United States Patent

[11] 3,562,400

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[21] Appl. No. 706,918
[22] Filed Feb. 20, 1968
[45] Patented Feb. 9, 1971

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[54] **PERCUSSION KEYER WITH PEDAL SUSTAIN FOR ELECTRONIC MUSICAL INSTRUMENT**
4 Claims, 2 Drawing Figs.

[52] U.S. Cl. 84/1.26
[51] Int. Cl. G10h 1/02
[50] Field of Search ..... 84/1.01, 1.04, 1.06—1.08, 1.1, 1.13, 1.17, 1.24—1.27, (E,F,O)

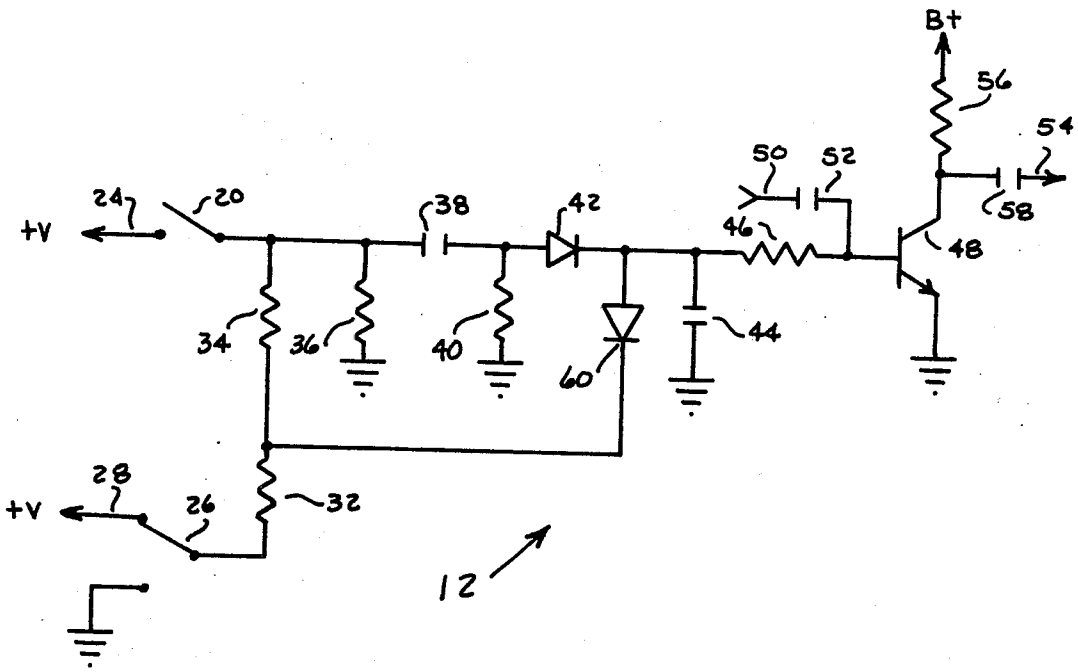
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ABSTRACT: A percussive musical note is simulated. A switch passes a pulse to an RC circuit which differentiates the leading edge. The formed signal simulates a percussive instrument. A second switch adds a sustained voltage to the pulse. A diode blocks part of the discharge path of the RC circuit and extends its decay time. Hence the note may be short or sustained.



