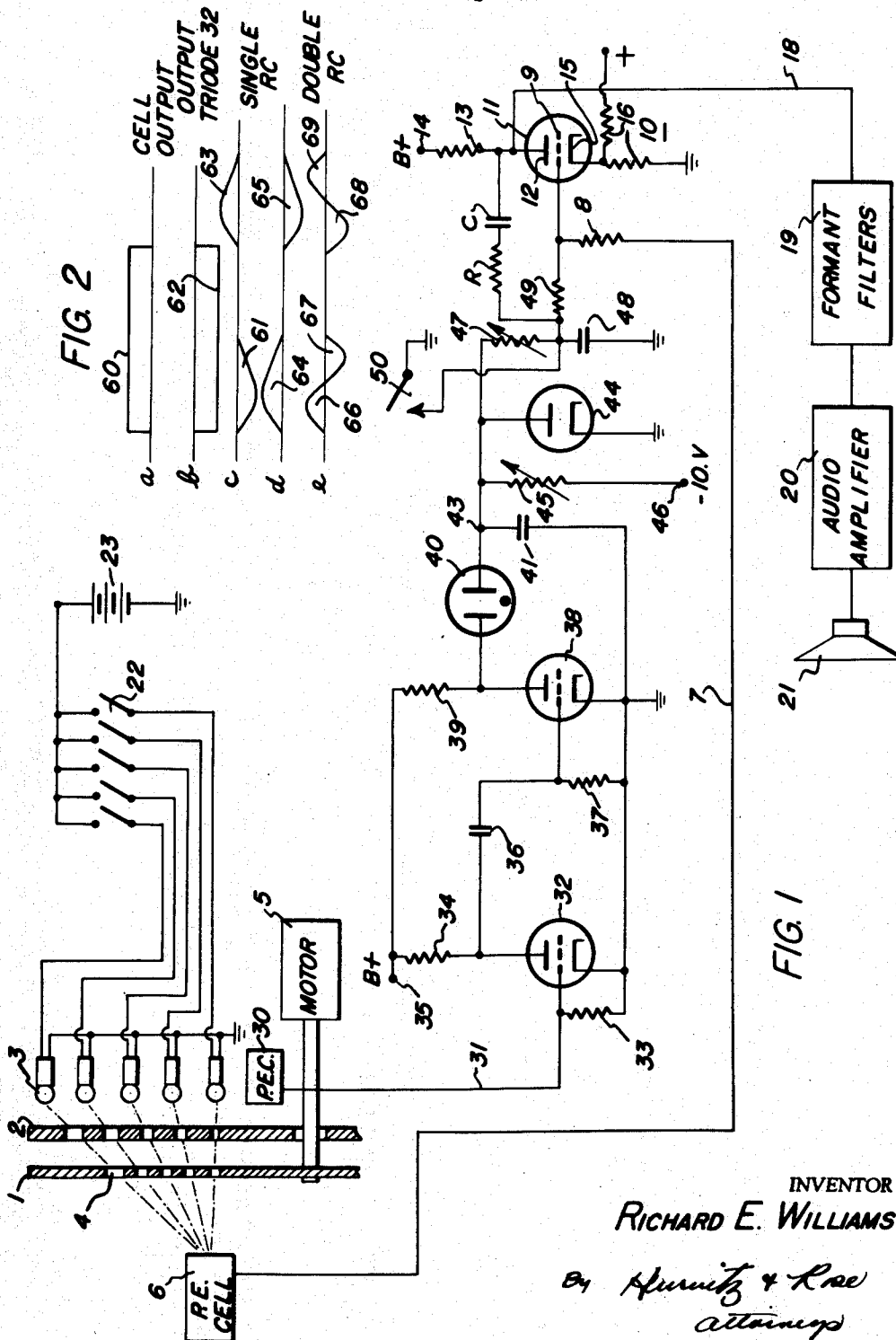


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PERCUSSION SYSTEM

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PERCUSSION SYSTEM

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The present invention relates generally to electronic musical instruments employing photoelectric tone generators, and more particularly to attack and decay circuitry for such musical instruments, which are arranged and adapted for providing percussive tonal effects.

