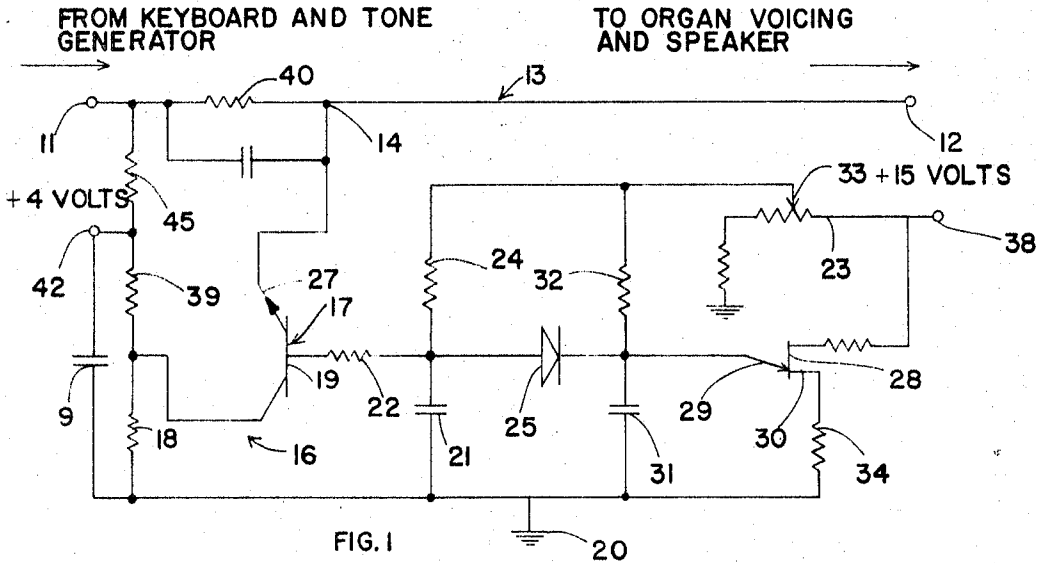
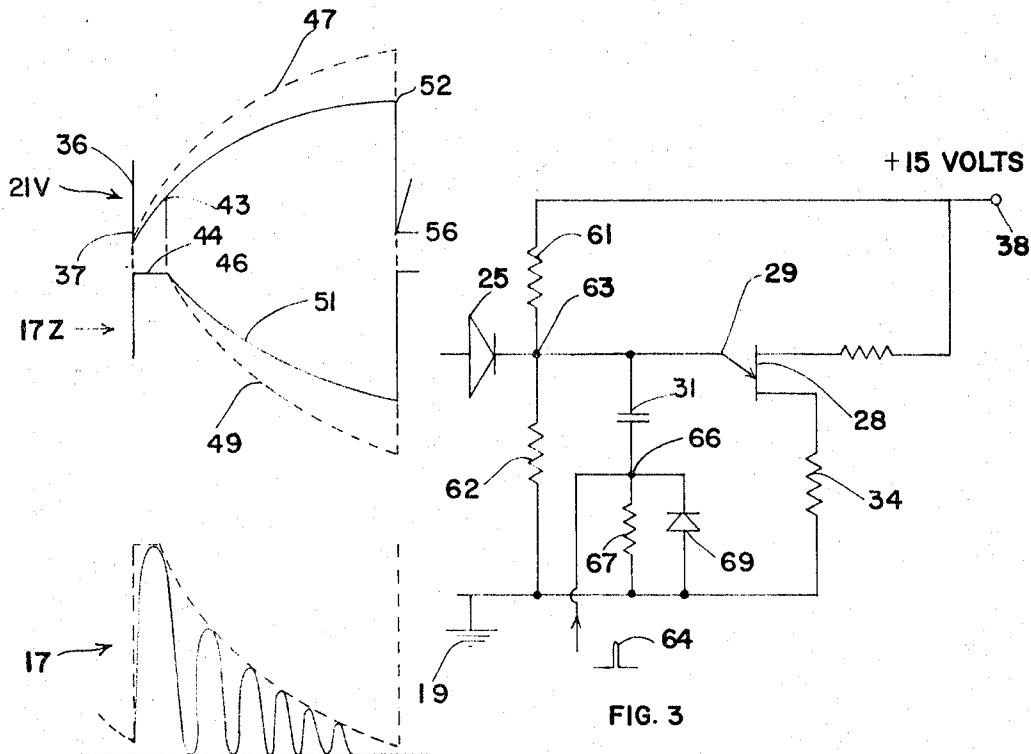


