

April 5, 1966

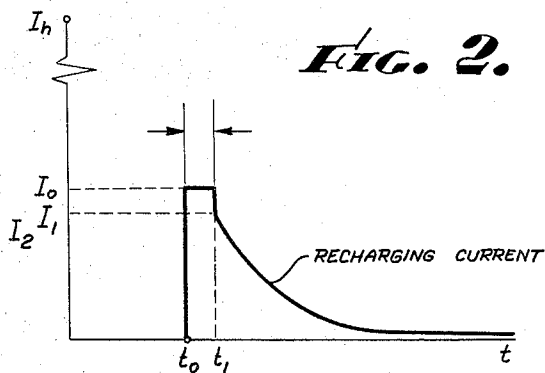
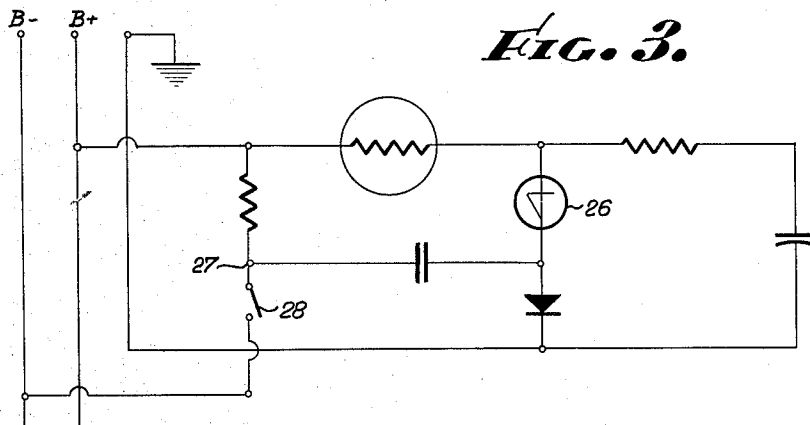
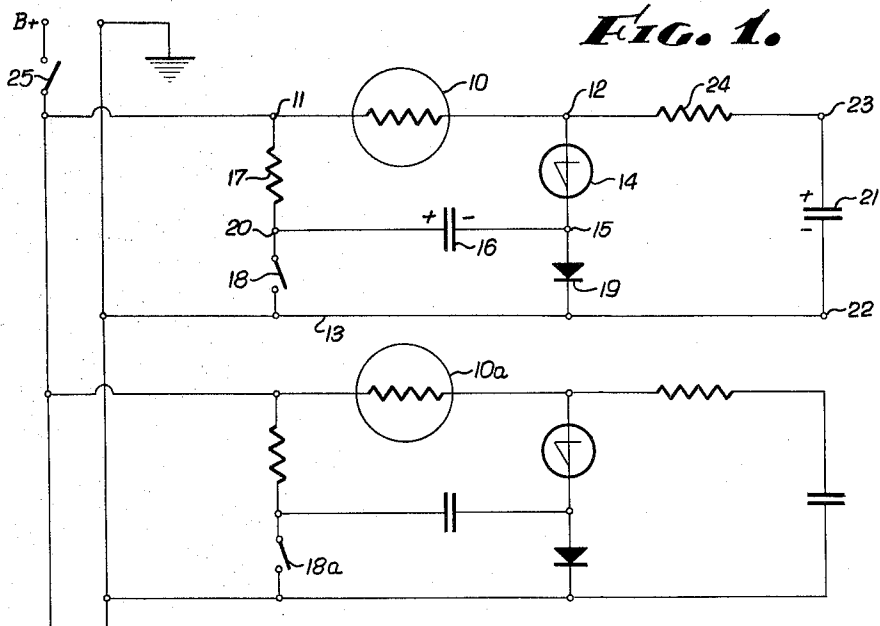
P. H. SHARP

