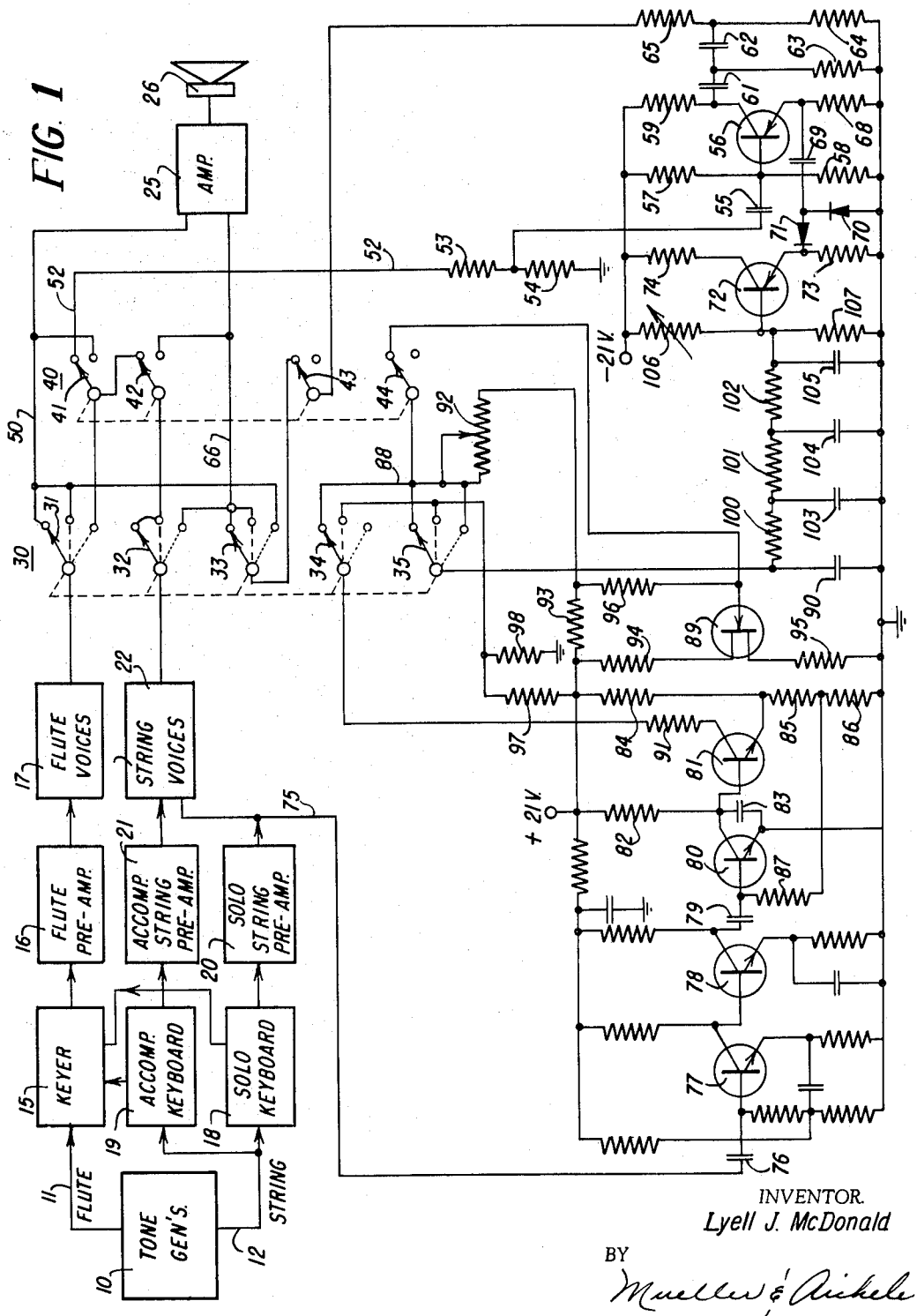
May 24, 1966 L. J. McDONALD 3,253,079

ELECTRONIC CONTROL SYSTEM

Filed May 27, 1963 2 Sheets-Sheet 1

FIG. 1



INVENTOR.
Lyell J. McDonald

BY
Mueller & Aichele
Attys.