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ELECTRIC ORGAN CIRCUIT

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ELECTRIC ORGAN CIRCUIT

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ABSTRACT OF THE DISCLOSURE

A percussion envelope is applied to a tone signal by selectively shunting tone signal away from the output circuit. Shunting is accomplished by a shunt-connected variable impedance, such as a transistor, the control electrode of which has applied thereto a repetitive voltage pulse which abruptly increases the shunt impedance and then gradually decreases the impedance to create a correspondingly shaped percussive envelope. The pulse is created by a pair of RC circuits, one of which controls the shape of the envelope, the other of which controls the repetition frequency of the pulses.

This invention relates to a circuit for an electric musical instrument such as an electric organ, and in particular to a percussion circuit for applying a percussive modulation envelope to the tone signals of the organ.

It is an object of this invention to provide an improved percussion circuit wherein minimum modulation or control signal is injected into the tone signal of the percussed musical tone.

It is a further object of this invention to minimize transient sounds injected into the tone signal of a percussed tone.

It is a further object of this invention to provide simplified means for providing a repeat percussion which automatically repeats a percussed tone at an adjustable rate determined by the organist.

It is a further object of this invention to provide a repeat percussion modulator in which the modulation envelope is automatically lengthened with decrease in frequency or repetition rate of the repeat percussion, thereby giving for many purposes an enhanced musical effect.

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 drawings, wherein:

FIG. 1 is a circuit diagram of one form of the present invention.

FIG. 2 are wave forms illustrating operation of the circuit of FIG. 1.

FIG. 3 is a circuit diagram illustrating a modification of the circuit of FIG. 1.

Referring to the drawings, FIG. 1 illustrates a shunt modulation circuit particularly suited for repeat percussion modulation. It includes an input terminal 11, to which is applied tone signal from tone signal sources or generators, and an output terminal 12 leading to the organ output system. In a typical organ the tone signal on the terminal 11 would be applied from tone signal sources in response to actuation of keyboard actuated switches. The output system often starts with the organ voicing circuitry and usually ends with a speaker. Intermediate the input and output terminals is a circuit 13 which transmits the signals from the terminal 11 to the terminal 12. The circuit 13 includes an intermediate terminal 14 (electrically the same as terminal 12), to which is connected a bypass or shunting circuit 16, comprising a transistor 17, a resistor 39, and signal return capacitor 9.

The circuit 16 serves to shunt tone signal current at

14 to the ground connection 20 and away from the output terminal 12, the amount of diversion or shunting being inversely proportional to the impedance of the circuit 16 at any particular moment. When the transistor 17 is in conduction, virtually all of the signal is shunted away from the terminal 12, because the resistance of the circuit 16 under such condition is much lower than the resistance of the output circuit connected to the output terminal 12. Therefore, there is virtually a grounded short circuit across the terminal 12 when the transistor 17 is conducting.

In accordance with the present invention, conduction of the transistor 17 is controlled by the voltage on the control terminal or base 19 of the transistor 17, and in accordance with the voltage on a capacitor 21 applied to the base 19 through a coupling resistor 22. Thus the charge on the capacitor 21 determines the conductance of the transistor 17 and hence the amount of tone signal shunted away from the output terminal 12.

The capacitor 21 is charged from a potentiometer 23 representing a source of voltage, and through a charging resistor 24. As the charge builds up on the capacitor 21, the impedance of the transistor 17 between its collector 26 and emitter 27 steadily decreases and thus steadily diverts more and more signal from the output terminal 12.

