes an amplifier control tube 64 and a series regulator tube 62. It will be understood that the various voltages on the supply lines will be dependent upon the relative values of the circuit components utilized in the practice of the invention. The plate of tube 64 is connected to the grid of tube 62 and from there to the 425 volt B+ line 67 through resistor 66. The control grid of the amplifier tube 64 returns to ground through a resistor 72. The cathode of tube 64 is connected to a positive potential of 75 volts and the second grid is connected to a positive potential of 170 volts.

Thermistors 74 are shown on the "keyer" side of the circuit and are connected in parallel with resistor 72 to the control grid of the amplifier tube 64. The thermistors 74 operate in the known manner to compensate for temperature rise, or drop, due to the proximity of heat producing assemblies in the organ as well as changes in the ambient temperature. The temperature compensating effect of thermistors 74 is particularly effective in causing the transistors to cut off at the desired time. When the temperature increases the I_{co} of the transistor increases which increases the current through resistor 32 which tends to hold the transistor conducting. The I_{co} of the transistor is the current through the collector-to-base junction when the emitter is open-circuited and the collector-to-base junction is reverse biased. The thermistors 74 act to raise the blocking voltage on line 88 which counters the effect of the increased I_{co} of the transistor. The thermistors 74 may be positioned at various point along the keyer chassis and connected together to function as one thermistor. The thermistors when used in multiples and spread out, average the temperature that the keyers experience from one part of the keyer section to another.

Switches 76 and 78, which are the equivalent of switch 44 of FIG. 1, control the blocking voltage applied to the keyers 60 and 70 by selectively connecting the resistors 80-81, 82-83, or 84-85 in the control circuit. Regardless of which path is chosen resistor 72 and thermistor 74 are in the circuit connected to the grid of tube 64. The switches 76 and 78 operate independently of one another and in addition to selecting the resistors in the control circuit, operate to make a connection to line 86 connected to the neon tubes 94.

For a more thorough understanding of the operation of the circuit of FIG. 2, it is pointed out that three control lines are connected to the two keyers including keys 98 and 100 respectively. These are representative of a large number of keyers which may be so connected. The first line 86 is the neon bulb conduction line, the second line 88 is the blocking voltage conduction line, and the third line 92 provides the keying voltage. Keying voltage supply 89 is connected to the line 92.

In operation, when the switches 76 and 78 are not operated and contacts 89 and 93 are open, resistors 80 and 81 are connected to the cathode of tube 62 and are in series with parallel resistor 72 and thermistor 74. Resistors 80 and 81 control the voltage applied to the grid of control tube 64 to provide the desired voltage at the cathode of tube 62. This voltage is applied to the blocking voltage line 88. With switch 78 in the unoperated position as shown, line 86 is connected to line 88 through contacts 95 and neon bulb 94 bridges resistor 28 so that resistors 28a, 30 and 32 are connected to the cathode of tube 62 through the neon lamp 94. This provides the potential on the capacitor 42 and on the base of transistor 22 to provide the normal keying action.

When the key 98 (or 100) is now operated a negative voltage from line 92 is applied through resistors 40, 30

and 32 to cause the transistor 22 to conduct as was described in connection with FIG. 1. Capacitor 42 and resistor 40 control (essentially) the build up of the voltage at the base electrode to control the attack characteristics of the tone and also controls the sustain and decay characteristics.