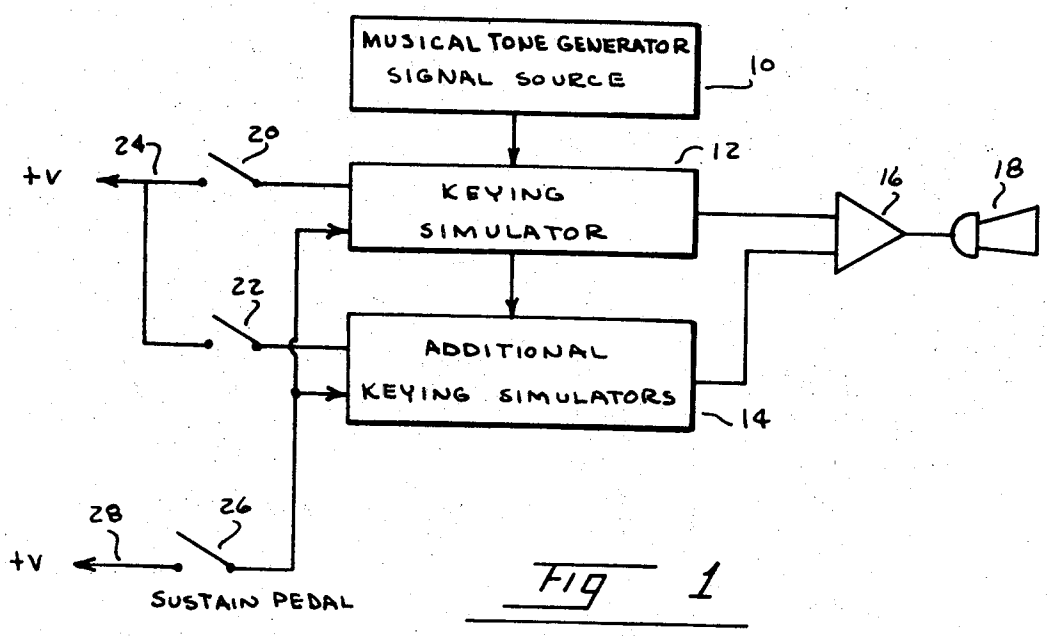


Fig 1

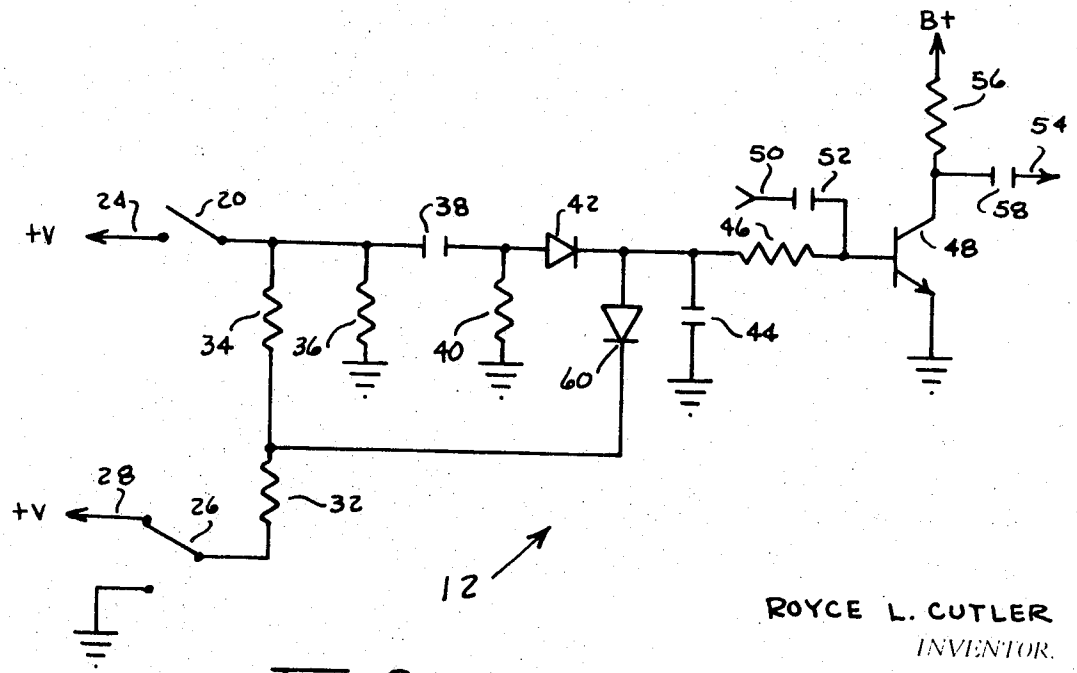


Fig 2

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PERCUSSION KEYER WITH PEDAL SUSTAIN FOR ELECTRONIC MUSICAL INSTRUMENT

