

April 1, 1958

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2,828,659

ELECTRICAL MUSICAL INSTRUMENTS

Filed July 12, 1954

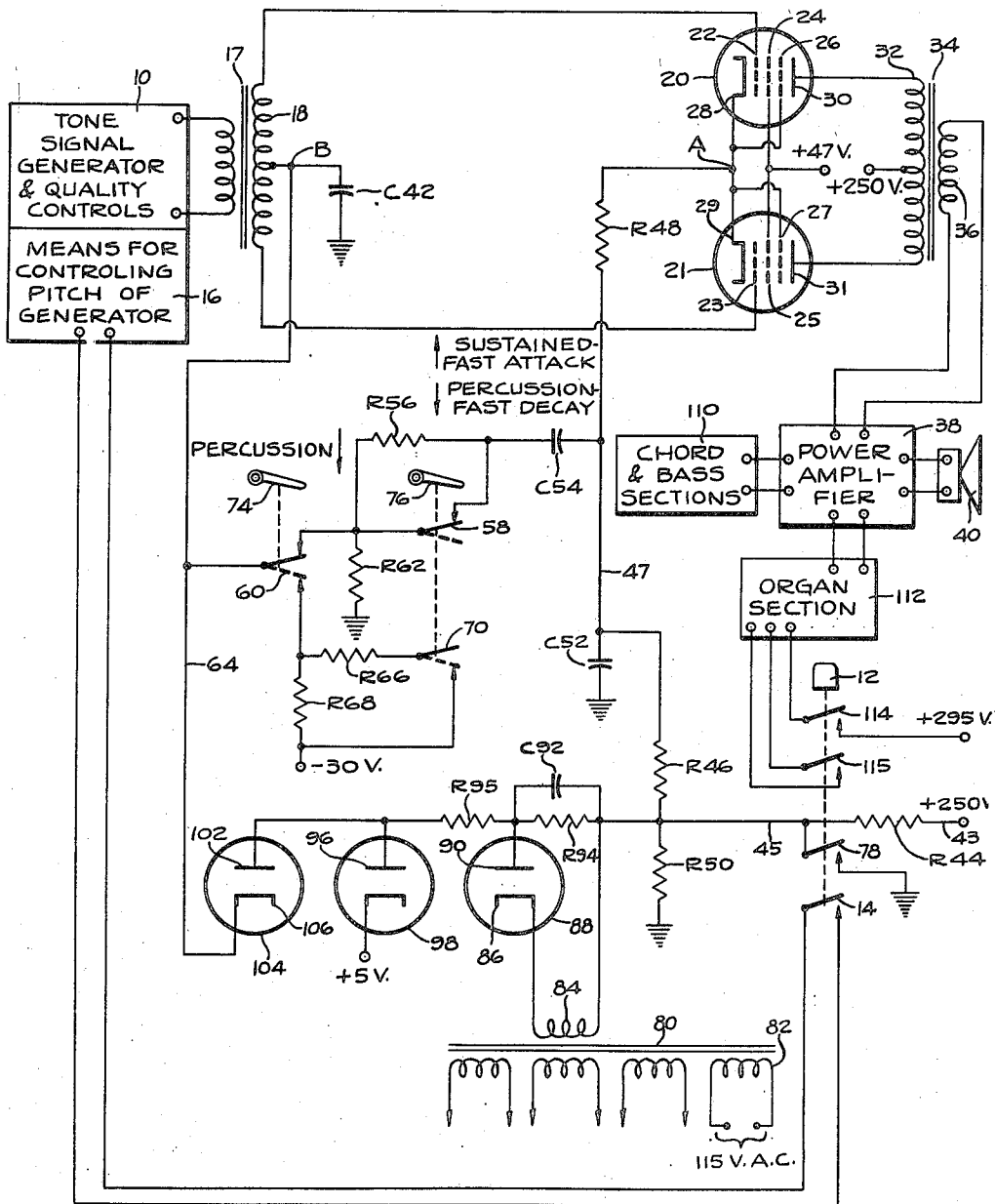


Fig. 1

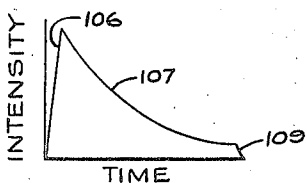


Fig. 2

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2,828,659

ELECTRICAL MUSICAL INSTRUMENTS

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Application July 12, 1954, Serial No. 442,524