May 24, 1966 L. J. McDONALD 3,253,079

ELECTRONIC CONTROL SYSTEM

Filed May 27, 1963 2 Sheets-Sheet 2

FIG. 2

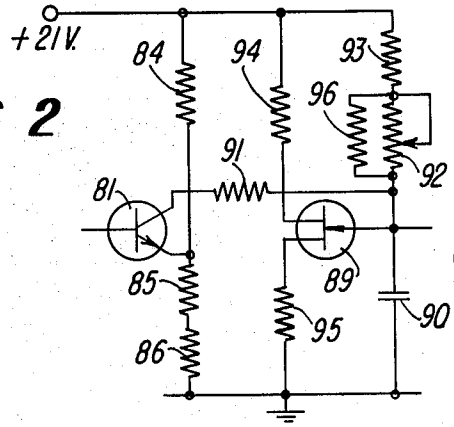


FIG. 3

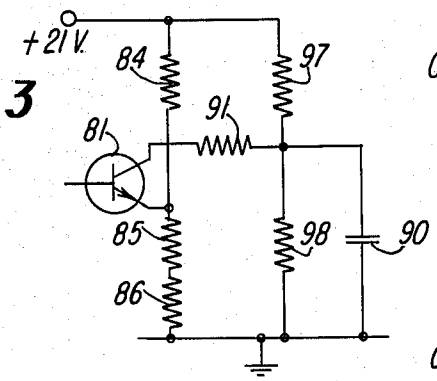


FIG. 4

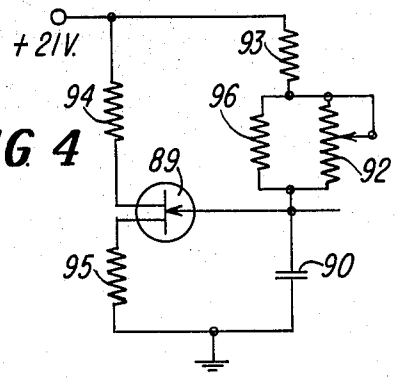


FIG. 5

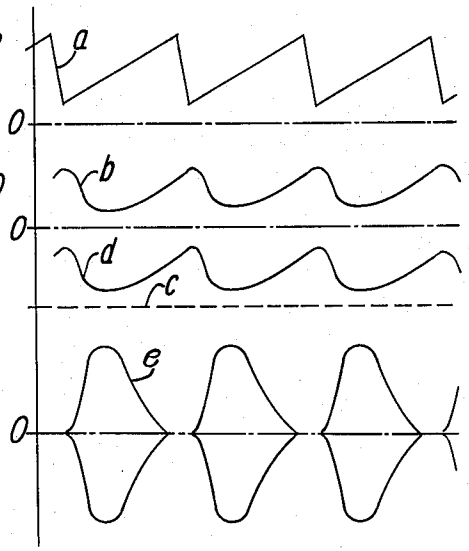
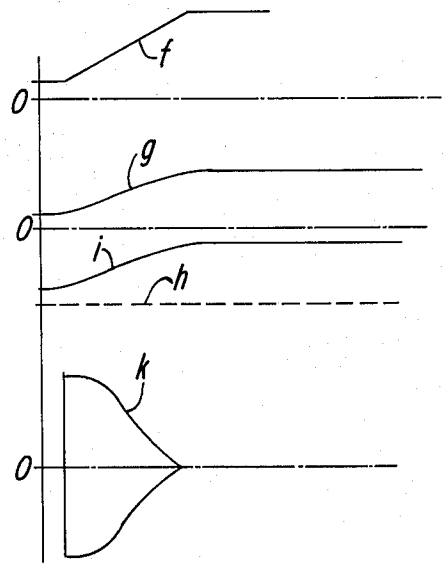


FIG. 6



INVENTOR.
Lyell J. McDonald

BY
Mueller & Aichele
Attys.

United States Patent Office

3,253,079

Patented May 24, 1966

3,253,079

ELECTRONIC CONTROL SYSTEM

Lyell J. McDonald, Elkhart, Ind., assignor to C. G. Conn Ltd., Elkhart, Ind., a corporation of Indiana

Filed May 27, 1963, Ser. No. 283,509
16 Claims. (Cl. 84—1.26)

This invention relates generally to percussion systems for electric organs, and more particularly to a transistorized percussion system wherein various different percussive effects can be selectively provided.

In electric organs and other electrical musical instruments it is desired to provide percussive effects to simulate the characteristics of certain instruments. By use of such a system it is possible to simulate the sounds produced by instruments such as the vibraharp and harpsichord which have strings and instruments which are struck such as the xylophone, marimba and bells. Although percussion systems have been used which require additional key contacts on the organs, this adds expense and makes it difficult to attach the systems to existing organs. United States Patent No. 3,039,347 describes a system wherein it is not necessary to use additional key contacts and the present invention relates to an improved system of this type which operates in a different manner, and which provides effects not possible with the prior system.

It is, therefore, an object of the present invention to provide a simple and improved percussion system for an electrical musical instrument.

Another object of the invention is to provide a percussion system wherein a plurality of different effects can be selected.

A further object of the invention is to provide a transistorized percussion circuit wherein no connection to a key contact is required.

A still further object of the invention is to provide a percussion system which may be used to provide percussive effects on either flute or string voices of an organ, and wherein repeat effects can be provided, with the speed of the repeat selected by the operator.

A feature of the invention is the provision of a percussion system including a transistor modulator to which organ signals are applied and which acts to cut off the signal to provide a burst of tone, with the signal being attenuated by degeneration action in the modulator. The transistor of the modulator has an emitter resistor providing degeneration, with a capacitor and a rectifier connected across the resistor to remove the degenerative effect when the rectifier is conducting.

Another feature of the invention is the provision of a transistorized percussion system including a unijunction transistor connected in a relaxation oscillator circuit which develops a sawtooth voltage wave across a capacitor, which wave controls the conductivity of a rectifier circuit which in turn controls the level of the organ signal. A variable resistor connected in the relaxation oscillator circuit permits control of the frequency of the sawtooth wave.

A further feature of the invention is the provision of an amplifier controlled by the solo string signals developed by an organ, which operates to trigger the unijunction relaxation oscillator so that the percussion effect is synchronized with the initiation of the string tone.

Still another feature is the provision of a percussion system for operation with string tones, wherein the presence of a string tone signal initiates a circuit to remove a short across a capacitor so that the capacitor charges to provide a linearly rising voltage which operates through the modulator and rectifier system to cut off the string tone providing a single burst. A switching arrangement is provided so that the percussion system can operate either in the repeat or single burst mode and so

that it can be applied to either string or flute tones in the organ.

The invention is illustrated in the drawing wherein:

FIG. 1 is a schematic diagram showing the percussion circuit and the coupling thereof to an electric organ;

FIG. 2 illustrates the portion of the circuit that produces the control voltage for string repeat operation;

FIG. 3 shows the portion of the circuit that provides string percuss operation;

FIG. 4 shows the portion of the circuit that produces the control voltage for flute repeat operation; and

FIGS. 5 and 6 include curves illustrating the operation of the circuit.

