

Dec. 10, 1968

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3,415,941

ORGAN CIRCUIT

Filed May 24, 1965

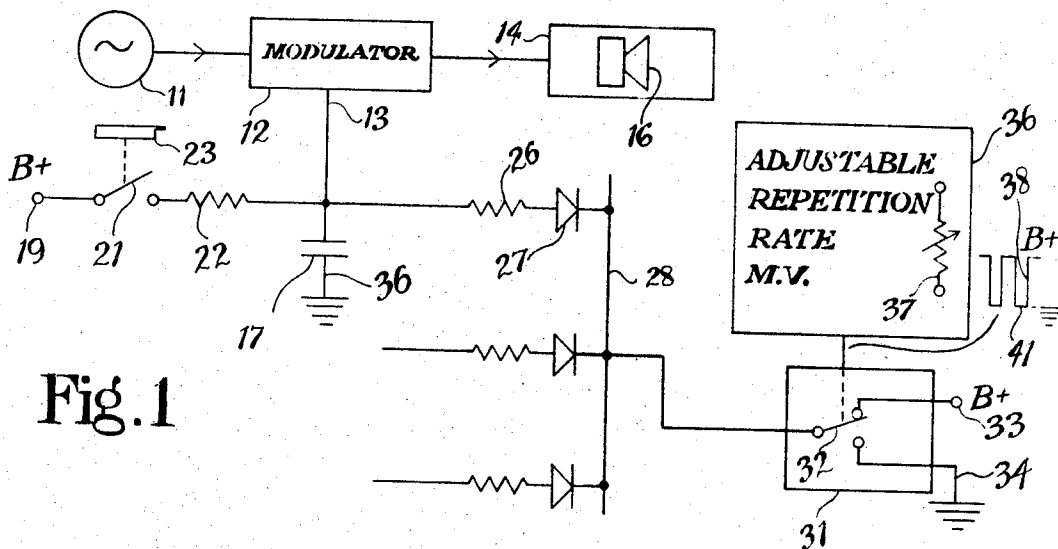


Fig. 1

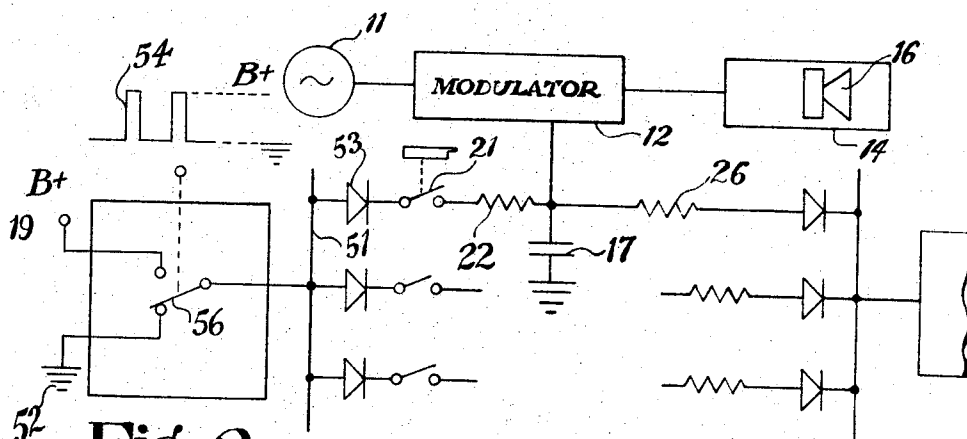


Fig. 2

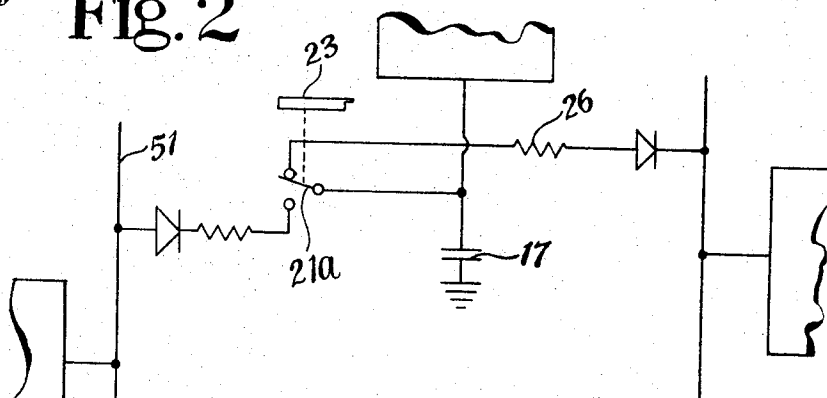


Fig. 3

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ORGAN CIRCUIT

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Filed May 24, 1965, Ser. No. 458,198

12 Claims. (Cl. 84—1.26)

ABSTRACT OF THE DISCLOSURE

The tone envelope of a musical instrument is controlled by a storage capacitor. The attack of the envelope is determined by the charging resistance of the capacitor circuit. The decay or sustain of the envelope is determined by the discharge resistance. Either or both resistances are in effect adjusted by the present invention by rapidly and alternately blocking and passing current through the resistance at a controlled and adjustable duty cycle. When the duty cycle is high, so that the circuit is closed during a high percentage of the time, the current flow is high and the resistance appears low. When the duty cycle is adjusted to be low, the current is correspondingly low and the apparent resistance is high. Thus, the apparent value of the resistance in the RC circuit is readily and adjustably controlled. The invention has the unique ability of requiring only one duty cycle control, preferably in the form of an adjustable multivibrator, for a large number of discharge (or charge) resistors.

This invention relates to a modulation circuit for an electronic musical instrument such as an electric organ, and has particular reference to a circuit for adjustably controlling the attack and/or decay of a percussion tone of the organ.

It is an object of this invention to provide an adjustable decay (or attack) for an organ tone in which the nature of the decay (or attack) is substantially the same irrespective of how many notes might be simultaneously played on the organ.

It is another object of this invention to provide means for adjusting the charge or discharge characteristic of the control capacitor of a percussion circuit without changing the potential to which the capacitor charges or discharges as the case may be.