For short sustain action, the switch 78 is moved to its operated position and switch 76 remains as shown. The resistors 80 and 81 are disconnected, since contacts 91 are open, and resistors 84 and 85 are connected in series with resistors 72 and 74 through contacts 93. Resistors 84 and 85 are of a higher resistance value and therefore the voltage applied to the grid of control tube 64 is less. This causes a decrease in plate current at tube 64 which in turn causes the plate voltage of tube 64 to rise and the grid voltage of tube 62 to rise with it since this plate and grid are directly connected. The voltage on the cathode of tube 62 will tend to follow the grid voltage and will rise thereby increasing the blocking voltage on line 88. As switch 78 opens contacts 95, the neon bulb 94 is disconnected from line 88 and is effectively out of the circuit. The discharge path from line 88 to capacitor 42 is therefore through resistor 28 in series with resistor 28a. As resistor 28 is much larger than resistor 28a, the resistance of the discharge path is greatly increased. Although the voltage on line 88 is increased, the resistance of the path to capacitor 42 is increased by a greater factor so that the discharge time for this capacitor is increased. This causes the transistor 22 to conduct for a longer time after key 98 is released to increase the sustain time of the tone applied to the keyer.

When long sustain is desired switches 76 and 78 are both operated. When the switches are in this position, resistors 84 and 85 are disconnected and resistors 82 and 83 are connected to resistors 72 and 74. Resistors 82 and 83 have less resistance than resistors 84 and 85 so that the voltage at the grid of tube 64 is more. This causes the voltage at the cathode of tube 62 to be less as previously described. Therefore the blocking voltage applied to the line 88 is less, and the voltage applied to capacitor 42 is less so that the discharge time is increased.

The neon lamps serve two important purposes in the operation of the keyer circuit. First, they provide effective short circuits across resistors 28, as described above, so that the blocking voltage, dropped about 60 volts by the neon tube, is applied to resistor 28a to provide the normal decay. When the neon bulb circuits are opened, the resistors 28 are in the discharge paths and increase the resistance thereof greatly to increase the sustain time. The second purpose of the neon lamps is to isolate the keyers so that each keyer can be operated by one simple switch. This switch (contacts 95 of switch 78) simultaneously changes the sustain duration of one or more keyers, and at the same time permits the independent operation of each keyer.

If the switches 76 and 78 are operated for long sustain action and the key 98 of one keyer is closed and the key 100 of another keyer is open, the voltage across the neon lamps 94 of the two keyers is not enough to cause these lamps to fire so that the keyers are isolated. However, if the switch 78 is operated and the switch 76 is not operated (i.e. short sustain), and the keys 98 and 100 are in the same condition as described above, the voltage across neon lamps 94 may be enough to cause the lamps to fire. Accordingly, there is a path for the blocking voltage applied to one keyer through the neon lamps 94 to the other keyers. Although this will change the resistance of the path for the blocking voltage of the capacitor 42 of the keyer which is operated the effective time constant is not substantially changed. This is because the coupling of the keyers through the neon lamps ties together the capacitors and resistors of the keyers which are coupled to increase the capacity and decrease the resistance by the same factor, which is governed by the number of keyers which are intercoupled. Further the neon lamps, when

they do fire, are fired for only a short time. The net effect of this is only a minor change in the sustain time.

A chart of component values for the circuit of FIG. 2 appears below. These values are not intended to be critical to the practice of the present invention but are given as an example of the values which may be used in order that the detailed description will be complete.

Resistor 20	680 ohms.
Transistor 22	Type 59625.
Resistor 28	2.2 megohms.
Resistor 28a	120,000 ohms.
Resistor 30	1.8 megohms.
Resistor 32	4700 ohms.
Resistor 40	6800 ohms.
Capacitor 42	1.35 microfarads.
Resistor 46	12,000 ohms.
Resistor 52	100,000 ohms.
Resistor 54	100,000 ohms.
Tube 62	Type 6EA8.
Tube 64	Type 6EA8.
Resistor 72	680,000 ohms.
Resistor 80	390,000 ohms.
Resistor 81	250,000 ohms.
Resistor 82	560,000 ohms.
Resistor 83	250,000 ohms.
Resistor 84	1 megohm.
Resistor 85	500,000 ohms.