In practicing the invention there is provided a transistorized percussion system for use in an electric organ and which includes switching and control means to connect the system for various modes of operation. The circuit includes a modulator or control stage to which organ signals are applied and from which percussed output signals are derived for amplification and reproduction. The switching system can be operated to apply either flute or string signals to the modulator. The modulator stage includes a transistor or other electron device, the gain of which is controlled by varying the degeneration therein. This is accomplished by the use of a variable impedance circuit connected to the emitter of the transistor, which may be formed by an emitter resistor shunted by a pair of diode rectifiers. The conductivity of the rectifiers is controlled to thereby control their dynamic resistance and the shunting effect thereof. When the rectifiers are fully conducting they have low resistance and effectively shunt the emitter resistor to reduce the degeneration. The rectifiers are connected in series to the output of an impedance matching transistor to which a control voltage is applied. This transistor reduces the conduction of the rectifiers so that the resistance thereof increases and the shunting effect is reduced. The control voltage may be produced by a relaxation oscillator including a unijunction transistor. This may be continuously operative to provide a sawtooth wave when used on flute tones to cause repeated percussive bursts. When operating on string tones, the signal from the solo string preamplifier of the organ is amplified to provide a trigger voltage for a control stage which shunts the capacitor of the unijunction relaxation oscillator. The trigger voltage renders the control system non-conductive to remove the shunt so that the oscillator produces a repeating sawtooth voltage across the capacitor. The system may also be operated to provide a single string percussive burst, in which case the relaxation oscillator is disconnected and the capacitor is charged by a voltage divider circuit.

Referring now to the drawings, in FIG. 1 the percussion system of the invention is shown connected to an electric organ. It is pointed out, however, that the percussion system may be used in other organ systems than that shown in FIG. 1. In FIG. 1 a plurality of tone generators **10** provide flute outputs **11** and string outputs **12**. The flute outputs are applied through keyers **15** to flute preamplifier **16** and to flute voicing circuits **17**. The keyers **15** may be controlled by a solo keyboard **18** and an accompaniment keyboard **19**. The solo and accompaniment keyboards may directly key the string tones, with the solo string tones being applied to solo preamplifier **20** and the accompaniment string tones being applied to accompaniment preamplifier **21**. The solo and accompaniment string tones are applied to the string voicing circuits **22**.

The percussion system is connected to the output of the flute and string voicing circuits, and selectively connects such circuits to output amplifier **25** and loudspeaker **26**. It is pointed out that a plurality of amplifiers with expression control may be used, and that a plurality of speakers

may also be used. The percussion system is controlled by selector switch 30 and on-off switch 40. Switch 30 has 5 movable contacts 31, 32, 33, 34 and 35 which are ganged together and are operable to three different positions. In the position shown by solid lines, percussion of string tones is provided and repeated percussive bursts are applied to the output amplifier 25. This mode of operation is identified as STRING REPEAT. In the next switch position, shown by dash lines, the percussive system applies the string tones to the modulator but only a single burst is provided. This mode is designated STRING PERCUSS. In the third position of switch 30, shown by dotted lines, the flute tones are applied to the modulator and repeated percussive bursts of flute tones are applied to the amplifier 25. This mode is designated FLUTE REPEAT. The on-off switch 40 has four movable contacts 41, 42, 43 and 44. This switch is illustrated in the on position.

Considering now the operation of the system, this will be explained first for the number one or STRING REPEAT mode of operation. It will be noted that the flute tones are applied through contact 31 to conductor 50 to the amplifier 25 and are not effected by the percussion system. The string tones are applied through contact 32 and through contacts 42 and 41 of switch 40 to conductor 52. This signal is applied across the voltage divider formed by resistor 53 and 54, with a portion of the string signal being applied through capacitor 55 to the base electrode of transistor 56. The base electrode is biased by the voltage divider including resistors 57 and 58, so that transistor 56 normally conducts. The collector electrode of transistor 56 is connected to the negative voltage supply by resistor 59. The output is derived from the collector electrode and applied through the filter including capacitors 61 and 62 and resistors 63, 64 and 65, through contacts 43 of the off-on switch 40, and contact 33 of the selector switch 30, to conductor 66 connected to amplifier 25. This filter acts to attenuate transients developed as the gain of transistor 56 is changed as will be described.

It is therefore seen that the signal representing the string voice is applied through the transistor 56 to the output amplifier, and this transistor functions as a modulator to provide the percussive effect. The gain of the modulator is changed by degenerative action in the emitter circuit of transistor 56. The emitter electrode is connected to ground through resistor 68, and is also connected by capacitor 69 to diode rectifiers 70 and 71. The dynamic resistance of these diodes is changed as the conduction thereof is changed. The diode rectifiers 70 and 71 are connected in series across resistor 73 connected from the emitter electrode of transistor 72 to ground. Conduction of transistor 72 produces a voltage across resistor 73 which controls the conductivity of diodes 70 and 71. The diodes 70 and 71 are effectively connected in parallel across resistor 68 by capacitor 69. Capacitor 69 has a value such that it has low impedance at the operating frequencies, so that the dynamic resistances of diode rectifiers 70 and 71 are effectively placed in shunt with resistor 68 to control the degeneration action in transistor 56.

Transistor 72 acts as an impedance matching device to control the low impedance diodes 70 and 71 from a higher impedance control voltage source. A negative bias voltage is applied to the base electrode thereof by the voltage divider 106, 107, and the collector electrode is connected to a negative supply by resistor 74. When transistor 72 is conducting, diode rectifiers 70 and 71 are also conducting and have low resistance. Since they are in shunt with the emitter resistor 68 of transistor 56, the diodes reduce the effective emitter resistance to reduce the degeneration in transistor 56. Transistor 56 therefore has high gain and amplifies the signal applied thereto so that there is substantial output. However, when transistor 72 is rendered less conducting, the emitter voltage drops and the resistance of diode rectifiers 70 and 71 increases. The effective shunting action on emitter resistor 68 is therefore reduced and the degeneration action is increased. In such case transistor 56 has its gain reduced and the signal applied to the output amplifier 25 of the organ decreases. The gain of transistor 56 may thereby be varied continuously over a wide range of values.