It is a further object of this invention to provide, in a percussion or sustain circuit for an electric organ, a simple means for achieving the effect of adjustable decay (or attack) without actually changing any resistance or impedance value in the circuit.

It is a further object to provide simplified means for controlling the decay (or attack) characteristics of a plurality of percussion or sustain circuits as employed in a polyphonic instrument.

In accordance with these and other objects which will become apparent hereinafter, preferred forms of the present invention will now be described with reference to the accompanying drawing wherein:

FIG. 1 is a circuit diagram of the present invention applied to the sustain or decay of an organ percussion tone.

FIG. 2 illustrates the application of the present invention to the attack of an organ tone.

FIG. 3 is a modification of the circuit of FIG. 2 to overcome certain possible shortcomings thereof.

Referring to FIG. 1 there is represented at 11 a tone signal source of given pitch. The organ comprises a plurality of such sources of different pitch, usually corresponding to the chromatic musical scale. Tone signal output from the source 11 is fed to a modulator or gate 12 where the shape of the tone envelope is determined by

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the potential on a control terminal 13. Modulated tone is then fed to an output system 14, usually common to all of the tone sources, and which usually includes some form of electro-acoustic transducer symbolized by the loudspeaker 16.

Normally, the modulator 12 is cut off so that tone signal does not pass to the output system 14. Application of control potential to the terminal 13 in effect unblocks or opens the modulator 12 and allows the tone to be sounded. The configuration of the tone envelope is determined by the wave shape of the control potential. Potential on the terminal 13 is derived from charge on a capacitor 17 connected to the terminal 13. Capacitor 17 is charged from a source of positive potential 19 through a normally open key switch 21 and charging resistor 22. The key switch 21 is linked to a keyboard key 23, which may be manual or pedal.

