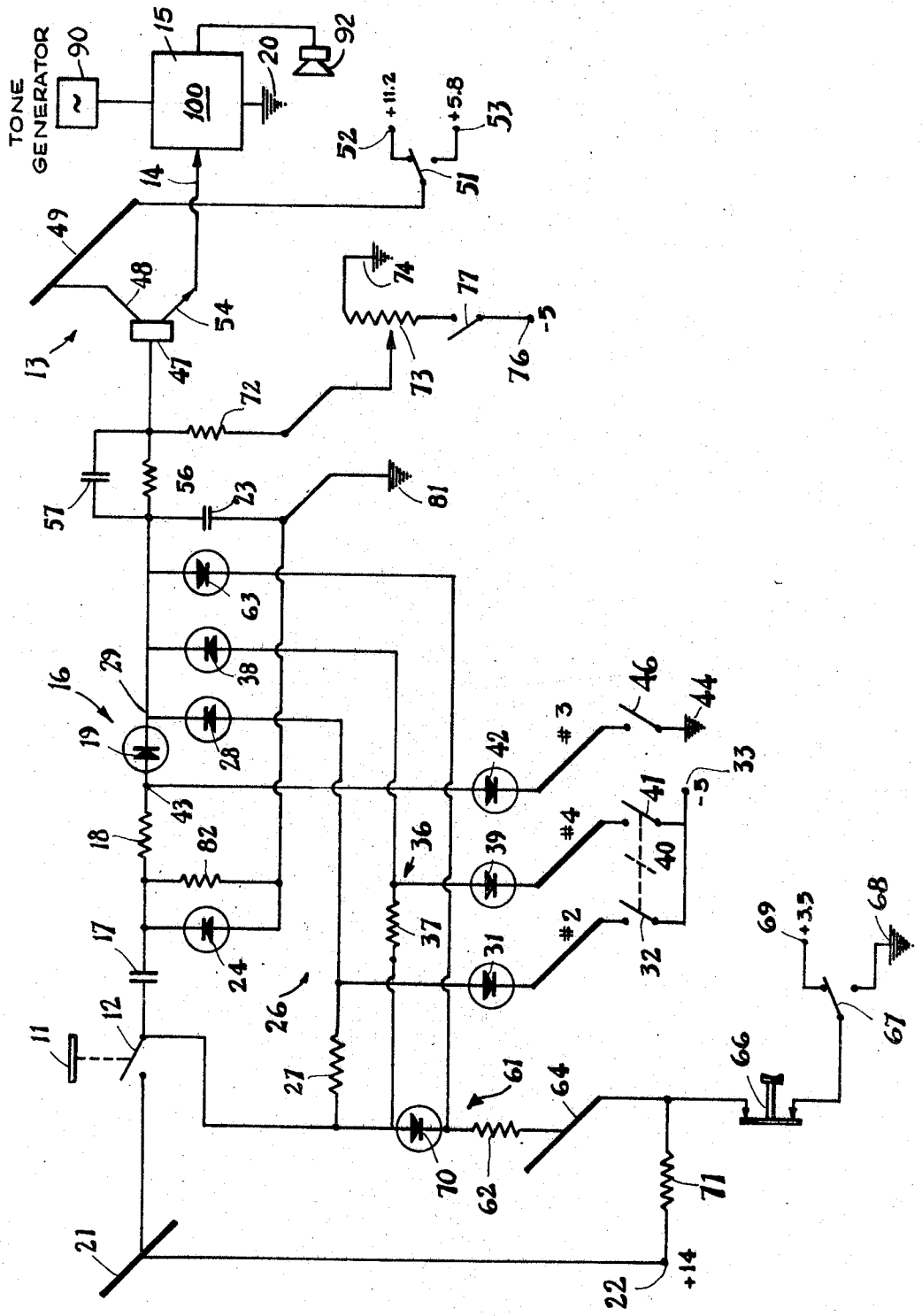
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PIANO KEYING CIRCUIT FOR ELECTRICAL MUSICAL INSTRUMENT, WITH SELECTIVE BY-PASS CIRCUITS FOR OTHER INSTRUMENTAL EFFECTS

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PIANO KEYING CIRCUIT FOR ELECTRICAL MUSICAL INSTRUMENT, WITH SELECTIVE BY-PASS CIRCUITS FOR OTHER INSTRUMENTAL EFFECTS

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ABSTRACT OF THE DISCLOSURE

A keying circuit is provided for an electrical musical instrument which permits the artist to simulate piano tones, and which includes a plurality of by-pass circuits which may be selectively actuated for other tonal effects.