In the STRING REPEAT mode, the conduction of transistor 72 is controlled by a circuit which responds to the presence of a solo string tone. The output of the solo string preamplifier 20 is applied through conductor 75 and capacitor 76 to transistor 77. Transistor 77 is of the NPN type energized from a positive potential supply and functions as an isolation amplifier. The string signal is directly applied from transistor 77 to transistor 78. Transistor 78 is also an NPN type transistor and operates as a voltage amplifier. The collector voltage of transistor 78 is applied through capacitor 79 to the base electrode of transistor 80.

Transistors 80 and 81 form a trigger circuit, with transistor 80 normally being only slightly conducting. This transistor conducts further when a signal is applied to the base electrode thereof from transistor 78. The emitter electrode of transistor 80 is connected to the reference potential, and the collector electrode is connected to the positive voltage supply through resistor 82. Resistor 82 and capacitor 83, which is connected between the collector electrode and ground, provide filtering action to remove the effects of the individual cycles of the string tone signals. The collector electrode of transistor 80 is connected directly to the base electrode of transistor 81, which is normally conducting. The emitter electrode of transistor 81 is connected to a voltage divider formed by resistors 84, 85 and 86. Resistor 86 also provides a relatively stable forward bias to transistor 80, which is applied through resistor 87 connected to the base electrode of transistor 80. This allows transistor 80 to conduct a controlled amount to reduce the voltage required across capacitor 83 in order to cut off transistor 81.

The transistor 81 provides a shunt circuit across capacitor 90, which is coupled to a relaxation oscillator circuit including unijunction transistor 89. The collector electrode of transistor 81 is connected through resistor 91, switch contact 34, conductor 88, and switch contact 35 to capacitor 90. Accordingly transistor 81, which is normally conducting, provides a shunt across capacitor 90 through the collector-emitter circuit of transistor 81 and resistors 85, 86 and 91. These resistors have relatively small values to rapidly discharge capacitor 90 to a low value. The minimum value of the voltage across capacitor 90 is determined by the voltage divider including resistors 84, 85 and 86 which provides a fixed bias to the emitter electrode of transistor 81. The voltage at the collector electrode of transistor 81 is only slightly more positive than the emitter voltage, and this is applied through resistor 91 to capacitor 90. When transistor 81 is cut off by the trigger signal, condenser 90 can charge through the circuit including switch contact 35, variable resistor 92 and resistor 93, which is connected to the positive potential supply.

Transistor 89 is of the unijunction type having its emitter electrode connected to capacitor 90 through switch contact 44 of the off-on switch 40, and contact 35 of the selector switch 30. Resistor 94 connects the Base 2 electrode of the unijunction transistor 89 to the positive supply, and provides temperature stabilization. Resistor 95 connects the Base 1 electrode of transistor 89 to ground. This resistor limits the Base 1 to emitter current so that it is held at a safe value and also controls the discharge time of capacitor 90 so that the transient generated by this discharge is minimized. Variable resistor 92 is connected to the emitter electrode of transistor 89 through switch contact 44, in parallel with resistor 96, and is connected in series with resistor 93 to the positive potential supply. Resistor 93 governs the maximum speed of the relaxation

oscillator, and resistor **96** controls the range afforded by the variable control **92**, to thereby define the minimum speed limit.

For ease in considering the operation of the control transistor **81** and the relaxation oscillator including unijunction transistor **89**, the circuit of these stages is shown in FIG. 2 with the switch contacts omitted. The circuit connections are the same as shown in FIG. 1. Resistors **92**, **93** and **96**, and capacitor **90** cooperate with unijunction transistor **89** to form a relaxation oscillator circuit which provides a sawtooth voltage wave across capacitor **90**. When transistor **81** is cut off so that the shunt across capacitor **90** is removed, the voltage on this capacitor is permitted to rise. When this voltage reaches a predetermined value, the unijunction transistor **89** conducts to discharge capacitor **90** through resistor **95**. The voltage across capacitor **90** therefore rises and falls to form a sawtooth voltage wave. The repetition rate of the wave can be controlled by adjusting resistor **92**.

The sawtooth voltage wave appearing across capacitor **90** is shown by curve *a* in FIG. 5. This voltage is applied through the resistor-capacitor wave shaping network including resistors **100**, **101**, and **102** and capacitors **103**, **104** and **105** to the base electrode of transistor **72** (FIG. 1). The voltage wave applied by this network to the base electrode of transistor **72** is shown by curve *b* in FIG. 5. As clearly shown by curve *b*, the wave shaping network attenuates the high frequency components of the sawtooth wave. As previously stated, fixed negative bias is applied to the base electrode of transistor **72** by the voltage divider including resistors **106** and **107** to cause this transistor to conduct. This voltage is shown by curve *c*. The voltage *b* opposes the fixed bias voltage *c* to produce the resultant voltage *d* which controls the conductivity of transistor **72**. As the resultant voltage becomes less negative, the transistor **72** conducts less, and the voltage across emitter resistor **73** drops. This reduces the forward bias applied to diodes **70** and **71** and increases their dynamic resistance. As diodes **70** and **71** are effectively connected in shunt with resistor **68** by capacitor **69**, increase in the diode resistance reduces the shunting effect and resistor **68** provides greater degeneration in transistor **56** to reduce its output and substantially cut off the signal applied therethrough.