The transistor 17 is blocked or rendered non-conductive by discharge of the capacitor 21. This is effected through a unijunction transistor 28 coupled to the capacitor 21 by a diode 25. The unijunction transistor 28 is rendered abruptly conductive whenever the voltage on its emitter 29 reaches and exceeds a certain magnitude relative to the voltages on its bases. Voltage on the emitter 29 is gradually increased by charging of a capacitor 31 through a charging resistor 32, from the same point as used to charge the capacitor 21, namely the slider 33 of the potentiometer 23.

The emitter 29 of the unijunction transistor 28 is normally substantially non-conducting. When the voltage on the emitter 29 attains a certain predetermined positive value, the transistor 28 breaks into conduction and the impedance from the emitter 29 to the base 30, drops to substantially zero. This permits both the capacitors 21 and 31 to discharge very quickly through the relatively low resistor 34. This abruptly establishes a relatively low voltage (about 2 volts in the illustrated example) on the base 19 of transistor 17, which abruptly blocks conduction and applied tone signal to the terminal 14 and hence to the output terminal 12.

In a preferred form of the present invention, the RC constants between the control circuit of the transistor 17, namely 24 and 21, and the control circuit for the unijunction 28 namely 32 and 31, are so adjusted that the capacitor 31 charges to a higher voltage than does the capacitor 21. Thus, until the unijunction 28 breaks down and abruptly conducts, the diode 25 is reversed biased, so that it is during this period virtually an open circuit. Thus in charging, the capacitors 21 and 31 do not interrelate with each other.

It will thus be seen that the repetition rate or frequency of each percussive burst is dependent entirely upon the RC constants 32, 31, while the shape of the modulation envelope is determined by the conduction characteristic of the transistor 17 and the RC constants 24, 21.

A further understanding of the operation of the circuit of FIG. 1 may now be had by reference to the wave forms of FIG. 2.

The wave form 21V represents the voltage on the capacitor 21. The line 36 represents the discharge or dumping of the capacitors 21 and 31 through the unijunction transistor 28. At the point 37 the capacitors are substan-

tially discharged, and the unijunction 28 returns to blocked or high impedance condition. Thus, at the point 37 the capacitor 21 starts to charge up through the charging resistor 24.

The transistor 17 does not immediately start to conduct, however, because its emitter 27 is not returned to ground but is returned to a 4 volt source shown at 42. In FIG. 1 the source of charging voltage applied to the terminal 28 is represented as 15 volts. Assume for illustrative purposes that the slider 33 is to the extreme right, so that the full 15 volts is applied to the RC circuit 24/21. Until the capacitor 21 charges to approximately 4 volts, the transistor 17 will not conduct, because its emitter is returned to terminal 42 through resistor 40 and 45. At point 43 in FIG. 2, the voltage at 19 has risen far enough to institute conduction of the transistor 17.

The graph designated 17Z in FIG. 2 is representative of the emitter/collector impedance of the transistor 17 as determined by the bias on the base 19. During the interval shown at 44 the impedance is relatively high, because the voltage in the base 19 has not reached the threshold point 43. At point 46 the impedance starts to drop, because the voltage on the capacitor 21 continues to rise, in turn instituting and increasing emitter/collector current. The dotted curve 47 illustrates the curve that would be followed by the voltage at 21 if the transistor 17 were in fact not in the circuit. The conduction from base to emitter in the transistor 17, however, in effect robs the capacitor 21 of some of the charging current it would otherwise receive. As a result there is a dropping or tapering off of the voltage at 19, and this is represented by the full line curve 48 in FIG. 2. This effect is reflected in the dotted line 49 and the full line 51 which illustrate the corresponding curves of the impedance value of the transistor 17, as the charging of capacitor 21 proceeds.

It will be remembered that as the capacitor 21 charges, the capacitor 31 is also charging from the same source, and through its charging resistor 32. At time 52 the charge on capacitor 31 has reached such a point that the unijunction transistor 28 breaks down, and both capacitors 21 and 31 discharge through the transistor 28 and resistor 34, to ground 20, with the capacitor 21 discharge also flowing through the diode 25. Discharge of the capacitors 21 and 31 drops the voltage at 19 almost to ground (actually about 2 volts), as shown at 56, and the charging cycle reinstitutes.