This invention relates to keying circuit for an electrical musical instrument. By means of this keying circuit, the artist or performer may, at will, select various tonal envelopes for the tones produced, such as piano or harpsichord, organ, organ with percussion attack, and accordion.

It is known to provide a keying circuit for an electronic musical instrument by means of which piano tone envelopes may be simulated. Such circuits have consisted, for example, of a plurality of key switches, one for each key of a keyboard instrument; a corresponding plurality of keyers, which, when appropriately stimulated, serve to apply an appropriate tone or tonal combination to the loudspeaker of the system; and a piano circuit connecting the key switch to the keyer. The piano circuit includes a series connected capacitor through which a pulse of current passes, as the capacitor is charged, to stimulate or activate the keyer with a pulse which simulates the envelope of a piano tone when a piano key is struck.

In accordance with the present invention, by-pass circuit means are provided, whereby other instrumental effects, such as organ or accordion, may be developed at the will of the performer, by the operation of suitable stops or tabs which operate switches linked thereto.

Circuit means are provided in accordance with this invention to allow the operator to select a sostenuto or sustain effect.

Also in accordance with this invention, means are provided to achieve the unique, short, initial percussive effect characteristic of the striking of a piano hammer against the piano strings.

A preferred form of the present invention will now be described in conjunction with the single drawing, which is a circuit diagram of a keyer circuit in accordance with the present invention.

In the drawing, **11** represents one of a plurality of keyboard keys on the keyboard of a musical instrument. Associated with each key **11** is a key switch means illustrated specifically here as a single-pole, single-throw switch **12**, which is normally open and which is closed whenever the performer depresses the key **11**. **13** is a keyer means corresponding to the key **11**, which, when appropriately stimulated, in accordance with the present invention, applies to its output **14** a signal or voltage of appropriate configuration that, in due course, becomes effectively the envelope for the audio tone sounded by the instrument. In the present circuit, it is contemplated that the output applied at **14** will in turn be used to open or render conductive or operative an appropriate modulator, keyer, oscillator, or other form of audio gate, to apply audio tone signals to the acoustic output of the instrument. The output gating circuit is shown generally at **15**, the ground **20** implying that it thus serves as a return path for currents passing through the keyer means **13**. If desired, the keying means **13** may itself constitute the audio gate, which case audio tones would be applied directly to the keying means **13** and upon appropriate stimulation, audio would pass into and out of the keying means.

Piano circuit means **16** serves to connect the switch **12** to the keyer **13**, so as to pulse-activate the keyer **13** every time the switch **12** is closed. The circuit **16** includes a capacitor **17**, connected in series between switch **12** and the keyer **13**, a resistor **18**, and diode **19**. The diagonal line **21** represents a bus which is common to a plurality of keys **11**, such as a given keyboard, or in fact, if desired, all of the keys of the instrument. The bus **21** is connected to a positive source of voltage, shown by way of example as a plus 14 volt source **22**. Upon closing of the switch **12**, a pulse of current passes from the source **22**, through the capacitor **17**, and to the keyer **13**. In so doing, it quickly and momentarily charges a capacitor **23** which functions to provide sustain or sostenuto.

When the switch **12** is opened, it is desirable for fast repeating that the capacitor **17** be quickly returned to quiescent (nominally discharged) condition. To this end, a diode **24** is provided, which serves in a discharge circuit for the capacitor **17**, in a manner which will be explained hereinafter.

As will be explained more fully hereinafter, the circuit heretofore described provides for pulse activation of the keyer **13** whenever the switch **12** is closed. In accordance with the present invention, there is also provided circuit means for achieving, at the will of the performer, either an organ simulating condition, or an accordion simulating condition; so that when appropriate tabs are operated, the depression of the key **11** will produce, not a piano simulating envelope, but an organ or an accordion simultating envelope. To this end, for organ simulation, a by-pass circuit means **26** is provided which by-passes the piano circuit means **16** to apply a non-percussion stimulus to the keyer **13**, so long as the key switch **12** remains closed. Specifically, this by-pass consists of a series connected resistor **27** and diode **28** connected between the key **12** and the circuit point **29** to the right of the diode **19**.