Capacitor **90** discharges rapidly to a low value to remove the reverse bias on transistor **72** so that its forward bias is high and the voltage across resistor **73** increases to cause diodes **70** and **71** to conduct more. This effectively reduces the resistance of the diodes to again shunt resistor **68** to reduce the degenerative effect. Therefore the maximum output is produced by transistor **56** and applied to the amplifier **25**. The envelope of the output of transistor **56** resulting from the control voltage across capacitor **90** is shown by curve *e* in FIG. 5. It is apparent that the gain of transistor **56** is repeatedly and successively increased and reduced to provide the desired percussive effect.

The action which has been described takes place when a key is operated to provide a tone to the solo string preamplifier **20**. When the key is released, no signal is applied to amplifiers including transistors **77** and **78** so that transistor **80** is substantially cut off and transistor **81** conducts. The collector electrode of transistor **81** is therefore held at a low value just above that at the emitter electrode provided by the voltage divider including resistors **84**, **85** and **86**. This voltage is connected through resistor **91** and switch contacts **34** and **35** to capacitor **90** to hold the voltage thereon to a low value to reset the system. The percussion system can then again be started when another key is operated.

When the switch **30** is in the center or STRING PERCUSS position, the output of the flute voices is again applied through contact **31** of selector switch **30** and conductor **50** to the output amplifier **25**. The output of the string voices is again applied through contact **32** of selector switch **30**, and contacts **42** and **41** of on-off switch **40** to conductor **52**, and through voltage divider **53–54** to the input of transistor **56**. Accordingly the modulator again operates on the string voices. Contact **34** of selector switch **30** connects the collector electrode of transistor **81** to the intermediate point of the voltage divider formed by resistors **97** and **98**. This point is also connected through contact **35** to capacitor **90**. For this mode of operation the relaxation oscillator including unijunction transistor **89** is not utilized. The active circuit elements for STRING PERCUSS operation are shown in FIG. 3.

When transistor **81** is conducting, and it is biased to be normally conducting, it operates to shunt capacitor **90**, as was described for the prior mode of operation. In this condition the voltage across capacitor **90** is such that when applied through the wave shaping network it combines with the fixed bias at the base electrode of transistor **72** to hold this transistor conducting, so that the diodes **70** and **71** conduct fully and transistor **56** produces full gain. Therefore the modulator is intially on to reproduce the string tones with a relatively sharp percussive attack. Then, when the trigger signal is applied to transistor **81**, this transistor is cut off and capacitor **90** charges from the voltage applied by the voltage divider including resistors **97** and **98**. This causes the voltage across capacitor **90** to rise substantially linearly to a value controlled by the voltage divider.

The voltage rise across capacitor **90** is illustrated by curve *f* of FIG. 6, and the voltage applied therefrom through the wave shaping network formed by resistors **100**, **101** and **102** and capacitors **103**, **104** and **105** (FIG. 1) to the base electrode of transistor **72** is shown by curve *g*. This combines with the fixed bias shown by line *h* to provide the resulting voltage *i*. The transistor **72** therefore becomes less conducting so that the voltage across resistor **73** is reduced to render diodes **70** and **71** less conducting. This increases the resistance of diodes and reduces the shunting effect of the diodes **70** and **71** across resistor **68** to thereby increase the degenerative action and substantially reduce the output signal, as shown by curve *k* of FIG. 7. This operation takes place when a key is operated to apply a signal to string preamplifier **20**, as previously stated. When the key is released transistor **81** again conducts so that the voltage across capacitor **90** is reset, as previously described.

In the third mode of operation wherein the selector switch **30** is positioned so that the movable contacts are in the lowermost positions, FLUTE REPEAT operation is provided. The flute signal is applied through contact **31** of selector switch **30**, and contact **41** of on-off switch **40** to conductor **52**. The signal is then applied from voltage divider **53**, **54** to the input of the transistor **56**. The string signals are applied through contact **32** of selector switch **30** and through conductor **66** to the output amplifier **25**. It will be noted that in this switch position, contact **34** connected to the collector electrode of transistor **81** through resistor **91**, is open. The circuit including transistors **77**, **78**, **80** and **81** is not used for the flute repeat mode of operation. For this operation, capacitor **90** is connected through contacts **35** and contacts **44** of the emitter electrode of unijunction transistor **89**, and this capacitor is not shunted so that the relaxation oscillator operates continuously. The circuit for FLUTE REPEAT operation is redrawn to FIG. 4 to eliminate the switch contacts.

During the FLUTE REPEAT mode operation, the relaxation oscillator including transistor **89** operates continuously to provide a sawtooth wave across capacitor **90**. This is illustrated by curve *a* of FIG. 5, being the same wave produced in the STRING REPEAT operation. The repetition rate of the sawtooth wave can be controlled by the variable resistor **92**. This voltage wave applied through the shaping network (curve *b*) controls tran-

sistor 72 as previously described so that the voltage across emitter resistor 73 is reduced to reduce the conduction of diodes 70 and 71. Diodes 70 and 71 therefore have increased resistance so that the shunting effect thereof on emitter resistor 68 is reduced and increased degeneration is provided in transistor 56. Accordingly the amplitude of the flute signal is repeatedly and successively increased and reduced as shown by curve *e* in FIG. 5.