As long as the key switch 21 is held closed, current flows through the resistor 22, resistor 26, and diode 27 to a common bus 28. Current may or may not in fact flow through 26, depending upon the potential of the bus 28, as will be discussed hereinafter. To the extent that current does flow through the resistor 26, the final potential on capacitor 17 is determined by the voltage division between resistors 22 and 26. If there is no current flowing to the bus 28, the full potential from the terminal 19 appears on the capacitor 17 through the RC charging circuit including the resistor 22. This potential opens the modulator 12 and allows tone signal from the source 11 to pass to the output system 14.

In some cases it may be more desirable to avoid the voltage division. This may be done by connecting the left hand side of resistor 26 to the left hand side of resistor 22, instead of the right hand side.

When the key 23 is released, opening the switch 21, modulator 12 does not instantly cut off, because of the residual charge on capacitor 17. The decay of tone through the modulator 12 is determined by the discharge characteristic of the capacitor 17.

The discharge circuit for the capacitor 17 consists of the resistor 26, diode 27, common discharge bus 28, and thence to a circuit represented by the block 31, which alternately and repetitively or cyclically places the bus 28 at the B plus potential of the terminal 19, or grounds the bus 28. This function of the circuit 31 is represented symbolically by a double-throw switch 32, one contact of which is connected to a B plus source 33, and the other which is grounded at 34. Since the capacitor 17 is also grounded at 36, the switch 32, when in its lower position, serves to complete a discharge circuit for the capacitor 17.

The discharge circuit for the capacitor 17, consisting of the resistor 26, diode 27, bus 28 and switch 32, constitutes in effect a gate means which is repetitively and alternately blocked and unblocked. Switch 32, when connected to the terminal 33, represents the blocked condition, because the diodes 27 are reverse biased and therefore current cannot flow. Switch 32 in the lower most position represents the unblocked condition, for then there is a discharge path through the resistor 26, diode 27, bus 28, switch 32, to ground 34. The RC discharge characteristic of the capacitor 17 is, under those conditions, determined primarily by the capacitance of 17 and the resistance of 26 (assuming negligible forward resistance in 27). During those portions of the cycle of switch 32 when current is flowing, the capacitor 17 is always discharging to the same potential, namely the ground potential 34 placed on the bus 28. By varying the duty cycle of the switch 32, so as to control the time ratio between the grounded condition and the B plus condition of the bus 28, the average discharge current can be controlled, with an effect equivalent to that of controlling the resistance of the discharge path. The

range of this control varies from an infinite resistance, (were the switch 32 to be permanently fixed to the terminal 33), down to the value of the resistance 26, (were the switch 32 to be permanently fixed to the ground terminal 34).

The variable duty cycle is effected by employing a multi-vibrator having an adjustable or controllable repetition rate. This is represented schematically by the block 36, the control of the repetition rate being illustrated schematically by the adjustable resistor 37. It is to be understood that the blocks 31 and 32 are, in actual circuitry, both combined into a single circuit denominated here as multi-vibrator means. The net effect of the multi-vibrator, however achieved, is to repetitively or cyclically apply B+ and ground to the common bus 28. This is represented by the wave form shown at 38. The adjustability is achieved by any means which controls the ratio between the B plus time and the ground time of the bus 28. This may be done by adjustably controlling the width of the pulses 41, or may be done, and preferably is done, by a multi-vibrator which delivers constant-width pulses 41 at a variable repetition rate.