4 Claims. (Cl. 84-1.26)

This invention relates generally to electrical musical instruments and more particularly to improved means for producing tones having a percussive intensity envelope.

Much of the charm of many musical instruments is due to the percussive type intensity envelopes of the tones produced. Such percussive tones are useful to provide emphasis and contrast with the sustained tones.

It is therefore an object of this invention to provide improved means and circuits whereby sharply percussive tones may be produced from a sustained tone signal source.

It is a further object of the invention to provide means controlled by the operation of a single key operated switch which will be effective to cause the tones to commence sounding with a sharp but transient-free attack, and thereafter to decay slowly, so as to produce a tonal intensity envelope of a shape characteristic of percussion instruments.

A further object is to provide an envelope controlling means which is effective to produce a slow decay in the intensity envelope which is characteristic of percussion instruments and which is initiated by the closure of a single pole single throw playing key operated switch.

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

Fig. 1 is a schematic wiring and block diagram of a musical instrument incorporating the invention; and

Fig. 2 is a diagram showing a representative tone intensity envelope attainable by the use of the apparatus shown in Fig. 1.

Referring to Fig. 1, the invention is illustrated as being embodied in a melody section of an instrument of the kind shown in my prior Patent No. 2,645,968, that is, an instrument capable of playing solo melody, organ, chord accompaniment, and bass tones. The solo section of the instrument comprises a tone signal generator 10 which may be considered to include also the various quality controls, octave couplers and other parts common to instruments of this character. The pitch of the signal produced by the generator 10 is determined by the depression of a playing key 12 which is representative of the keys of several octaves of keys. Each playing key 12 operates a switch 14 which, by means of a pitch controlling means 16, conditions the generator 10 to provide a signal corresponding in pitch to that of the particular key 12 which is operated.

The output of the generator 10 is coupled by a transformer 17 to the input of push-pull control pentodes 20 and 21, the secondary 18 of the transformer being connected to the control grids 22 and 23 of the pentodes 20 and 21 respectively. The screen grids 24 and 25 are connected to a suitable source of operating potential indicated as a +47 v. terminal, while their suppressor grids 26 and 27 are connected to the cathodes 28 and 29. The cathodes are connected to a terminal A while the plates 30 and 31 of these pentodes are connected to the end terminals of the primary 32 of an output transformer 34 having a cen-

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ter tap which is connected to a terminal +250 v. The secondary 36 of the transformer 34 is connected to a power amplifier 38 which supplies one or more speakers 40.

The secondary of transformer 18 has a center tap connected to a terminal B. It will thus be apparent that the degree of amplification provided by the pentodes 20 and 21 will depend mainly upon the difference between the potentials on terminals A and B, that is, the grid bias on the pentodes 20 and 21. A relatively large capacitor C42 is connected between terminal B and ground, representative of any point of unvarying or fixed potential.

As will appear hereinafter, when none of the playing keys is depressed the terminal B will be maintained at a potential of about +5 volts while the terminal A will be at a potential of approximately +35 volts so that with the particular pentodes employed, 6BA6 type, the pentodes 20 and 21 will be biased beyond cutoff, both because of the 30 v. negative bias existing between the cathodes and grids and also because the screen voltage relative to the cathode voltage is reduced to +12 volts.