The present invention is applicable particularly to electric organs of the type employing photoelectric generators. In such systems one or more tone wheels may be employed, each tone wheel being provided with a plurality of recorded sound tracks, and each track preferably pertaining to one pitch or tone of the organ. The tone tracks are rotated with respect to a plurality of light sources on one side, and a photoelectric cell on the other side, each tone track modulating the light deriving from one or more of the light sources and the light being intercepted, after modulation, by the photoelectric cell, whereby the output circuit of the photoelectric cell includes electrical signals modulated in accordance with the recorded tones. The organ is played by depressing keys of one or more manuals, and depression of any key effects energization and consequent illumination of one or more of the lamps, and consequent generation of tones corresponding with the energized lamps. Systems of the general type described are well-known, per se. The present invention concerns itself with the introduction of percussive effects in such organs.

In accordance with a primary feature of the present invention a supplementary photoelectric cell is employed, which may be preferably of the photo-voltaic or voltage-generating type, and which is illuminated by all the lamps, or by a predetermined plurality of the lamps of the organ. If the lamps are arrayed over a considerable area, a plurality of such photo-voltaic cells may be connected in cascade, so that signal will be generated in response to illumination of any one of the lamps for which percussive effects is desired, and so that at least one of the cells will remain unsaturated by light, under all conditions of operation. The output of the photo-voltaic cell (or cells) is applied to the input of a voltage amplifier, so arranged that one positive output pulse only is generated in response to energization of any lamp and one negative pulse only, in response to deenergization of any lamp, regardless of the energized condition of the remainder of the lamps. Across the output circuit of the amplifier is connected in series a gaseous discharge cell, for example, a two electrode neon cell and a condenser. The voltage applied on the neon cell in the absence of pulses is insufficient to fire the cell, but the positive pulses are of sufficient magnitude to ignite the cell, thereby connecting the condenser in series with a positive voltage source, and charging the condenser substantially instantaneously. A negative voltage source is connected in series with a high resistance to the junction of the condenser and the neon cell, so that the junction is normally maintained at the potential of the negative source, and so that when the condenser charge varies, as because the neon cell fires, the negative source tends nevertheless to recharge the condenser to the voltage of the negative source, but very slowly because of the interposition of the high resistance. A diode is connected with its anode at the junction of the condenser in the neon cell, and its cathode connected to ground, said diode acting as a clamping circuit for preventing the potential of the junction rising above ground level. Connected across the diode is a resistance and condenser in series, the constants of

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which are selected to absorb very rapid changes, which might otherwise give rise to clicks in the output of the system. The condenser is connected to the grid of a tone amplifier, to which is also connected an input circuit deriving from that photoelectric cell of the system which is subjected to tone modulated light. Both connections to the grid proceed via isolating resistances, so that interaction of the two input circuits is prevented. The output of the tone amplifier then proceeds via formant filters and an audio power amplifier to an electro-acoustic transducer.

Connected between the junction point of the condenser and the neon cell and ground is a switch, which constitutes, in its closed position, a short circuit around the condenser, preventing any change of voltage thereacross, and in its open condition permitting control of the voltage across the condenser. This switch constitutes a percussive stop and is controlled by means of a stop tab, in an actual organ.

The tone amplifier is, in the absence of control pulses, subjected to the voltage of the negative source, and has a gain characteristic such as to provide substantially zero gain in response to that voltage applied to the control grid. Accordingly, the tone amplifier is normally cut-off. In response to an input pulse of positive polarity, the voltage across the condenser rises rapidly to ground potential, which increases the gain of the amplifier rapidly to substantially full gain. On cessation of the control pulse, the neon cell de-ignites, and the condenser in series therewith discharges through the high resistance to the potential of the negative source. The discharge occurs quite slowly, so that the gain of the amplifier is reduced with corresponding slowness to a condition of substantially zero gain.

The net effect is a rapid rise in gain and a slow decrease in gain of the tone amplifier in response to each depression of a key of the organ, regardless of the condition of the remaining keys, i.e., whether they are or not depressed.

It is, accordingly, a primary object of the present invention to provide a novel system for introducing percussive effects in a photoelectric musical instrument.

It is a further object of the invention to provide a percussion circuit for photoelectric organs which shall be operated in response only to each energization of a lamp of a photoelectric organ, regardless of the condition of the remaining lamps, and not in response to de-energization.

It is another object of the invention to provide a percussive system which is entirely electronic, and which does not rely upon the use of relays or other mechanically moving elements.

Still a further object of the invention resides in the provision of a percussive circuit for a musical instrument which is extremely simple, requires a minimum number of inexpensive parts, is positive in action, and requires no maintenance.

A further object of the invention resides in the provision of a gain controllable amplifier, in which the gain of the amplifier increases always to the same predetermined value, and decreases from the same predetermined value, in sequence, and automatically, in response to a control pulse of given polarity.