The following values are given for the components in the circuit of FIG. 1 as representative values which have been found to provide desirable operation, but this circuit is not limited to the use of these values:

Transistor 56	Type 2N323.
Resistor 57	43,000 ohms.
Resistor 58	100,000 ohms.
Resistor 59	4700 ohms.
Capacitor 61	.039 microfarad.
Capacitor 62	.015 microfarad.
Resistor 63	33,000 ohms.
Resistor 64	100,000 ohms.
Resistor 68	27,000 ohms.
Capacitor 69	3 micorfarads.
Diode 70	Type 1U1 (selenium).
Diode 71	Type 1U1 (selenium).
Transistor 72	Type 2N323.
Resistor 73	3300 ohms.
Resistor 74	10,000 ohms.
Transistor 80	Type 2N292.
Transistor 81	Type 2N292.
Resistor 82	100,000 ohms.
Capacitor 83	.47 micorfarad.
Resistor 84	1800 ohms.
Resistor 85	820 ohms.
Resistor 86	10 ohms.
Resistor 87	10,000 ohms.
Transistor 89	Type 2N1671 (unijunction).
Capacitor 90	4 microfarads.
Resistor 91	1500 ohms.
Resistor 92	375,000 ohms.
Resistor 93	27,000 ohms.
Resistor 94	1200 ohms.
Resistor 95	33 ohms.
Resistor 96	220,000 ohms.
Resistor 97	47,000 ohms.
Resistor 98	270,000 ohms.
Resistor 100	18,000 ohms.
Resistor 101	27,000 ohms.
Resistor 102	56,000 ohms.
Capacitor 103	.27 micorfarad.
Capacitor 104	.47 micorfarad.
Capacitor 105	.47 micorfarad.
Resistor 106	300,000 ohms.
Resistor 107	56,000 ohms.

The system described provides three separate modes of operation by switching of the different circuit portions. The control or modulator stage acts on the signal applied thereto in accordance with the degenerative effect thereon resulting from the change in resistance of the diodes which shunt the degeneration producing resistor. The diodes are rendered conducting in various degrees by an impedance matching stage operated by the control voltage. The control voltage is developed across a capacitor which may be charged only once, or repeatedly charged and discharged by a relaxation oscillator to provide repeated percussive bursts. For FLUTE REPEAT operation, the oscillator operates continuously and causes repeated burst of the flute tone signals applied to the control stage. For string percussive effects, a trigger circuit responds to string tone signals to remove a shunt circuit across the control voltage capacitor. This is accomplished by rendering non-conductive the transistor in the shunt circuit. For STRING PERCUSS operation, the oscillator is disconnected and the capacitor charges to provide a single burst of string tone when the string tone signal is applied. For STRING REPEAT operation, the capacitor is permitted to charge in response to a string tone, and then is repeatedly discharged by the relaxation oscillator. The connection of the signals to the control stage and therefrom to the organ output, and the various modes of operation are provided by an ON-OFF switch and a three position selector switch which provides the different connections for the three modes of operation. A third control permits selection of the repetition rate of the relaxation oscillator.

The system described therefore provides the desired percussive effects in a relatively simple circuit which can be easily controlled by the operator. The system has been found to be very effective in actual use.

I claim:

1. A percussion system for use in an electric organ which produces string tone signals and flute tone signals including in combination, a control stage having first transistor means with input, output and common electrodes, switch means for selectively applying string tone signals and flute tone signals to said input electrode, feedback means including diode means for selectively controlling the impedance of said feedback means, means connecting said feedback means to said common electrode of said transistor means, second transistor means, means connecting said second transistor means to said diode means for controlling the conductivity of said diode means, and control means including a relaxation oscillator for providing a control voltage, means connecting said relaxation oscillator to said second transistor means for applying the control voltage to said second transistor means and switch means controlling the operation of said control means and selectively rendering said relaxation oscillator operative.

2. A percussion system for use in an electric organ including in combination, a control stage having a transistor with base, emitter and collector electrodes, input circuit means, means connecting said output circuit means to said base electrode and output circuit means, means connecting said output circuit means to said collector electrode, feedback means including diode means for selectively controlling the effect of said feedback means, means connecting said feedback means to said emitter electrode for controlling the signal in said output circuit means, control means for controlling the conductivity of said diode means, said control means including a relaxation oscillator having capacitor means and means for charging said capacitor means, means connecting said capacitor means to said diode means, transistor means for shunting said capacitor means, and means responsive to a signal produced by the organ for applying a trigger signal to said transistor means for rendering said transistor means non-conductive.

3. A percussion system for an electric organ including in combination, a control stage having a transistor with base, emitter and collector electrodes, input circuit means, means connecting said input circuit means to said base electrode, output circuit means, means connecting said output circuit means to said collector electrode, feedback means including variable impedance means for selectively controlling the effect of said feedback means, means connecting said feedback means to said emitter electrode for controlling the signal in said output circuit means, control means including capacitor means and means for charging said capacitor means, means connecting said capacitor means to said variable impedance means for controlling the impedance thereof, transistor means for selectively shunting said capacitor means, and means responsive to a signal produced by the organ for applying a trigger signal to said transistor means for rendering said transistor means non-conductive.

4. A percussion system for use in an electric organ including in combination, a control stage having input and

output circuits, said input and output circuits including feedback means for controlling the signal in said output circuits, said feedback means including variable impedance means for selectively controlling the effect of said feedback means, and control means for controlling the impedance of said variable impedance means, said control means including shunting means for selectively disabling said control means, and means connecting said control means to said variable impedance means, said shunting means being responsive to a signal produced by the organ and being rendered ineffective by such a signal.

5. A percussion system for use in an electric organ including in combination, a control stage having input and output circuits, said input and output circuits including feedback means for controlling the signal in said output circuit, said feedback means including diode means for selectively controlling the effect of said feedback means, control means for controlling the conductivity of said diode means, said control means including a relaxation oscillator having a unijunction transistor for causing repeating action and shunting means for disabling said control means, said shunting means being responsive to a signal produced by the organ and being rendered ineffective by such a signal, and switch means for selectively rendering said oscillator and said shunting means operative.