SUMMARY OF PROBLEM AND SOLUTION

Percussive keyboard instruments normally include the piano, harpsichord, clavichord, and the like. The musical tones from such instruments can be simulated in electronic signal generating apparatus. However, certain striking characteristics are inherently involved in the construction of such keyboard musical instruments. For instance, most percussive keyboard instruments use a striking mallet or hammer which taps a plurality of strings to obtain the tone. The manner of striking the strings materially alters the quality of the tone and its duration. The modern piano sustains a note for a long period if the piano key remains depressed. On release, the note is damped or muted rather quickly. An alternative mode of operation is presently provided wherein the keys of the entire keyboard are provided with the sustain feature so that all notes struck are sustained through operation of a foot pedal.

It is with the foregoing percussive keyboard tones and qualities that the present invention is described as an apparatus for simulating percussive keyboard striking characteristics. More particularly, the circuit of the present invention is adapted to provide an electronic keying apparatus which simulates the sustain or muted characteristics of a conventional percussive instrument keyboard and wherein a sustain pedal feature is also incorporated with the present invention. With the above summary in view, those skilled in the art will perceive many objects of the present invention, which will be more readily understood from a consideration of the following specification and included drawings, wherein:

FIG. **1** is a block diagram schematic of the device of the present invention cooperating with an electronic tone generating apparatus; and,

FIG. **2** is a schematic wiring diagram of the present invention.

Attention is first directed to FIG. **1** of the drawings which illustrates a musical tone generator signal source indicated by the numeral **10**. Such a signal source is an electronic tone generator as typically found in numerous electronic organs or other devices wherein the musical tone is an electrical signal conducted by appropriate wiring to the present invention for use as will be explained. The signal source **10** is normally communicated with the keying simulator **12** of the present invention. Since the present invention is designed for use with an entire keyboard, additional keying simulators are indicated at **14** in FIG. **1**, it being appreciated that the number is increased without limit and that all simulators are preferably identical save for their connection to signals of different frequencies or voicing from the musical tone generator **10**. The outputs of the various simulators **12** and **14** are input to a suitable amplifier **16** which then communicates with a suitable output device, a speaker **18**, or the like. The means **10**, **16** and **18** are shown as supporting structures for an understanding of the present invention **12**, and may vary in many details in a variety of instruments presently made or available in the future.

The device of the present invention incorporates the keying simulator **12** which is actuated by a switch means **20**. While the switch means **20** is represented as a single-pole, single-throw switch in FIG. **1**, it will be appreciated that it is preferably a key of the keyboard which is adapted to control the output signal from the tone generator **12** to shape the musical note supplied to the amplifier **10**. Moreover, the additional keying simulators indicated generally at **14** are likewise provided with suitable keyboard means **22** which are represented schematically as identical switches and which are suitably connected for operation of the keying simulators **14** for the entirety of the keyboard. Preferably, all of the keys **20** and **22** are connected in parallel to a voltage source **24** at a suitable level of perhaps 10 to 20 volts cooperative with the solid state circuitry to be described.

The present invention includes a sustain pedal **26** connected to a suitable voltage source **28**. The pedal **26** is represented schematically in FIG. **1** as a single-pole, single-throw switch when the input to all the keying simulators **12** and **14** are sustained as a group. Again, referring to the example of the modern piano, the sustain pedal **26** operates the entirety of the keyboard whereby striking any note forms a sustained tone without regard to the duration of the key depression.

Referring now to FIG. **2**, it will be noted that the switches **20** and **26**, having the preferred forms of a keyboard striking means and a foot-operated sustain pedal, respectively, are connected to the indicated voltage sources for operation of the present invention. Two series resistors **32** and **34** each having a resistance approximating 100,000 ohms communicate the switches **20** and **26**. The switch means **20** is preferably grounded by a smaller resistor **36**. A series capacitor **38** and appropriately grounded resistor **40** cooperate as a differentiator for the pulse formed by the switch means **20**.