It is another object of the invention to provide a novel system for generating a percussive tonal envelope in musical instruments in response to a control pulse, the percussive envelope having a predetermined fixed maximum and minimum value.

Still another object of the invention is to provide a percussive system which shall be operated only in response to pulses of a given polarity, and not in response

to pulses of the opposite polarity, selection being accomplished by a neon cell.

It is another object of the invention to provide a percussive circuit for electronic organs in which the rate of rise and the rate of decay of a percussive tonal envelope may be independently readily controlled over a wide range of values.

The above and still further objects, features and advantages of the present invention will become apparent upon consideration of the following detailed description of one specific embodiment thereof, especially when taken in conjunction with the accompanying drawings, wherein:

FIGURE 1 of the accompanying drawing is a schematic circuit diagram of a system according to the invention; and

FIGURE 2 illustrates certain wave forms occurring in the system.

Proceeding now more particularly to the accompanying drawing, the reference numeral 1 denotes a tone disc applicable to photoelectric organs employing selective illumination of tone tracks by means of selectively energizable lamps.

The reference numeral 2 denotes a slit disc, containing a plurality of slits, one for each tone track, which serves to guide light from an array of lamps 3 to appropriate ones of the pitch or tone tracks 4 of the pitch disc 1. The pitch disc 1 is rotated at a predetermined rate by means of a motor 5, and the light deriving from the lamps 3, and modulated by the pitch disc 1, are all collected by means of a photoelectric cell 6. The output of the photoelectric cell is applied via a lead 7 and an isolating resistance 8 to the grid 9 of a tone amplifier stage 10. The stage 10 comprises a triode 11, the anode 12 of which is in series with an anode load 13 and a B+ terminal 14. The cathode 15 of the triode 11 is connected to ground via a bias circuit 16, comprising a voltage divider connected to a source of positive voltage, thus eliminating need by a by-pass condenser.

The output from the amplifier stage 10 is taken at the anode 12, via a lead 18, and proceeds to formant filters 19, and thence to a power audio amplifier 20 and an electro-acoustic transducer 21, all in cascade.

The lamps 3 are selectively controlled by means of key-operated switches 22, all of which are connected in parallel to a voltage source 23, which is capable of supplying the required current and voltage to the lamps 3. Accordingly, the lamps 3 will be selectively energized in accordance with the selected ones of the switches 22, depression of a key of an organ, for example, resulting in closure of a corresponding one of the switches 22.

In accordance with the present invention a supplementary photoelectric cell of the photo-voltaic or voltage-generating type is provided, which is identified by the reference numeral 30. This cell is so positioned with respect to the lamps that it may be illuminated by all of the lamps 3 of the array, and if this proves to be difficult or impossible at any given case, or if it leads to saturation of the cell in some conditions of operation, a plurality of similar suitably located cells may be connected in cascade. The cell 30 is connected via a bus to the grid of a triode amplifier tube 32, the grid being connected to ground via a grid leak 33 in conventional fashion. It is important to note that no differentiation takes place, because no coupling condenser is employed. The triode 32 is anode-loaded by means of a resistance 34 and is supplied with anode voltage from a B+ terminal 35, in conventional fashion. The anode of the triode 32 is coupled via a coupling condenser 36 and a grid leak 37, constituting a differentiating network, to a grid of a further triode 38, which is in turn anode-loaded by an anode resistance 39 and supplied with anode voltage from the B+ terminal 35. In response to rise of a pulse generated by the photoelectric cell 30, a positive pulse appears at the anode of the triode 38. This occurs whenever one of the lamps 3 is energized, and in response

to the transient increase in illumination which occurs on such energization. Once the lamp has been energized, the output of the photoelectric cell 30 becomes a steady voltage, which is not transferred to the triode 38 because of the presence of the series coupling condenser 36.

It follows that in response to and concurrent with depression of any key of the electronic organ, a corresponding one of the switches 22 is closed, a corresponding one of the lamps 3 is energized, and a pulse of positive polarity appears at the anode of the triode 38. When the key is released, on the contrary, only a negative pulse appears at the anode of the triode 38, and while the key remains depressed, no change in voltage is detectable at this anode, from the no signal condition.