The diode 27 forms a portion of the gate circuit and is valuable in the circuit to isolate one note from the other. The term diode as used herein refers to any current-conducting element having a curve relation between voltage and current that possesses two markedly different impedances. In the example shown, assume that the voltage on the left-hand side of the diode 27 is negative with respect to the right hand side or terminal of the diode. Under these circumstances the diode 27 exhibits high impedance. As the voltage on the left hand terminal of the diode 27 goes more positive relative to that on the right hand terminal, a point or region is reached where the impedance abruptly drops. In a typical diode, this region is not a point but represents a rounding or knee of the curve, although ideally it would occur abruptly. Also, in an ideal diode this point would occur exactly where the voltage on the left hand terminal becomes positive relative to that on the right hand terminal. As a practical matter, the voltage on the left hand terminal must, in fact, become somewhat more positive than that on the right hand terminal before the knee of the curve is encountered.

With this understanding of the term diode as employed herein, it will be readily seen that when the discharge bus 28 is at B plus potential, the diode 27 is reverse biased, presenting a very high impedance—virtually an open circuit—to the discharge of the capacitor 17. When the bus 28 is grounded, the diode 27 is forward biased by virtue of the differential in potential between the voltage on the capacitor 17 and the ground connection made to the bus 28. This presents a very low impedance to current flow.

The circuit described above is repeated for each of the various notes, except, however, that the bus 28 and the associated circuits 31 and 36, and the output circuit 14 are common to all (or a large group) of the notes.

A striking advantage of the present invention is that the decay or sustain characteristic of the tone is independent of the number of key switches 21 closed at any one time. If the effect were to be achieved by actually varying a common resistance in the RC discharge circuits, the decay characteristic would shift depending on the number of notes being played at any one time, because the discharge current would change through the common impedance or resistance, and thus affect the decay characteristic of the tone. For this reason, it is important that the resistance between the common bus 28 and the lower or ground side 36 of the capacitor 17 be as low as feasible during those portions of the cycle when the multi-vibrator represented by the switch 32 is in its lower position. On the other hand, the impedance or resistance between the common bus 28 and the source 33 of B plus voltage is of little moment, because no current is flowing during that condition.

The multi-vibrator represented by the blocks 31 and 36 may assume any of a number of well-known forms to achieve the function described hereinbefore. It may, in fact, be a physical switch shown at 32, a uni-junction multi-vibrator, or any other suitable oscillating circuitry to produce the prescribed conditions. It is, of course, necessary that the pulse or repetition rate be high relative to the time of the modulation envelope effected in the modulator 12. That is to say, the rate should be sufficiently high so that the capacitor 17 appears virtually as a short circuit at those frequencies.

The principles of the present invention may also be employed to adjustably control the attack of a tone passing through the modulator 12. This is illustrated in FIG. 2, wherein like numerals have been employed to represent like elements. In FIG. 2 there is a common charging bus 51 to which is selectively and alternatively applied, by switch 56, B plus from the terminal 19 or ground from the ground connection 52. This intermittently applied B plus is transmitted to the capacitor 17 through a diode 53, the key switch 21, and the charging resistor 22.

The operation of circuit of FIG. 2 is substantially the same as that described in connection with FIG. 1. The higher the pulse repetition rate, illustrated by the pulse stream 54, the lower will be the apparent or effective charging resistance. In the extreme, if the switch 56 is fixed to the B plus terminal 19, the charging resistance is simply the resistance 22. If the switch 56 were fixed to ground 52, the charging resistance would, in effect, be infinite, because there would be no potential tending to charge the capacitor 17. In between these two variables, as determined by the pulse repetition frequency, the charging resistance can be made any apparent value desired. This, of course, will control the shape and nature of the attack of the envelope of the tone passing through the modulator 12.

The circuit of FIG. 2 is subject to a possible weakness in that the discharge resistor 26 is permanently connected to the capacitor 17. Thus, if the sustain or decay timing is set very short, it is possible that the capacitor 17 might never attain its full designated charge, because the moment a charge appears on the capacitor 29 it starts to leak off or disappear through the discharge circuit, including the resistor 26. Thus, the circuit of FIG. 2 would be unsatisfactory for operation with a slow or long attack and a fast or short sustain or decay.