The means for normally maintaining the terminal A at a cutoff potential comprises a circuit between terminal A and a resistor R44 which is connected to a +250 v. terminal. In addition, this circuit includes a conductor 45, a relatively low value resistor R46, a conductor 47 and a resistor R48. The conductor 45 is connected to ground by a resistor R50 while the conductor 47 is connected to ground by a relatively larger value capacitor C52. A capacitor C54 has one terminal connected to the conductor 47 and its other terminal connected to a high value resistor R56 and one pole of a switch 58. The other pole of the switch 58 is connected to the resistor R56, to one pole of a double throw switch 60, and to ground through a relatively low value resistor R62. The movable contactor of the switch 60 is connected to a conductor 64 which connects with terminal B. The other fixed contact of switch 60 is connected to resistors R66 and R68. Upon closure of a switch 70 the resistor R66 is connected in parallel with resistor R68. The resistor R68 is connected to a -30 volt terminal of the power supply. The switch 60 is operated by a "percussion" tablet 74, while switches 58 and 70 are operated by a "sustained-fast-attack-percussion-fast decay" tablet 76.

The playing key 12, upon depression thereof, closes a switch 78, thereby connecting the conductor 45 to ground. The transformer 80 of the power supply of the instrument, in addition to having its primary winding 82 which is connected to the source of alternating current, has a number of secondary windings including a secondary winding 84, one terminal of which is connected to the conductor 45 and the other terminal of which is connected to the cathode 86 of a diode 88. The plate 90 of the diode 88 is connected to the conductor 45 by filter capacitor C92 in parallel with a load resistor R94. The winding 84, the diode 88 and its associated components are proportioned to place a negative voltage of approximately thirty volts across resistor R94. Due to the voltage dividing effect of resistors R44 and R50 the potential on conductor 45 will tend initially to rise to +65 v., but due to the subsequent current flow through resistors R94, R95 and the diode 98, the potential on this conductor will normally be +35 volts. The potential on the plate 90 of diode 88 will be the same as that on its cathode, namely +5 volts. The voltage drop across the resistor R95 is negligible thus leaving the cathode potential of the diode 98, and on the plates 96 and 102, at about +5 volts. This potential +5 volts is also present at the cathode 106 of the diode 104, and therefore, substantially this potential is present across the capacitor C42, when the switch 60 is in its dotted line position.

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The impedance of resistors R68 and R66 are of very high value relative to the impedance of the circuits including the diodes 104 and 98, so that the potential at point B is not exactly +5 volts, but very close to this value. The rate at which the voltage on terminal B approaches this potential is relatively rapid being limited principally by resistors R46, R50, and R95, which are of relatively low value by comparison with the values of resistors R66 and R68.

Upon depression of the playing key 12, with switch 60 in its dotted line position, the switch 14 will close first to cause the pitch of the signal supplied by the generator to correspond to that of the playing key, and will thereafter close switch 78. As a result, the terminal A will rapidly be reduced to an initial self bias potential of about +5 volts because the time constant of the mesh comprising resistors R46 and R48 and capacitor C52 is small. The capacitor C42 is relatively large so that terminal B will initially be at its substantially +5 volt potential. However, the diode 104 is immediately rendered non-conducting because the conductor 45 is connected to ground and the plate 102 of the diode 104 will immediately have its potential lowered to -30 volts by virtue of the -30 volt potential generated by diode 88 and its associated components. However, because the percussion tablet 74 has been depressed to move switch 60 to its dotted line position, the capacitor C42 will commence slow discharge to -30 volts through a path including either the resistor R66 if switch 70 is open, or through the resistor R63 and resistor R66 if switch 70 is closed. The capacitor C42 will continue to discharge either until terminal B reaches -30 volts, or until the playing key 12 is released. Upon release of the key the potential on terminal A will again rapidly rise to +35 volts so as to bias the pentodes 20 and 21 beyond plate current cutoff.

The diode 98 is inserted in the circuit in order to make it possible to insure that the voltage on terminal B, when the playing key is not depressed, shall be very closely held to +5 volts. Any other suitable means to maintain this potential on terminal B, while switch 78 is open, might be substituted.