6. A percussion system for use in an electric organ including in combination, a control stage having a transistor with input, output and common electrodes, feedback means including diode means for selectively controlling the effect of said feedback means, means connecting said feedback means to said common electrode, control means for providing a control voltage for controlling the conductivity of said diode means, said control means including a relaxation oscillator for causing said control voltage to vary in a substantially sawtooth wave form and shunting means for selectively shorting said control voltage, trigger means responsive to a signal produced by the organ for disabling said shunting means, switch means, and means connecting said switch means to said oscillator and to said shunting means and having a first position rendering said oscillator operative and a second position rendering said shunting means operative.

7. A percussion system for use in an electric organ including in combination, a controlled amplifier having a transistor with input, output and common electrodes, resistor means, means connecting said resistor means to said common electrode for providing degenerative feedback for controlling the signal at said output electrode, capacitor means and rectifier means, means including said rectifier means connecting said capacitor means to said resistor means for controlling the feedback provided by said resistor means, control means for providing a control voltage for controlling the conductivity of said rectifier means, said control means including a relaxation oscillator for causing said control voltage to vary in a sawtooth wave form and shunting means for selectively shorting said control voltage, trigger means responsive to a signal produced by the organ for disabling said shunting means, and switch means, and means connecting said switch means to said oscillator and to said shunting means and having a first position rendering said oscillator operative and a second position rendering said shunting means operative.

8. A percussion system for use in an electric organ for selectively causing percussive effects of string tone signals and flute tone signals applied to an amplifier, said system including in combination, a control stage having input circuit means and output circuit means, switch means having first and second positions for applying the string tone signals to said input circuit means and a third position for connecting the flute signals to said input circuit means, said switch means connecting said output circuit means to the amplifier, said control stage including degenerative feedback means for attenuating the signal in said output circuit means, control means for selectively controlling the effect of said feedback means, said control means including a relaxation oscillator for causing recurring action in said feedback means so that the gain of said control stage is repeatedly attenuated, said control means further including blocking means responsive to a string tone signal for rendering said control means operative only when such string tone signal is applied to the amplifier, said switch means rendering said oscillator operative in said first and third positions and rendering said blocking means operative in said first and second positions.

9. A percussion system for use in an electric organ for selectively causing percussive effects of string tone signals and flute tone signals applied to an amplifier, said system including in combination, a control stage having input circuit means and output circuit means, switch means having first and second positions for applying the string tone signals to said input circuit means and a third position for connecting the flute signals to said input circuit means, said switch means connecting said output circuit means to the amplifier, said control stage including degenerative feedback means for attenuating the signal in said output circuit means, control means including a capacitor and means for charging said capacitor so that a control voltage is developed across said capacitor, means connecting said capacitor to said feedback means for rendering said feedback means effective, said control means including means cooperating with said capacitor to form a relaxation oscillator for shorting said capacitor in recurring cycles so that the gain of said control stage is repeatedly increased and attenuated, said control means further including shunting means, means connecting said shunting means across said capacitor means, amplifier means responsive to the string tone signals for disabling said shunting means when such string tone signal is applied to said amplifier means so that a control voltage is developed across said capacitor, said switch means rendering said oscillator operative in said first and third positions to provide repeated bursts of signals, and rendering said shunting means operative in said first and second positions so that a voltage is developed across said capacitor when a string tone signal is applied to attenuate the output of said control stage.

10. A percussion system for an electric organ including in combination, a control amplifier having a transistor with input, output and common electrodes, input circuit means, output circuit means, means connecting said input circuit means to said input electrode, means connecting said output circuit means to said output electrode, variable impedance means having an impedance which varies in response to an applied control signal, means connecting said variable impedance means to said common electrode for controlling the signal applied by said transistor to said output circuit means, control means including a relaxation oscillator for providing a voltage wave having a cyclic variation of sawtooth waveform, said control means including filter means for attenuating high frequency components of said sawtooth waveform, and means connecting said filter means to said variable impedance means for controlling the impedance thereof to thereby control the signal applied to said output circuit means.

11. A percussion system for use in an electric organ including in combination, a control stage having an electron device for controlling the level of signals produced by the organ, said control stage including feedback means for controlling the gain thereof, said feedback means including variable impedance means responsive to a control voltage for selectively controlling the gain of said stage, control means including capacitor means, circuit means for charging said capacitor means to produce a sawtooth voltage wave thereacross, and filter means connected to said capacitor means for attenuating the high frequency components of the sawtooth voltage wave, and means connecting said filter means to said variable impedance means for controlling the impedance of said impedance means

to thereby control the gain of said control stage, and switch means for selectively applying signals to said control stage and for selectively connecting said circuit means to said capacitor means to thereby control the operation of said control means.

12. A percussion system for an electric organ including in combination, a control stage having a first transistor with base, emitter and collector electrodes, input circuit means, means connecting said input circuit means to said base electrode, output circuit means, means connecting said output circuit means to said collector electrode, feedback means including diode rectifier means for selectively controlling said feedback means, means connecting said feedback means to said emitter electrode for controlling the signal in said output circuit means, a second transistor having base, emitter and collector electrodes, means connecting said rectifier means to said emitter electrode of said second transistor, control means including capacitor means and means for charging said capacitor means, circuit means cooperating with said capacitor means to form a relaxation oscillator to repeatedly discharge said capacitor means and produce a sawtooth wave across said capacitor means, and filter means coupling said capacitor means to said base electrode of said second transistor, said filter means attenuating high frequency components of said sawtooth wave and applying a voltage to said second transistor for controlling the conductivity of said rectifier means and thereby controlling the output of said control stage.