On operation of the switch means **20**, it will be appreciated that an essentially square pulse is formed by the means **20**. The pulse has a positive-going leading edge in the circuitry presently illustrated. The trailing edge, generated on opening the switch **20**, is a negative-going voltage change. The derivative of the leading and trailing edges of the pulse is a positive-going spike and then a negative-going spike output by the differentiating means to the diode **42**. The diode **42** passes the positive-going spike which occurs on closure of the switch means **20**. However, on opening the switch means **20**, which generates the negative-going spike, forms a signal which the diode means **42** blocks, its anode falling below the voltage of the cathode.

The positive-going spike passed by the diode **42** charges a capacitor **44** with a positive charge on its ungrounded plate. A very large resistor **46**, preferably in the megohm range, forms a path to ground through the base of a transistor **48**. The emitter of the transistor **48** is grounded to complete the ground path for discharging the positive charge placed on the plates of the capacitor **44**. Significantly, bleeding the charge from the capacitor **44** through resistor **46** and the base of the transistor **48** serves as the bias voltage for the transistor **48** which amplifies in response to its bias voltage.

The musical tone from the generator means **10** is input to the simulator **12** by a conductor **50** which has a suitable blocking capacitor **52** interposed between the conductor and the base. In the quiescent condition, the absence of a suitable bias voltage for the base of the transistor **48** prevents amplification. However, provision of the bias for the base of the transistor then enables the transistor to substantially amplify the tone signal from the conductor **50** for an output conductor **54**.

The complete transistor circuit incorporates a load resistor **56** in the collector circuit and a suitable DC blocking condenser **58** to prevent passage of the DC level to the output conductor **54**. Thus, it will be understood and appreciated that bleeding the charge on the ungrounded plate of the capacitor **44** through the transistor forms a suitable bias for the transistor to turn it on, somewhat rapidly, upon closing the switch **20** just as a key of a percussive keyboard instrument strikes a note.

Considering now operation of the circuitry when the switch **20** is maintained closed, the following will be noted. Closure and subsequent opening of the switch **20** forms first a positive-going and then a negative-going spike presented to the anode of the diode **42**. The positive-going spike, which occurs first, is passed to charge the capacitor **44**. The bias of the transistor rises rapidly and then decays somewhat in an exponential manner through a resistive network to ground including the resistor **46** and the base-emitter junction of the transistor **48**. This decay continues exponentially and is unaltered by the negative-going spike from the differentiator which is blocked by the diode **42**. Therefore, it should be concluded that closure of the key **20** for an indefinitely long interval simulates a sustained tone in the manner as a percussive keyboard instrument wherein the RC time constant (of capacitor **44** and resistor **46**) achieves proper simulation of the desired characteristics of the keyboard.

On the other hand, should the key **20** be closed and rapidly opened, the following occurs. First, the positive-going spike is passed by the diode **42** and quickly charges the capacitor **44** which begins the exponential decay. However, when the key (the switch means **20**) is opened a short interval after closure, a second conducting path to ground for the capacitor **44** is enabled. As previously noted, the resistor **46** is preferably in the megohm range. This provides a first path to ground, including portions of the transistor **48**. However, when the key **20** is opened, it is essentially grounded by the relatively small resistor **36**. This provides a second or parallel path to ground from the capacitor **44** through the diode **60** in the forward direction, and the resistors **34** and **36**. This path to ground has a resistance of perhaps about 125,000 ohms, which is perhaps one-tenth to one-fiftieth of the resistance of the other path to ground. This causes a substantially rapid discharge of the capacitor **44** and consequently drops the bias voltage for the transistor **48**.