Adjustment of the slider 33 away from the positive voltage terminal 38 lowers the charging potential available to the two capacitors 21 and 31 and thus lengthens the charging time to attain a given voltage on the two capacitors. In the case of the capacitor 21 this produces a longer tail; that is the charging curve is flatter and produces a more gradual tapering off of the percussed tone passed to the output terminal 12. The envelope of the percussed tone is substantially as shown at 17' in FIG. 2. That is, the amplitude of the tone signal passed to the output terminal 12 is proportional to the magnitude of the bypass or shunting impedance connected to the point 14.

Lowering the voltage from the potentiometer 23 also decreases the rate of charge of the timing capacitor 31, so that the percussed tones are repeated at a lower frequency. It has been found that when the percussion repetition rate or frequency is decreased, as by lowering the voltage from 23, a more desirable musical effect is achieved if the tone envelope is also given a less abrupt sustain or trailing edge, as shown at 51 in FIG. 2. This is achieved inherently in the circuit of FIG. 1. If the charging voltage for the capacitor 21 were constant while that for the capacitor 31 were variable, a setting for a very fast repetition rate, coupled with constant percussion duration, would tend to drive all the percussion pulses together. That is, there would be insufficiently noticeable separation between the percussive tones. Conversely if the modulation envelope were fixed short enough to accommodate

fast repetition rates, it would be objectionably short when slower rates are used. Thus the simultaneous adjustment of repetition rate and envelope sustain automatically relates the two variables to accommodate each other.

The collector 26 of transistor 17, instead of being returned to the terminal 42, is returned to a voltage divider 39-18, which places the collector 26 at a very small voltage below the 4 volts of terminal 42. The purpose of this is to offset the small voltage developed between collector 26 and the point 14, due to the base-emitter current in the transistor 17. By offsetting this small voltage there is eliminated or minimized a modulation thump which would otherwise appear as the result of the DC being injected into the tone signal circuit at 14. The offset voltage, i.e. below the 4 volts of terminal 42, employed by returning the collector 26 to the point between resistors 29 and 18 need be only very small, because the voltage developed by the base/emitter current in the transistor 17 is only a very small voltage. This is because of the fact that, as the base/emitter current begins to flow, it is accompanied by a marked drop in collector/emitter impedance of the transistor 17; hence the resulting voltage which needs to be offset is only a very small one.

The circuit of FIG. 1 is free-running because of the regular and periodic charge and discharge of the capacitor 31. It therefore produces a repeat or automatic percussion in the tones which are modulated in passing from the terminal 11 to the terminal 12. That is, the organist does not play a key each time that a tone sounds, but instead the tone sounds automatically at a repeat frequency determined by the setting of the potentiometer slider 33.

It may be desired to employ the circuit for non-repeat percussion, as for example to give a percussed tone only at the instant a key is played. In this case the circuit of FIG. 1 may be altered as shown in FIG. 3, wherein like reference numerals denote like parts. In FIG. 3 the capacitor 31 is charged from a voltage divider consisting of resistors 61 and 62 connected across the positive source of voltage 38. The resistor 67 completes the charging path for the capacitor 31, enabling it to gather the threshold charge for the emitter 29 of the transistor 28. This threshold charge is not high enough to fire the unijunction transistor 28, and the capacitor 31 of course charges only to the potential of the point 63 as determined by the voltage division between 61 and 62.

In order to fire the unijunction 28 and thus produce a percussive burst of tone, a positive pulse 64 is applied to the point 66 representing the junction point between the capacitor 31 and the resistor 67. Pulse 64 may be derived from the actuation of any key through the use of suitable circuitry, many forms of which are found in the art. For example, the sensing of current flow whenever a key is actuated may be translated into the pulse 64 and employed for this purpose. Alternatively, tone signals appearing anywhere in the circuit upon closing of a key may be detected and such detection employed to form the pulse 64. The pulse 64 is coupled through the capacitor 31 on to the emitter 29 of the unijunction 28 and raises the voltage to the firing point. Thereupon the unijunction 28 fires and the capacitor 31 discharges as in the FIG. 1 circuit, through the resistor 34. A low impedance return path to the bottom of the capacitor 31 is provided by the diode 69.