A characteristic curve illustrating the tonal intensity envelope is shown in Fig. 2. The rise, or attack portion 106 of the curve is relatively steep and represents the time during which the potential at terminal A drops rapidly to a potential of approximately +5 volts, which is due to cathode current flow through resistors R46 and R48.

The rate at which the potential on terminal A drops should be very rapid but not so rapid as to introduce undesirable key click transients. The portion 107 of the curve represents the time during which the capacitor C42 is discharging through either the resistance R63 alone or through both resistors R66 and R68, depending upon the position of switch 70. The sharp decline portion 109 of the curve represents the change in intensity of the tone after switch 78 has been opened, but before switch 14 has opened, upon the release of the playing key as the potential on terminal A rapidly rises to cutoff value. It will be clear that if switch 70 is closed the decay portion 107 of the curve will be much steeper than when it is open. The actuators for the playing key operated switches 14 and 78 are so arranged that upon depression of the key, switch 14 closes before switch 78, and upon the release of the key switch 14 opens after the switch 78 has opened.

When the switch 70 is open the decay time corresponding to the portion 107 of the curve 108 will be long and the tone will be similar to a chime tone with respect to its intensity envelope. When switch 70 is closed the decay portion 107 of the curve 108 will be about five times as fast as when the switch 70 is open and the tone will have an intensity envelope similar to that of a banjo or marimba tone.

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It will be noted that this circuit is unique in that closure of a single switch 78 results in starting changes in potentials on two terminals. The potentials on terminals A and B change at different rates, the potential on the terminal A being changed very rapidly and that on the terminal B relatively slowly.

As thus far described the invention may be utilized as a solo or melody instrument. However, the invention may be employed to great advantage when used in an instrument of the kind disclosed in said Patent No. 2,645,968. The instrument therein described, in addition to having a melody section, has chord and bass sections, herein indicated by a block 110 coupled to the power amplifier 30. It also has an organ section indicated by the block 112. The playing key 12, in addition to operating the switches 14 and 78, operates switches 114 and 115 which respectively tune one of the oscillators of the organ section and apply an operating potential thereto.

When the controls of the organ section are set so as to produce soft flute-like tones and the controls in the solo section 10 are set for the production of relatively bright string-like tones at low intensity, it will be apparent that upon depression of a playing key the spring-like tone will initially mask the soft flute-like tone, but as the string-like tone decays, the flute-like tone will continue at the same low level. The effect will be that of the tones of many instruments wherein as the tone decays the higher harmonics decrease in intensity relative to the fundamental and lower harmonics. The sustained flute tone will continue as long as the key is held depressed whereas the string-like tone will eventually decay to zero intensity.

While the values of most of the components are not critical, it has been found that excellent musical results are obtained if their values are as set forth below in kilohms "K," megohms "M," and microfarads "Mfd." Wide variations in these values are possible without detracting appreciably from the quality of the music which may be produced by the instrument.

R46	1.0 K
R48	4.7 K
R50	27.0 K
R56	22.0 M
R62	.68 M
R66	3.9 M
R68	15.0 M
R87	5.6 K
R95	1 K
C42	.15 Mfd.
C54	.1 Mfd.

It will be understood that there will be a switch 78 for each of the keys and that these switches will be connected in parallel or, if desired, a single switch 78 may be employed and an actuator therefor, common to all of the keys, may be substituted.

The instrument is played in the usual manner of a melody instrument or in the manner of the playing of the instrument shown in my aforesaid prior patent. If the percussion effect is not desired the stop tablet 74 is operated to move the switch 60 to its full line position in which event the tones produced will be sustained tones having a fast attack, provided the switch 58 is in its dotted line position, and having slower attack if the switch 58 is closed. In general the circuits as they operate with the switch 60 in its dotted line position are disclosed in a number of prior patents including the one mentioned above.