This weakness may be remedied by the circuit shown in FIG. 3, wherein there is employed for the key switch, instead of a single-throw switch 21, a double-throw switch 21a. In the off position, i.e. when the note 23 is not played, the sustain capacitor 17 is connected to the discharge resistor 26. When the note 23 is played, the switch 21a is connected to the charge circuit, or charging bus 51. Thus, by use of a double-throw switch, the charge and discharge circuits are mutually isolated, so that the attack and decay adjustment are completely independent of each other.

It will be obvious that the present invention can also be applied to an instrument in which the playing of a key institutes discharging, rather than charging, of a capacitor, to cause tone to sound.

Furthermore, it will be recognized that this invention can be applied to a tone generator having a frequency-stable output whose amplitude is proportional to a control voltage, in this case, the voltage appearing at 13. In such case the tone generator would replace the tone source 11 and modulator 13 shown in FIG. 1.

While the instant invention has been shown and described herein in what is conceived to be the most practical and preferred embodiments, 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. Circuit for controlling the shape of the tone envelope of an electronic musical instrument, comprising: capacitive means and resistive means connected together, means for causing a current to flow through said capacitive and resistive means, circuit means for modulating a tone signal in accordance with the voltage on said capacitive means, gate means forming at least a portion of said resistive means, free-running means for repetitively blocking and unblocking said gate means at a frequency which is high relative to the time of modulation of the tone signal, and means for adjusting the time ratio between blocked and unblocked condition of said gate means, thereby to control the average value of said current, whereby the apparent resistance of said resistive means, to direct current, is controlled.
2. Circuit for controlling the sustain time of a note in an electronic musical instrument comprising: a capacitor, means for charging said capacitor in response to playing of a note, means responsive to charge on said capacitor for enabling a tone to be sounded by the instrument, a discharge circuit for said capacitor, release of a note serving to institute discharge of said capacitor through said discharge circuit, gate means for forming at least a portion of said discharge circuit, means for repetitively blocking and unblocking said gate means, and means for selectively controlling the time ratio between blocked and unblocked condition of said gate means, thereby to control the apparent DC resistance of said discharge circuit.
3. Sustain control circuit for an electric organ having a plurality of tone sources, a corresponding plurality of playing keys effective to cause tones from said tone sources to be sounded, and a corresponding plurality of capacitors chargeable by playing of said keys to maintain the sound of the tones in response to the charge thereon, characterized by: a discharge bus common to said capacitors for transmitted discharge current from said capacitors, a plurality of discharge circuits corresponding to said capacitors for transmitting discharge current to said discharge bus, gate means connected to said bus for completing a discharge path for said capacitors, free running means for intermittently blocking and unblocking said gate means, and means for controlling the time ratio between blocked and unblocked condition of said gate, thereby to control the average current therethrough and thus control the discharge rate of the capacitors.
4. Circuit for controlling the shape of the tone envelope of an electronic musical instrument having: capacitive means and resistive means connected together, means for causing a current to flow through said capacitive and resistive means, and circuit means for modulating the tone signal in accordance with the voltage on said capacitive means, characterized by: diode means forming at least a portion of said resistive means, said diode means, when reverse biased serving to substantially block passage of current therethrough, and when forward biased serving to pass current therethrough, free-running means for repetitively reverse biasing and forward biasing said diode means at a frequency which is high relative to the time of modulation of the tone signal, and