The diode 69 appears as a virtual open circuit to the positive pulse 64; therefore none of the pulse 64 is dissipated in the diode.

When employing the modification shown in FIG. 3, the resistor 24 (FIG. 1) may be connected either to an adjustable source of voltage such as the slider 33 of FIG. 1, or to a fixed source of voltage.

It will thus be seen that the circuit of FIG. 3 in contrast to that of FIG. 1, employs substantially the same elements but instead of being automatically and periodically fired at a predetermined frequency, is selectively fired

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at the will of the organist by the injection of the firing pulse 64.

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. Percussive modulation circuit for an electrical musical instrument comprising:

a source of tone signal,

an output system,

first circuit means for transmitting said tone signal to said system,

second circuit means for generating voltage pulses which drop abruptly and then rise gradually, and

variable impedance means connected to said first circuit means for shunting said signal from said output system, having a control terminal connected to said second circuit means, the impedance of said variable impedance means being raised abruptly and then gradually decreased in response to said voltage pulses on said terminal,

with consequent passage, through said first circuit means, of a percussive tone signal having abrupt attack and extended decay.

2. Circuit in accordance with claim 1 comprising adjustable means for controlling said second circuit means thereby to determine the magnitude versus time characteristic of said variable impedance means.

3. Circuit in accordance with claim 2, wherein:

said second circuit includes a capacitor connected to said control terminal, and means for charging said capacitor,

and said adjustable means includes means for controlling the rate at which said capacitor charges.

4. Circuit in accordance with claim 1 including means for effecting automatic periodic repetition of said voltage pulses.

5. Circuit in accordance with claim 4 wherein said means for effecting automatic periodic repetition of said voltage pulses includes a capacitor, discharge means for discharging said capacitor, and means for controlling the moment at which said discharge means effects said discharging.

6. Circuit in accordance with claim 5 wherein said discharge means comprises:

second variable impedance means having a terminal the voltage on which effects abrupt decrease in the impedance as said voltage increases, and including a second capacitor connected to said last named control terminal, and

diode means connected between said first named capacitor and said second variable impedance means for effecting discharge of said first named capacitor through said second variable impedance means.

7. Percussion circuit for an electric musical instrument comprising:

variable impedance means for controllably passing tone signals, and having a control terminal the voltage

on which determines the magnitude of signal passed, a first capacitor,

a voltage source for charging said first capacitor, circuit means for charging said first capacitor from said voltage source,

circuit means for applying the voltage on said first capacitor to said control terminal,

a discharge impedance for discharging said first capacitor and comprising a variable impedance whose magnitude abruptly drops as the voltage applied thereto reaches and exceeds a certain value,

a second capacitor connected to said discharge impedance to apply a voltage thereto,

non-linear impedance means connected from said first capacitor to said discharge impedance for permitting said first capacitor to discharge therethrough and through said discharge impedance, and

circuit means for charging said second capacitor.

8. Repeat percussion circuit for an electric musical instrument comprising:

variable impedance means for controllably passing tone signals, and having a control terminal the voltage on which determines the magnitude of signal passed,

a first capacitor,

a voltage source for charging said first capacitor,

circuit means for charging said first capacitor from said voltage source,

circuit means for applying the voltage on said first capacitor to said control terminal,

a discharge impedance for periodically discharging said first capacitor and comprising a variable impedance whose magnitude abruptly drops as the voltage applied thereto reaches and exceeds a certain value,

a second capacitor connected to said discharge impedance to apply a rising voltage thereto,

non-linear impedance means connected from said first capacitor to said discharge impedance for permitting said first capacitor to discharge therethrough and through said discharge impedance, and

circuit means for charging said second capacitor from said voltage source.

9. Circuit in accordance with claim 8, wherein said voltage source comprises means for adjusting the voltage magnitude, said first and second capacitors being charged from the same magnitude voltage of said source.

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