The invention provides therefore a transistor keyer circuit for an electronic organ to control the magnitude of an oscillator tone signal that reaches the output circuit of the keyer. The bias current which controls the keyer output is controlled so that it increases or decreases gradually with time thereby varying the oscillator signal in the keyer output circuit in a similar manner. Variation of the sustain time or interval is provided by changing the magnitude of the blocking voltage applied to the base bias control circuit of the transistors of the keyer and/or by changing the release time constant of that control circuit. Several keyers may be connected together and means are provided in the present invention to effectively isolate the individual keyers.

I claim:

1. In an electronic organ including a tone generator for providing a signal corresponding to a musical tone, a keyer adapted to control the attack and decay of the tone including in combination, a transistor having input, output and control electrodes, means for applying the signal from the tone generator to said input electrode, means connected to said output electrode for deriving the signal therefrom, and a control circuit connected to said control electrode including blocking voltage supply means for applying a first potential to said control electrode to prevent conduction between said input electrode and said output electrode, said control circuit including switch means for controlling the amount of blocking voltage applied to said control electrode, said control circuit having means including a key for applying a second potential to said control electrode to override said first potential and cause said transistor to conduct, said last named means including storage means for applying a portion of said second potential to said control electrode, with said portion gradually diminishing after said key is released.

2. The structure of claim 1 wherein said storage means includes capacitor means, and said second potential charges said capacitor means to provide a voltage at said control electrode to render said transistor conducting, with said capacitor means storing a potential to hold said transistor conducting to provide sustain action.

3. The structure of claim 1 wherein said storage means includes capacitor means and means forming a discharge path therefor, and said second potential charges said capacitor means to apply a potential to said control electrode to render said transistor conducting, with said first potential being continuously applied to said capacitor

means and acting to reduce the charge stored thereon by said second potential.

4. In an electronic organ including a plurality of tone generators for providing signals corresponding to musical tones, and playing keys for controlling the tones, a keying system for controlling the attack and decay of the tones including a plurality of keyers, each keyer including a transistor having input, output and control electrodes, means applying the signal from a tone generator to each of said input electrodes, means coupled to said output electrodes for utilizing the signals therefrom, and a control circuit connected to each of said control electrodes including means for selectively applying a first potential to said control electrodes to hold said transistors non-conductive, each of said keyers including a switch coupled to a playing key for applying a second potential to said control electrode of said transistor thereof to override said first potential and cause said transistor to conduct, whereby said transistors may be individually rendered conducting by operation of the playing keys.

5. The keying system in accordance with claim 4 wherein said control circuit includes thermistor means for raising said first potential applied to said control electrodes of said keyers with increase in temperature.

6. A keying circuit for controlling the application of a plurality of signals from signal sources to an output circuit, and wherein the attack and decay of the signals are controlled, said circuit including a plurality of keyers, each keyer including a transistor having input, output and control electrodes, means for applying a signal to each of said input electrodes, means coupled to said output electrodes for utilizing the signals therefrom, and a control circuit connected to each of said control electrodes including means for applying a first potential to said control electrodes to hold said transistors non-conductive, each of said keyers including a key for applying a second potential to said control electrode of said transistor thereof to override said first potential and cause said transistor to conduct, whereby said transistors may be individually rendered conducting by operation of said keys of said keyers, each of said control circuits including a neon lamp for applying said first potential to said control electrode of the transistor of each keyer and providing isolation between said keyers.

7. A keying system for controlling the attack and decay of a plurality of signals from sources including in combination, a plurality of keyers each including a transistor having input, output and control electrodes, means for applying a signal to each of said input electrodes, means coupled to said output electrodes of each transistor for deriving a signal therefrom, a control circuit connected to said control electrode of each transistor including resistor means and capacitor means, and voltage supply means for applying a first potential of one polarity to said control circuits, said first potential being applied across said capacitor means of each control circuit to said control electrode of the associated transistor to hold such transistor non-conducting, each of said keyers including a key for applying a second potential of opposite polarity to said control circuit to override said first potential and cause said transistor to conduct, said capacitor means charging to said opposite polarity by said second potential whereby said transistor continues to conduct for a sustain interval after said key is released, said first potential discharging said capacitor means after said key is released and charging the same to said one polarity to cut off said transistor, and switch means coupled to said voltage supply means for changing said first potential to thereby change the duration of said sustain interval, each of said control circuits including a neon bulb connected to said resistor means thereof and to said switch means and rendered selectively conductive by said switch means to bridge at least a portion of said resistor means to change the discharge time of said capacitor means of the control circuit, said neon bulbs of said control circuits