13. A percussion system for use in an electric organ including in combination, a transistor control stage having input circuit means and output circuit means, said stage including means for controlling the level of the signal in said output circuit means in accordance with a control voltage, control means including a relaxation oscillator for producing a recurring sawtooth voltage wave, filter means for reducing the high frequency components of said sawtooth wave coupling said oscillator to said control stage and applying a voltage to said control stage so that the gain of said control stage is repeatedly increased and decreased, and switch means for selectively rendering said oscillator operative.

14. A percussion system for use in an electric organ for selectively causing percussive effects of string tone signals and flute tone signals applied to an amplifier, said system including in combination, a transistor stage having input circuit means and output circuit means, switch means having first and second positions for applying the string tone signals to said input circuit means and a third position for applying the flute tone signals to said input circuit means, said switch means connecting said output circuit means to the amplifier, said transistor stage having degenerative feedback means including a resistor forming a part of said input circuit means and said output circuit means for attenuating the signal in said output circuit means, said feedback means including first capacitor means and rectifier means connected in series with each other across said resistor for selectively controlling the degenerative action of said feedback means, control means including second capacitor means and means for charging said second capacitor means, means connecting said second capacitor means to said rectifier means for controlling the conductivity of said rectifier means in accordance with the voltage developed across said second capacitor means so that the gain of said transistor stage is controlled, relaxation oscillation means including said second capacitor means acting to discharge said second capacitor means in recurring cycles so that the gain of said transistor stage is repeatedly increased and reduced, trigger means including a transistor and amplifier means, and means connecting said transistor in shunt across said second capacitor means for holding said second capacitor means at a predetermined voltage, said amplifier means operating in response to a string tone signal to actuate said trigger means and render said transistor non-conductive so the voltage across said second capacitor means increases, said switch means rendering said oscillator means operative in said first and third positions and rendering said trigger means operative in said first and second positions.

15. A percussion system for an electric organ for selectively causing percussive effects of string tone signals and flute tone signals applied to an amplifier, said system including in combination, a control stage having a first transistor with input, output and common electrodes, switch means having first and second positions for applying the string tone signals to said input electrode and a third position for applying the flute signals thereto, said switch means connecting said output electrode to the amplifier, degenerative feedback means including a resistor, means connecting said resistor to said common electrode for attenuating the signal at said output electrode, first capacitor means and first rectifier means connected across said resistor, control means including second capacitor means and means for charging said second capacitor means, said control means including a second transistor having input and output electrodes and means biasing said second transistor to be conductive, second rectifier means, means connecting said second rectifier means in series with said first rectifier means to said output electrode of said second transistor, said second transistor controlling the conductivity of said first and second rectifier means to thereby control the impedance of said rectifier means and the degenerative action in said control stage, means connecting said second capacitor means to said input electrode of said second transistor for cutting off said second transistor in response to a voltage developed across said second capacitor means, a relaxation oscillator including said second capacitor means for shorting said second capacitor means in recurring cycles so that the voltage across said second capacitor means alternately increases and is shorted to form a sawtooth wave, trigger means including third and fourth transistors, means connecting said fourth transistor to said second capacitor means, said third transistor being normally non-conductive and said fourth transistor being normally conductive to hold said second capacitor means discharged, amplifier means, and means connecting said amplifier means to said trigger means and operative in response to a string tone signal to apply a voltage to said third transistor to render said third transistor conductive and thereby render said fourth transistor non-conductive so that a control voltage is developed across said second capacitor means, said switch means rendering said oscillator operative in said first and third positions whereby said sawtooth wave developed across said second capacitor means causes repeated percussive signals at said output electrode of said control stage, and rendering said trigger means operative in said first and second positions so that a voltage is developed across said second capacitor means to attenuate the signal at said output electrode of said control stage in response to a string tone signal.

16. A percussion system for an electric organ for selectively causing percussive effects of string tone signals and flute tone signals applied to an amplifier, said system including in combination, a first transistor stage having base, emitter and collector electrodes, switch means having first and second positions for applying the string tone signals to said base electrode and a third position for applying the flue tone signals to said base electrode, said switch means connecting said collector electrode to the amplifier, degenerative feedback means including a resistor, a first capacitor and rectifier means connecting said first capacitor across said resistor, control means including a second capacitor and means for charging said second capacitor, said control means including a second transistor stage having an emitter circuit including said rectifier means and base circuit, means connecting said base circuit to said second capacitor, means connected to said second transistor stage for biasing said second transistor stage to be

conductive whereby said rectifier means is held conductive, with the voltage applied to said base circuit of said second transistor stage by said second capacitor rendering said second transistor stage less conductive to thereby control the conductivity and the impedance of said rectifier means, the impedance of said rectifier means controlling the degenerative action in said first transistor stage to thereby control the signal at said collector electrode of said first transistor stage, a relaxation oscillator including a unijunction transistor and said second capacitor means and acting to short said second capacitor means in recurring cycles so that the gain of said first transistor stage is repeatedly increased and attenuate, trigger means including third and fourth transistor stages and means biasing said fourth stage so that said fourth stage is normally conducting, means connecting said fourth stage to said second capacitor means for holding said second capacitor means discharged, transistor amplifier means, and means connecting said transistor amplifier means to said trigger means and operative in response to a string tone signal to render said third transistor stage conducting and thereby cut off said fourth transistor stage so that a control voltage is developed across said second capacitor means, said switch means rendering said oscillator operative in said first and third positions and rendering said trigger means operative in said first and second positions.

References Cited by the Examiner

UNITED STATES PATENTS

2,485,538 10/1949 Rowe ---------- 84—1.25

FOREIGN PATENTS

652,542 11/1962 Canada.

OTHER REFERENCES

G. E. Notes on Application of Silicon Unijunction Transistor, 5/61 (page 37 relied on).

ARTHUR GAUSS, *Primary Examiner.*

D. D. FORRER, *Assistant Examiner.*