The anode of the triode 38 is connected via a neon cell 40 and a large condenser 41 back to ground at its cathode. The neon cell 40 and the voltages available thereto are so selected that steady voltage at the anode of the triode 38 is not sufficient to fire the neon cell 40. It follows that negative pulses at the anode of the triode 38 have no effect, but the circuitry is so arranged that positive pulses are sufficient to fire or ignite the neon cell 40, in effect closing the circuit for the condenser 41 and charging same toward the voltage of the anode 38. Connected across the condenser 41 is a diode 44, the cathode of which is grounded. It follows that the ungrounded terminal of the condenser 41 can never rise higher than ground potential, even when the neon cell 40 is ignited, the diode 43 constituting a clamping device.

Between the junction 43 of the neon cell 40 and the condenser 41 is connected an extremely high resistance 45, which is in turn connected in series with a negative voltage terminal 46. The diode 44 presents no conductive path to ground for a negative voltage at the terminal 46. Accordingly, the normal condition of charge for the condenser 41 is that the ungrounded terminal of the condenser 41, i.e., the junction point 43, is at the negative voltage of the terminal 46. When the neon cell conducts, a high positive voltage is applied to the terminal 43, which in effect discharges the condenser 41, bringing the ungrounded terminal to ground potential, but being incapable of raising the potential of the ungrounded potential of the condenser 41 above ground because of the clamping diode 44. The anode of the diode 44 is connected to ground through a relatively high resistance 47 and a condenser 48, in series. The junction of the resistance 47 and the condenser 48 is connected via an isolating resistance 49 to the grid 9 of the triode 11. The grid 9 of triode 11 is, accordingly, continually maintained at the voltage of the terminal 46, until such time as the neon cell 40 fires, raising the terminal 43 to ground potential, and correspondingly raising the potential of the grid 9 to ground potential. For ground potential condition of the triode 11, it has normal gain. When subjected to the negative voltage of the terminal 46, the amplifier stage 10 is inoperative, or at least operative at sufficiently low gain substantially to prevent amplification of tone signals applied to the stage 10 via the lead 7.

The switch 50 serves to short or open the condenser 48, according as the switch 50 is closed or opened. When closed, the percussive system is disabled, resistance 49 then constituting a grid bias resistance.

The anode of the triode 11 is coupled back to the ungrounded terminal of capacitor 48 via a series connected capacitor C and resistance R. These elements, together with condenser 48 provide a low frequency degenerative feedback path for the triode 11, when the system is percussive, which is eliminated under normal conditions, i.e., when switch 50 is closed. This feedback greatly reduces low frequency thump during percussion, and in addition the condenser C provides a Miller rundown, increasing the capacity of the timing circuit for a given value of condenser 48.

The present system employs a single RC coupling cir-

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cuit between the P.E. cell 30 and the trigger tube 40, i.e., the triode 32 is directly coupled to the P.E. cell 30, and the triode 38 is RC coupled to the triode 32, no coupling condenser being required between P.E. cell 30 and triode 32. This presents an unobvious advantage, eliminating any necessity for flip-flop circuits for assuring that percussive effects will occur on depressing a key only, and not on releasing a key.

The output of the P.E. cell, in response to depression and raising of a key, is essentially a square wave, 60, as at FIGURE 2, which is reversed in phase by triode 38. The single RC coupling circuit, comprised of capacitor 36 and resistance 37, is essentially a differentiating circuit, generating a negative pulse 61 at the initiation of the phase reversed square wave 62 and a positive pulse 63 at the rise of the phase reversed square wave 62. The triode 38 introduces a further phase reversal, generating pulses 64 and 65 (line *d* of FIGURE 2). The trigger tube 40 fires in response to pulse 64 and not in response to pulse 65, and in response to firing of trigger tube 40 a percussive wave form is generated. Where two RC cascaded coupling circuits employed, as for example by providing a coupling capacitor in series with bus 31, both the rise and the fall of pulse 60 would give rise to a pair of pulses of successively opposite polarities, as 66, 67, and 68, 69. The trigger tube 40 would accordingly fire in response to both the rise and the fall of the pulse 60.