In accordance with the present invention, means are provided for disabling the by-pass circuit **26** so as to render it ineffective to apply a non-percussive stimulus to the keyer **13**. This means employs the diode **28** as one of a pair of back-to-back diodes, the other one of which is shown at **31**. This is achieved by connecting the diode **31** to the juncture between the resistor **27** and the diode **28**. The other side of the diode **31** is connected through a single-pole, single-throw switch **32** to a terminal **33** having a potential of minus five volts. Terminal **33** in effect thus returns to the other side of the source **22**, but is at minus five volts relative to a zero reference (ground) with respect to which the terminal **22** is biased by plus fourteen volts. The by-pass circuit **26** serves to apply an organ simulating keying stimulus or signal to the keyer **13**.

In order to simulate an accordion, a by-pass circuit **36**, similar to the circuit **26**, parallels the circuit **26**. It consists of a resistor **37**, diodes **38** and **39**, and switch **41**, returning to the minus five volt terminal **33**. An interlock, represented schematically at **40**, is provided between switches **32** and **41** to prevent both of the switches from being open at the same time. The purpose of this interlock will become apparent hereinafter. In order to disable or render ineffective the piano keying circuit **16**, when either of the circuits **26** or **36** is to be employed, there is provided a disabling means consisting of a diode **42**, through which the terminal point **43** to the left of the diode **19** is grounded at **44** by way of a single-pole switch **46**.

The keyer **13** consists of a transistor, the base **47** of which constitutes the input that receives the stimulating

voltage initiated through the switch **12**. The collector **48** is connected to a bus **49**, which in turn is connected through a double-throw switch **51**, either to a terminal **52** on which resides plus 11.2 volts or a terminal **53** on which resides plus 5.8 volts. The transistor **13** is connected as an emitter follower, so that the emitter **54** constitutes the output terminal **14** discussed hereinbefore.

The circuitry interposed between the switch **12** and the keyer **13** includes a series connected resistor **56**. In accordance with the present invention, a capacitor **57** is connected in shunt with the resistor **56** to provide a small initial surge of voltage to the keyer **13**, which effects simulation of the striking of a piano hammer against the piano strings. This effect may be negated by connecting the collector **48** to the plus 5.8 voltage source **53**, as will be explained hereinafter.

In accordance with the present invention, sustain circuit means **61** are provided. This circuit in the case of piano operation is associated with the simulation of sostenuto, and in the case of organ operation, with organ sustain. The circuit includes a resistor **62** connected through a diode **63** to the junction point **29**. The other end of the resistor **62** is connected to a bus **64** and thence through a switch **66** to a double-throw switch **67**, the terminals of which are connected respectively to ground **68** and to 3.5 volts shown at **69**. The bus **64** is returned to the plus fourteen volt terminal **22** through a resistor **71**. Diode **70**, by applying a reverse bias to diode **63** while switch **12** is closed, prevents current from being bled away from point **29** through sostenuto path **61**.

The sustain or decay characteristics of the tone are also controlled by a discharge circuit consisting of resistor **72** connected to the base **47** and leading to a potentiometer **73**, connected between ground **74** and minus five volts at **76**. A switch **77** is provided to isolate the potentiometer **73** from the minus five volt potential, if desired.

It is to be understood that the various potentials referred to represent voltage levels all referred to a common reference of which the ground symbol represents zero voltage. It will be further understood that in each case the diagonal lines exemplified by the bus **21** represent buses common to a plurality of keys **11**. The components below each of the several buses are likewise common to a plurality of keys. Thus, for example, the switches **32**, **41**, and **46** are common to a plurality of circuits, one of which is described in the figure. By the term diode used herein is meant broadly any unilateral conducting device which has, in the operating ranges of this circuit, a very high resistance in one polarity and a very low resistance in the opposite polarity.

Function and operation of the circuit illustrated will now be described.

PIANO OR HARPSICHORD

If a piano or harpsichord effect is desired, the switches are set, through appropriate tab operation, as follows: switch **32** closed; switch **41** closed; switch **46** open; switch **77** closed; switches **51** and **67** in upper position.

The sostenuto switch **66** is normally biased to closed position. It is opened, usually by a knee control, by the performer whenever he wishes to simulate depression of the sostenuto pedal of a piano (or organ sustain).