- means for adjusting the time ratio between reverse bias and forward bias condition of said diode means, thereby to control the average value of said current, whereby the apparent resistance of said resistive means to direct current is controlled.
5. A sustain control circuit for an electric organ having a plurality of tone sources, a corresponding plurality of playing keys effective to cause tones from said tone sources to be sounded, and a corresponding plurality of capacitors chargeable by playing of said keys to maintain the sound of the tones in response to the charge thereon characterized by: a discharge bus common to said capacitors for transmitting discharge current from said capacitors, a plurality of diodes corresponding and connected respectively to said capacitors for transmitting discharge current from the capacitors to said discharge bus, said diodes, when reversed biased by application of reverse bias potential to said discharge bus, serving to substantially block passage of discharge current through said diodes, and when forward biased, by application of forward bias potential to said bus, serving to permit passage of discharge current to said discharge bus, bias means for intermittently and cyclically applying a reverse bias potential and a forward bias potential to said discharge bus, thereby to intermittently block and enable passage of discharge current through said diodes, and means for controlling the time ratio between reverse bias and forward bias on said discharge bus, thereby to control the average discharge current through said diodes and thus control the discharge rate of said capacitors.
 6. Control circuit in accordance with claim 5 wherein: said bias means includes multi-vibrator means for developing forward bias pulses of substantially constant pulse width, and said controlling means includes means for controlling the pulse repetition rate of said multi-vibrator means.
 7. Control circuit in accordance with claim 5 including: a plurality of charging circuits, one for each said capacitor, each charging circuit having therein a key switch operable by a respective said playing key, a source of charging voltage connected and common to each of said charging circuits for supplying charging potential for said capacitors, and wherein: said bias means cyclically applies to said discharge bus, a potential substantially at least as large as said charging potential, and a potential substantially less than said charging potential, whereby discharge current is substantially blocked because of absence of effective potential difference when said discharge bus is at said first mentioned bias potential, and flows to said substantially less potential during those portions of the bias cycle when the bias is at said substantially less potential.
 8. Circuit in accordance with claim 7 wherein the return impedance between said common bus and said capacitors is very low during those portions of the bias cycle when the diodes are forward biased.
 9. Circuit for controlling the shape of the tone envelope of an electronic musical instrument, comprising: storage circuit means, means for modulating a tone signal in accordance with the energy stored in said storage circuit means, gate means forming at least a portion of said storage circuit means, free running means for repetitively blocking and unblocking said gate means, and means for selectively controlling the time ratio between blocked and unblocked condition of said gate means,

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thereby to control the average rate of change of energy stored in said energy storage circuit means.

10. Circuit for controlling the shape of the tone envelope of an electronic musical instrument having a plurality of tone sources, a plurality of playing keys, a plurality of storage circuit means, means for storing energy in said storage circuit means, and means for modulating tone signals from said tone sources in accordance with the energy stored in said storage circuit means, characterized by:

a bus common to a plurality of said storage circuit means,

gate means connected to said bus for changing the energy stored in said storage circuit means, free running means for repetitively blocking and unblocking said gate means, and means for selectively controlling the time ratio between blocked and unblocked conditions of said gate means, thereby to control the rate of change of energy in said storage means.

11. An adjustable circuit comprising: impedance means, voltage means for passing a current through said impedance means, circuit-breaking means for selectively passing and blocking said current through said impedance means, free-running means for actuating said circuit-breaking means to alternately pass and block said current at

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a repetition rate which is very high with respect to the frequency of any variation in the voltage of said voltage means, and

means for selectively adjusting said free-running means, thereby to adjust the ratio between passing and blocking time of said circuit-breaking means, whereby the apparent impedance of said impedance means is made to vary inversely with the duty cycle of current passing condition, imposed by said free-running means on said circuit-breaking means.

12. Circuit in accordance with claim 11, wherein: said impedance means comprises a resistor, and including additionally

a capacitor connected to said resistor to form thereby with an RC circuit,

whereby adjustment of said free-running means controls the time constant of said RC circuit.

References Cited

UNITED STATES PATENTS

Re. 25,515	1/1964	Peterson	84—1.26
2,486,208	10/1949	Reinstra	84—1.26
2,783,672	3/1957	Hanert	84—1.26
2,828,659	4/1958	Hanert	84—1.26

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