Reviewing now the operation of the present system, as the keys of an electronic organ incorporating the system are manipulated, various ones of the switches 22 are selectively closed. Closure of any one of the switches 22 results in illumination of the corresponding one of the lamps 3, the light from which passes through the modulating pitch disc 1 to the photoelectric cell 6, resulting in generation of tonal signal which is applied to the tonal amplifier stage 10 for further processing in the formant filters 19 and eventual amplification by means of the audio amplifier 20 to a sufficient level for radiation as sound. The tonal amplifier stage 10 is, however, normally maintained inoperative or at sufficiently low gain that transfer of signal therefrom does not occur, by reason of the application to the grid 9 of the stage 10 of a negative voltage deriving from the terminal 46. Whenever one of the lamps 3 is energized, a positive signal is generated at the output of the photo-voltaic cell 30, which is amplified by the cascaded triode tubes 36 and 38, but differentiated only once by RC circuits 36, 37, and appears at the anode of the tube 38 as a single high positive pulse. This high positive pulse fires the normally de-ignited neon cell 40, permitting passage of current into the condenser 41. The condenser 41 is normally maintained with its ungrounded terminal at a negative voltage deriving from the terminal 46. When the neon cell 40 ignites, the voltage of the ungrounded terminal condenser 41 rises to ground potential, being prevented from rising farther by the clamping diode 44. The resistance 47 and the condenser 48, in series, constitute a click filter, which prevents extremely rapid application of voltage rise to the grid 9 of the triode 11. The rise time is made sufficiently slow that audible clicks are avoided. When the pulse available at the anode of the triode 38 has terminated, because the illumination from the array of lamps 3 has attained a steady state, the condenser 41 proceeds to vary its charge so that its ungrounded terminal may re-attain the voltage of the terminal 46. This is a relatively slow process since the discharge must take place through the high resistance 45. Accordingly, there is generated a percussive tonal envelope which has a relatively rapid rise and a relatively slow decay. The rise time may be adjusted by adjusting the resistance 47, while the decay time may be adjusted by varying the value of the resistance 45.

Raising a previously depressed one of keys 22 has no effect on the percussive effect generating system, since

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only a negative pulse is thereby generated at the anode of triode 32.

The function of the present system, in a general sense, is then to effect percussive translation of tones from the tone generator of a photoelectric organ, by generating a rapidly rising AVC voltage in response to and concurrent with actuation of any key, followed by a relatively slow decay of gain, to a no-gain condition, in the ensuing time.

In response to closure of any key, all the keys concurrently depressed give rise to tones having percussive effects which are co-extensive with the percussive effect allocable to the last depressed key.

The entire percussion circuit may be readily disabled by means of a stop switch 50, which shorts out condenser 48 when closed.

While I have described and illustrated one specific embodiment of my invention, it will be clear that variations of the details of construction which are specifically illustrated and described may be resorted to without departing from the true spirit and scope of the invention as defined in the appended claims.

What is claimed is:

1. In combination, a gaseous conduction device and a condenser connected in a series circuit, means normally maintaining a voltage across said gaseous discharge device and said condenser in series which is lower than ignition voltage for said gaseous conduction device, a source of negative voltage, a high resistance, means connecting said source of negative voltage via said high resistance to the junction of said gaseous conduction device and said condenser, a diode connected from the said junction to a point of reference potential in conductive direction, and means for supplying pulses in series with said series circuit which are of magnitude sufficiently great to effect discharge of said gaseous discharge device.

2. In a pulse forming system, a condenser having a first terminal and a second terminal, said second terminal being connected to a point of reference potential, a gaseous conduction device, a source of positive pulses, said gaseous conduction device having a first electrode connected directly to said first terminal and a second electrode connected directly to said source of positive pulses, a diode having an anode and a cathode, means connecting said anode to said first terminal and said cathode to said point of reference potential, a high resistance, a source of negative voltage connected to said first terminal via said high resistance, and a pulse output circuit connected to said first terminal.

3. In a pulse forming circuit, a condenser having a first terminal and having a second terminal connected to a point of reference potential, a diode having an anode connected to said first terminal and a cathode connected to said point of reference potential, a high resistance, a source of negative voltage connected via said high resistance to said first terminal, an output lead connected to said first terminal, and means for applying positive voltage pulses to said first terminal.

4. The combination according to claim 3, wherein is further provided a switch connected for selectively interconnecting said terminals via a resistive path.

5. The combination in accordance with claim 2, wherein is further provided an amplifier and an electro-acoustic transducer in cascade with said amplifier, said amplifier having signal input terminal for application of electronic tone signals and an automatic gain control circuit, and means for connecting said output lead to said automatic gain control circuit, said automatic gain control circuit being arranged and adapted for reducing the gain of said amplifier in response to voltage negative with respect to said reference potential.

6. The combination according to claim 5, wherein is provided an array of normally unenergized electric lamps, means for energizing said lamps selectively, and means

responsive to energization of any one of said lamps under any condition of energization of the other lamps of said array for generating one of said positive voltage pulses.

7. The combination according to claim 6, wherein said last means includes at least one photoelectric cell exposed to said array of lamps.

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