In quiescence, with switch **12** open, capacitor **17** will have a minus five volt charge thereon, from the minus five volt potential **33**. Source of this charge may be traced from ground **81** through diode **24** (and resistor **82**), capacitor **17**, resistor **27**, diode **31**, switch **32** to the minus five volt terminal **33**. Upon closing of a key switch **12**, plus 14 volts is applied to the capacitor **17** from the source **22**. There is thus in effect a 19-volt potential difference, causing current to flow through the capacitor **17**, resistor **18**, diode **19**, capacitor **57** (and resistor **56**), the base **47** of the transistor keyer **13**, and thence through the output circuit **15**. This forward biases the emitter follower to cause current to flow from the collector **48** to

the emitter **54** and thence through the output lead **14** to the gating circuits **15**, which complete the keying function and allows tone signal to flow from the tone generators **90** to the acoustic output system, such as the loudspeaker **92**.

Capacitor **23** is much smaller than capacitor **17**. Thus, when capacitor **17** starts to charge, capacitor **23** becomes substantially fully charged very quickly, because of the relatively small effective impedance in series therewith, represented by **17**, **18**, and **19**. Thereafter **17** charges more slowly, primarily through resistor **82**, while capacitor **23** discharges through resistance **56** and the base/emitter junction of **13**, and also through resistor **72** to the potential determined by the slider on the potentiometer **73**. As long as the switch **12** remains closed, this phenomenon continues until **17** becomes fully charged and **23** becomes fully discharged. The result is a pulse, i.e. a rise, and then a fall, of voltage on base **47**, producing a pulse at the output **14**, the nature of which simulates the configuration of the envelope of a piano tone.

When switch **12** is opened, the discharge of capacitor **23** is also considerably influenced by the discharge path through diode **63**, resistor **62**, to bus **64**, sostenuto switch **66** and thence to the biasing terminal **68** or **69**.

A staccato effect is achieved if the key switch **12** is opened before **17** is fully charged. When this happens the capacitor **17** immediately begins to discharge. This reverses the polarity of the voltage across resistor **82**, forward biases diode **24**, and reverse biases diode **19**. Discharge of capacitor **23** is accelerated through the sostenuto resistor **62**. This results in termination of the tone which, while abrupt, is not completely instantaneous, since there is some small tail effected through the remnant of charge on the capacitor **23**.

If this opening of the switch **12** is effected with the sostenuto switch **66** open, then there is a long decay period in the pulse, because the discharge path for the capacitor **23** is limited to the keyer **13** and the resistor **72**. The tone is thus prolonged to simulate the effect of a piano with the sostenuto pedal depressed.

As noted above, the playing of a key and closing of a switch **12** places capacitor **17** in a positive charged condition, i.e. The left side of **17** is positive with respect to the right side. When the switch **12** is opened, it is desirable to quickly discharge (and than reverse charge) capacitor **17**, in order to ready the circuit for the possible replaying of the key, as when notes are played in rapid succession on a piano. This is effected in the present circuit by the diode **24** which provides a discharge path for the capacitor **17** through elements **27**, **31**, **32**, **33**, **81**, **24**, and back to the capacitor **17**.

The function of the capacitor **57** is to provide an overshoot in the initial voltage rise at the base **47** whenever the key **12** is closed. This modifies the pulse so that, when formed into a tone envelope, it simulates the striking of the hammer on a piano string.

The chief reason for the interlocking of switches **32** and **41**, to assure that at least one of these switches will always be closed, is to assure maintenance of this discharge path for capacitor **17** through the diode **24**. Furthermore, when properly played, there should be no occasion for the performer to have **32** and **41** open simultaneously, since this would represent a setting of the stop tabs simultaneously for organ and accordion, which, of course, is a musical incompatibility.

ORGAN CIRCUIT

To create an organ effect, the switches are placed as follows: **32** open; **41** closed; **46** closed; **77** closed; **51** and **67** in lower position.

The closing of switch **46** effectively disables the piano circuit **16** by clamping the point **43** to ground through the diode **42**. Closing the switch **41** effectively reverse biases diode **38** by applying minus five volts to the right-hand side of resistor **37**. This leaves the circuit consisting

of resistor **27** and diode **28** as the only on which can transmit current to the keyer from the switch **12**.