Describing the bias voltage of the transistor **48**, rapid closure and opening of the switch means **20** in simulation of a rapidly struck percussion instrument keyboard, the bias voltage rises quite rapidly, begins its exponential decay, and then falls rapidly toward zero, beginning at the interval of opening the switch means **20** whereby the note is terminated or muted and is not sustained. Through occurrence of the foregoing variations of the bias for the transistor **48**, a keyboard percussive instrument is simulated in the same manner as the key is struck or held down by the player.

In operation of the sustain pedal which is represented schematically by the switch means **26**, the quiescent condition is at the grounded terminal indicated in FIG. **2**. This occurs in the absence of the sustain pedal operation. However, when it is desired to sustain a note without holding a key closed, the switch means **26** is closed to communicate a suitable bias potential through the switch **26** to the resistor **32**. In the preferred embodiment, economy of power supply construction is provided by making the potentials **24** and **28** equal.

In the preferred embodiment, the sustain pedal function operates in the following manner. On closure of the switch **26** to the bias potential **28**, the resistors **32** and **34** (a voltage divider) form a fairly high blocking voltage at the cathode of the diode **60**. The blocking voltage operates in the following manner when the sustain pedal is used. Assume, for purposes of discussion, that the switch **20** is rapidly closed and then opened after the sustain pedal is operated. As before, rapid closure and opening forms a positive square wave way which is differentiated by the circuitry. The differentiation provides first a positive-going spike and then a negative-going spike to the diode **42**. The positive-going spike is passed by the diode **42** and is stored on the capacitor **44** and exponentially decayed by the resistor **46** through the base of the transistor to control its amplification. When the switch means **20** is opened, the potential at the midpoint between divider resistors **32** and **34** remain high because the sustain pedal is closed. This blocks operation of the diode **60** to prevent discharge through the second path to ground from the capacitor **44**. Thusly, the capacitor **44** is discharged only through the resistor **46** and the transistor **48** to continue the exponential decay associated with a sustained note. This results from the blocking conduction through the diode **60** which thereby denies a second and substantially smaller path to ground which rapidly bleeds the condenser **44** when the sustained function is not desired.

From the foregoing, it will be appreciated and understood that the device of the present invention simulates percussive keyboard instruments as described for the preferred embodiment. While those skilled in the art may provide substantial modifications in the device of the present invention, the scope of the present invention is determined by the claims appended hereto.

I claim:

1. A transistorized circuit for use in an electronic musical instrument to simulate a percussive keyboard effect when supplied with a signal representative of a musical note comprising:

a. A transistor having base, collector and emitter;

b. A switch suitably adapted to be used as a key of a keyboard;

c. A voltage source connected to said switch;

d. Diode means connected to the other side of said switch and having an anode and cathode arranged to pass a voltage surge of one polarity;

e. RC differentiating circuit means connected to receive a voltage level on closure of said switch for forming an output signal which builds toward a peak and decays toward a lesser value in an exponential fashion;

f. Said base of said transistor means being connected to receive the output signal from said RC circuit means in a manner to control operation of said transistor;

g. Said transistor being connected to amplify a signal representative of a musical note with the gain of said transistor being imposed on the signal representative of the musical note;

h. An additional switch connected with a voltage source to provide a voltage level when closed; and

i. Said additional switch being connected to said base to provide sustained conduction of said transistor in the manner of a sustained percussive musical note after said first switch is operated.

2. The invention of claim **1** wherein said musical note signal is input to the base of said transistor and said RC circuit means is connected thereto to bias operation of said transistor in a manner such that gain of said transistor is varied.

3. The invention of claim **1** wherein said additional switch is connected by a series resistor to said series capacitor and provides a voltage level tending to sustain its voltage level after closing and opening of said switch.

4. The invention of claim **1** wherein the time rate of operation of said RC circuit means is determined at least partially by a first resistive discharge path and a second resistive discharge path and wherein said additional switch means is connected to a diode to bias one of said resistive discharge paths to a blocked condition to reduce the rate of discharge and therefore extend the discharge time of said RC circuit means.