While I have shown and described a particular embodiment of my invention, it will be apparent to those skilled in the art that numerous modifications and variations may be made in the form and construction thereof, without departing from the more fundamental principles of the invention. I therefore desire, by the following claims, to

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include within the scope of my invention all such similar and modified forms of the apparatus disclosed, by which substantially the results of the invention may be obtained by substantially the same or equivalent means.

I claim:

1. In an electrical musical instrument having an amplifying output system including an electron discharge device and having a terminal the potential of which determines the degree of amplification, a first point of fixed potential of value such that when impressed upon said terminal will cause the amplification factor of the electron discharge device to be high, a capacitor coupled between said terminal and a point of unvarying potential, a second point of fixed potential of value such that when impressed upon said terminal will cause the amplification factor of the electron discharge device to be low, a relatively high value impedance element connecting said capacitor and terminal to said second point of fixed potential, a variable impedance electronic means coupled to said capacitor and terminal, a playing key, means for supplying a direct current voltage to said variable impedance electronic means of such value as to cause said means to offer relatively low impedance when said key is released, said variable impedance electronic means comprising a rectifying diode and switch means closed by the operation of said key for causing a change in the potential on said variable impedance electronic means, thus to cause the impedance thereof to rise to a relatively high value, whereby said relatively high value impedance element becomes effective slowly to change the potential on said capacitor toward that of said second point of fixed potential.

2. In a tone intensity envelope controlling means for an electrical musical instrument having a keyboard comprising a plurality of playing keys and having an output amplifier including two terminals A and B the relative direct current potentials of which determine the degree of amplification of the amplifier, the combination of a key, a switch closed by the operation of the key, means connecting said switch between said terminal A and a source of fixed potential, a second source of fixed potential of value such that when connected to terminal A will cause the electron discharge device to be cut off, a resistance and capacitance mesh effectively connecting the second source to terminal A when said switch is open, said mesh being effective to cause rapid transientless increase in amplification in said device upon closure of said switch, low changeable impedance means normally maintaining an operating bias potential on terminal B, means operable upon closure of said switch to render said last named means ineffective, a capacitor connected between terminal

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B and a point of fixed potential, a high impedance means connecting terminal B to a potential source of such value as to gradually change the potential on terminal B to such value as will greatly reduce the degree of amplification of said electron discharge device, whereby upon depression of a key the tone produced will have an intensity envelope with controlled fast attack followed by slow decay upon depression of the key, and controlled fast decay upon release of the key.

3. In an electrical musical instrument having electrical tone signal generating means, an output system including gain varying tone intensity envelope control means having two terminals A and B, the intensity of the tonal output of the control means increasing upon a decrease in the direct current potential impressed upon terminal A and increasing upon an increase in the direct current potential impressed upon terminal B, a plurality of playing keys, a relatively low impedance circuit means effective when no keys are depressed to impress a relatively high potential on the terminal A and effective upon depression of a playing key, rapidly to decrease the potential of terminal A, a low impedance circuit means effective when no key is depressed to maintain a relatively high potential upon terminal B and rendered ineffective upon depression of a key, a high impedance circuit means connected to terminal B and materially effective only upon the depression of a key to lower the potential on terminal B, and a capacitor connected between terminal B and a point of fixed potential, said capacitor and high impedance circuit means having a relatively long time constant whereby the potential decrease on terminal B through the effective operation of the high impedance circuit means is delayed.

4. In an electrical musical instrument having a tone signal generating means, an output system including an amplifier, a keyboard comprising a plurality of playing keys, first means operable upon depression of one of the playing keys to cause a rapid increase in the gain of the amplifier, circuit means including a high impedance and a capacitance for causing gradual reduction in the gain of the amplifier to cut off, electronic rectifying means connected to the capacitance, the rectifying means being of normally low impedance, and means greatly to increase the impedance of the electronic rectifying means upon depression of a playing key.

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