Upon closing of switch **12**, current flows through **27** and **28** to charge capacitor **23**, thus causing the desired tone to sound. The piano hammer effect present in the operation of the piano circuit, because of the overshoot through capacitor **57**, is eliminated by placing the collector **49** at 5.8 volts, instead of 11.2. This is because the drive provided by the overshoot through capacitor **57** takes the transistor base beyond the effective gain range of the transistor, when the collector has only a 5.8 volt bias. As a result, the overshoot passes directly from base **47** to emitter **54** without gain, and is for practical purposes lost.

Since there is now a direct current path from the source **22** to the keyer **13**, the tone is sustained as long as the switch **12** remains closed. When the switch **12** is opened, the charge on capacitor **23** quickly, although not instantaneously, dissipates through the sostenuto resistor **62**. If the knee-operated switch **66** is open, the only discharge path for **23** is through resistor **56** and thence through the dual path represented by keyer **13** and resistor **72**. Thus along sustain tone is produced, the length of which is dependent upon the setting of the slider of potentiometer **73**.

For conventional organ simulation, it is preferred to have a very, very short sustain time. To this end, the sostenuto circuit is grounded through switch **67** and the resistor **72** is returned to a negative voltage by the closing of switch **77**.

ORGAN WITH PERCUSSIVE ATTACK

To simulate an organ with percussive attack, the switch positions are the same as described above for the organ, except that switch **46** is open, thereby placing the piano keying circuit **16** also into operation. In addition, the switch **51** is placed in its upper position, thereby bringing the effect of capacitor **57** back into the picture. Finally, it is preferred for this mode of operation to open switch **77**, thereby giving a somewhat longer sustain time which may be musically desirable with very sharp attack.

The operation in this mode represents simply a combination of the operation of the piano and the organ circuits described hereinbefore. This in effect means that the attack is a sharp, abrupt attack as with the piano, but the tone continues as in an organ, as long as switch **12** remains closed.

ACCORDION

To simulate an accordion tone, the switches are placed as follows: **32** closed; **41** open; **46** closed; **77** open; **51** and **67** in upper position.

Accordion operation is essentially similar to organ operation, except that the attitude of switches **32** and **41** is interchanged. This brings into play the by-pass resistor **37** instead of the resistor **27**. Resistor **37** is considerably larger than is resistor **27**, thus producing a much longer attack time, since the charging time for capacitor **23** is thus much longer. Additionally, it is preferred to have a short sustain and to this end the switch **67** is placed in the upper position in which the sostenuto circuit is returned to 3.5 volts. In similar vein, by opening switch **77**, a somewhat longer sustain is also brought about.

While it is preferred to place switch **51** in the upper position, thereby biasing the collector to 11.2 volts, the effect of the position of switch **51** in accordion operation is virtually negligible. This is because, irrespective of what the collector voltage is, the charging of capacitor **23** is so slow that the overshoot capacitor **57** can have little effect, irrespective of the collector bias.

The operation of the sostenuto circuit **61** is as follows:

The closing of a key switch **12** forward biases diode **70** and reverse biases diode **63**. When the switch **12** is opened, however, the condition is reversed; diode **63** is forward biased while diode **70** is reverse biased. This permits rather rapid discharge of capacitor **23** through resistor **62**, down to whatever voltage level is set by the switch **67**. When the sostenuto switch **66** is operated to open position, the principal discharge path for capacitor **23** is removed, thus causing the note to be sustained, in all modes of operation: organ, piano, and accordion.

As an example, a circuit having the following parameters has been operated very successfully.

Capacitor **17**.—40 microfarads.
Capacitor **23**.—10 microfarads.
Capacitor **57**.—4 microfarads.
Resistor **18**.—470 ohms.
Resistor **56**.—68,000 ohms.
Resistor **82**.—68,000 ohms.
Resistor **27**.—1,500 ohms.
Resistor **37**.—10,000 ohms.
Resistor **62**.—4,700 ohms.
Resistor **72**.—100,000, 120,000, 180,000, 220,000 ohms.
Potentiometer **73**.—1,500 ohms.
Resistor **71**.—22,000 ohms.
Transistor **13**.—2N2924.

Resistor **72** has four values as shown, because the notes of the scale were divided into four groups, having the four values shown above.

Whereas the present invention has been shown and described herein in what is conceived to be the best mode contemplated, it is recognized that departures may be made therefrom within the scope of the invention which is, therefore, not to be limited to the details disclosed herein, but is to be afforded the full scope of the invention as hereinafter claimed.