further operating to substantially isolate said keyers from one another to allow said keyers to operate independently.

8. A keying system in accordance with claim 7 wherein said voltage supply means includes voltage regulator means having thermistor means for raising said first potential with increase in temperature to temperature compensate said keyers.

9. A keying system for controlling the application of signals from a plurality of signal sources to an output circuit, and for selectively sustaining the applied signals, said system including in combination, a plurality of transistor keying devices each having input, output and control electrodes, means for applying signals from the sources individually to said input electrodes of said keying devices, means coupled to said output electrodes of said keying devices for utilizing the signals therefrom, a plurality of control circuits individually connected to said control electrodes of said keying devices, each of said control circuits including capacitor means and means including a neon lamp for applying a first potential to said capacitor means to charge the same to provide a bias at said control electrode of the associated keying device to hold the same non-conductive, a key switch coupled to each control circuit for applying to said capacitor means a second potential of opposite polarity to said first potential to charge said capacitor means to provide a bias at said control electrode of the associated keying device to cause the same to conduct, whereby each of said keying devices is individually rendered conducting by operation of the associated key switch and is cut off in response to said first potential upon release of said key switch, and single switch means coupled to said plurality of control circuits for selectively completing the potential applying circuits through said neon lamps, said switch means being operative to open the circuit through said neon lamps and thereby sustain the signal applied through a conducting keyer.

10. A keying system for controlling the application of signals from a plurality of signal sources to an output circuit, and for sustaining the applied signals, said system including in combination, a plurality of semiconductor keying devices each having input and output electrodes, means for applying signals from the sources individually to said input electrodes, means coupled to said output electrodes for utilizing the signals therefrom, a plurality of control circuits individually connected to said keying devices for controlling the conduction thereof, each of said control circuits including capacitor means and means including a neon lamp for applying a first potential to said capacitor means to charge the same to a potential to hold the associated keying device non-conducting, a key switch individually coupled to each control circuit for applying to said capacitor means thereof a second potential of opposite polarity to said first potential to charge said capacitor means to a potential to cause said keying device to conduct, whereby each of said keying devices is individually rendered conducting by operation of the associated key switch and is cut off in response to said first potential upon release of said key switch, and single switch means coupled to said plurality of control circuits for selectively applying a potential to said neon lamps for application thereby to said capacitor means, said switch means being operative to remove the potential from said neon lamps and thereby delay the cut off of a conducting keying device, so that the signal applied there-through is sustained.

11. A keying system for controlling the application of signals from a plurality of signal sources to an output circuit, and for sustaining the applied signals, said system including in combination, a plurality of keyers each having input and output terminals, means for applying signals from the sources individually to said input terminals, means coupled to said output terminals for utilizing the signals therefrom, a plurality of control circuits individually connected to said keyers, each of said control

circuits including a neon lamp for applying a first potential to the associated keyer to hold said keyer non-conducting, a key switch coupled to each control circuit for applying thereto a second potential of opposite polarity to said first potential to override said first potential and cause the associated keyer to conduct, whereby each of said keyers is individually rendered conducting by operation of the associated key switch and is cut off in response to said first potential upon release of said key switch, and single switch means coupled to said plurality of control circuits for selectively completing the potential applying circuits through said neon lamps, said switch means being operative to open the circuit through said neon lamps and thereby sustain the signal applied through a conducting keyer.

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