What is claimed is:

1. In a keying circuit for an electrical musical instrument having:

key switch means, keyer means, and piano circuit means, including a capacitor connected in series between said key switch means and said keyer means, for causing said keyer means to be pulse-actuated by said piano circuit means upon operation of said key switch means, thereby to simulate the envelope of a piano or harpsichord; the combination comprising:

by-pass circuit means by-passing said piano circuit means for applying a continuous stimulus to said keyer means so long as said key switch means remains in operated position thereby to simulate a non-percussion instrument, such as an organ,

by-pass circuit disabling means for selectively rendering said by-pass circuit means ineffective to apply said continuous stimulus to said keyer means, and

piano circuit disabling means for selectively rendering said piano circuit means ineffective to pulse-actuate said keyer means.

2. The combination of claim **1** wherein said piano circuit means comprises:

piano circuit diode means connected in series between said capacitor and said keyer means, said combination including,

a source of direct voltage having one side connected to have its voltage applied to said capacitor upon operation of said key switch means, and wherein

said by-pass circuit means shunts said series-connected capacitor and diode means.

3. The combination of claim **2** in which said piano circuit disabling means comprises:

series-connected diode means and switch means connected to said piano circuit means between said capacitor and said piano circuit diode means,

circuit means for returning said series-connected diode means and switch means to the other side of said voltage source and wherein,

said by-pass circuit disabling means comprises a pair of back-to-back diodes, one being connected in that portion of said by-pass circuit means which shunts said series-connected capacitor and diode means, the

other being connected to a circuit returning to the other side of said voltage source.

4. The combination of claim 2, including a sustain capacitor connected to said keyer means, and

sostenuto circuit means connected between said sustain capacitor and the other side of said source.

5. In a keying circuit for an electric musical instrument having:

key switch means,

keyer means,

piano circuit means comprising:

capacitor means and diode means connected in series between said key switch means and said keyer means,

a source of direct voltage having one side connected to have its voltage applied to said capacitor means upon operation of said key switch means,

a sustain capacitor connected to said keyer means for providing a sostenuto effect, the combination comprising,

selectively actuable sostenuto-defeating circuit means connected between said sustain capacitor and said key switch means for rapidly discharging said sustain capacitor upon release of said key switch means.

6. In a keying circuit for an electric musical instrument having:

key switch means,

keyer means,

piano circuit means comprising:

capacitor means and diode means connected in series between said key switch means and said keyer means,

a source of direct voltage having one side connected to have its voltage applied to said capacitor means upon operation of said key switch means,

a sustain capacitor connected to said keyer means for providing a sostenuto effect, the combination comprising,

sostenuto-defeating circuit means connected to said sustain capacitor to discharge the same, said sustenuto-defeating circuit means comprising:

a first diode having one side connected to said keyer means,

circuit means for returning the other side of said first diode to the other side of said voltage source, and

a second diode connected between said key switch means and the other side of said first diode.

7. In a keying circuit for an electrical musical instrument having:

key switch means, keyer means, and piano circuit means, including a capacitor connected in series between said key switch means and said keyer means, for causing said keyer means to be pulse-actuated by said piano circuit means upon operation of said key switch means, thereby to simulate the envelope of a piano or harpsichord; the combination comprising:

by-pass circuit means by-passing said piano circuit means for applying a continuous stimulus to said keyer means so long as said key switch means remains in operated position thereby to simulate a non-percussion instrument, such as an organ, and

by-pass circuit disabling means for selectively rendering said by-pass circuit means ineffective to apply said continuous stimulus to said keyer means, said by-pass circuit disabling means comprising gating means and means for selectively biasing said gating means to conduction or non-conduction condition.

8. A keying circuit for an electric musical instrument having a key switch, keyer means, and a source of direct voltage connected to apply keying potential to said keyer means upon operation of said key switch, characterized by said keyer means including:

a transistor having at least an input terminal and a biasing terminal,

parallel capacitor and resistor circuit means connected between said key switch and said input terminal for providing a voltage overshoot upon actuation of said key switch, and

biasing means connected to said biasing terminal of said transistor for applying a plurality of significantly different biasing voltages to said biasing terminal,

one of said biasing voltages having a value which renders said voltage overshoot from said parallel capacitor and resister circuit means ineffective.

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