3,244,790

PERCUSSION CIRCUIT UTILIZING A SINGLE-POLE KEY SWITCH

Filed Aug. 2, 1962

5 Sheets-Sheet 1



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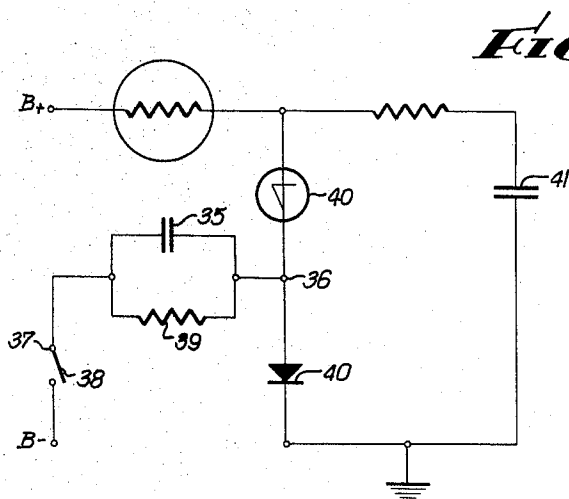
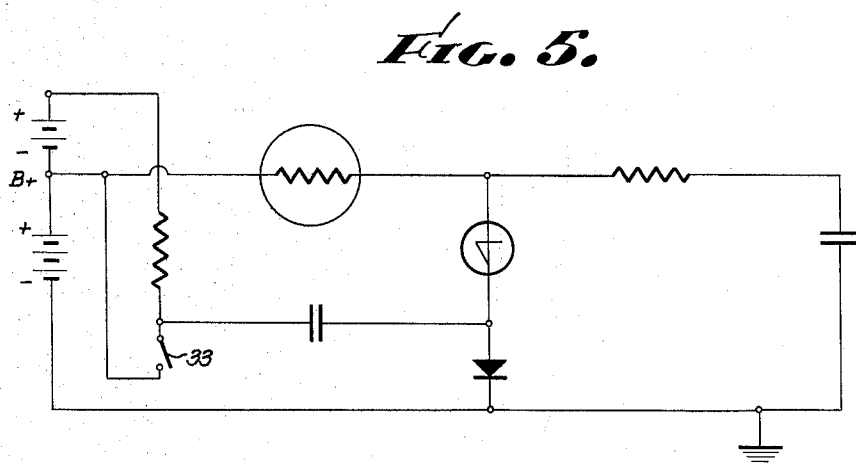
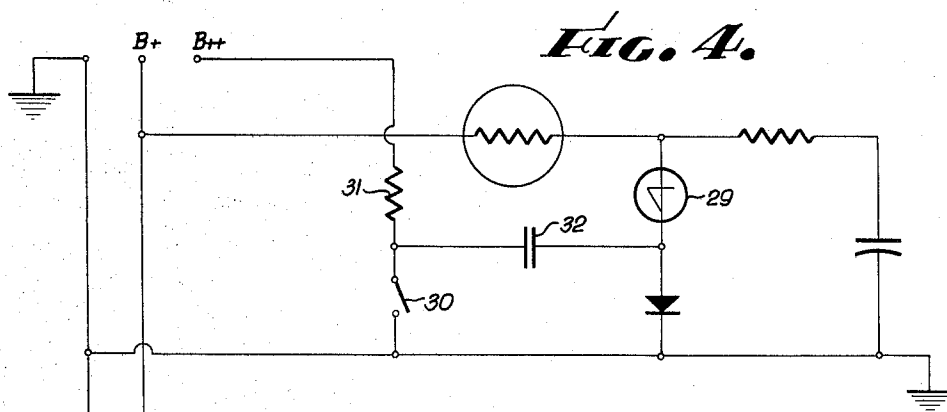
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PERCUSSION CIRCUIT UTILIZING A SINGLE-POLE KEY SWITCH

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5 Sheets-Sheet 2



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PERCUSSION CIRCUIT UTILIZING A SINGLE-POLE KEY SWITCH

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FIG. 7.

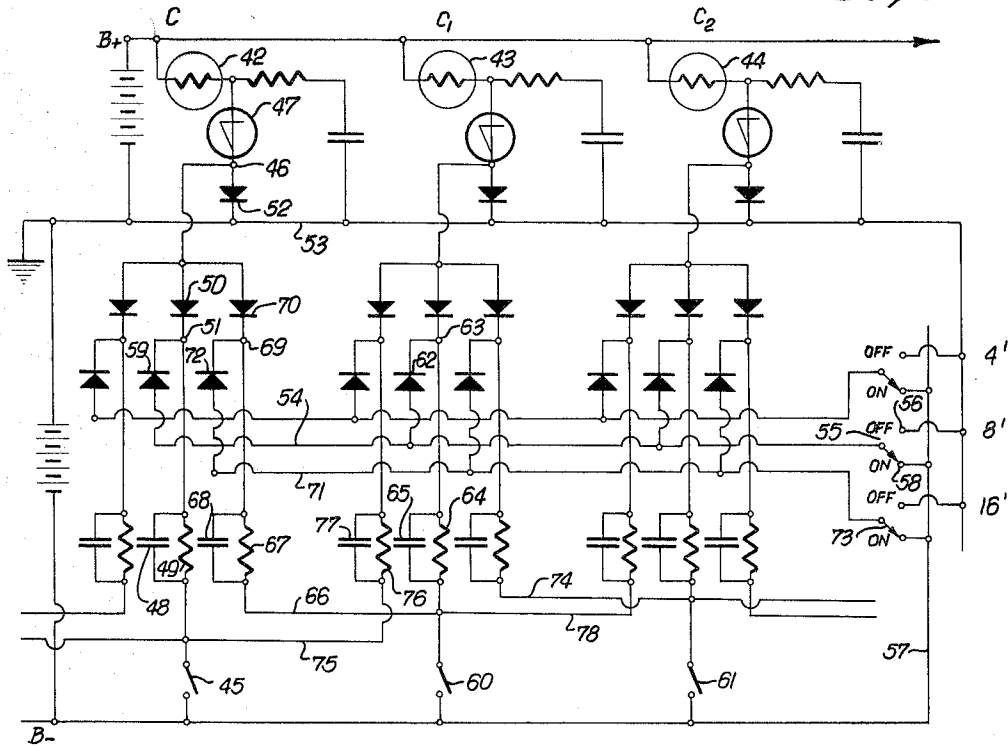
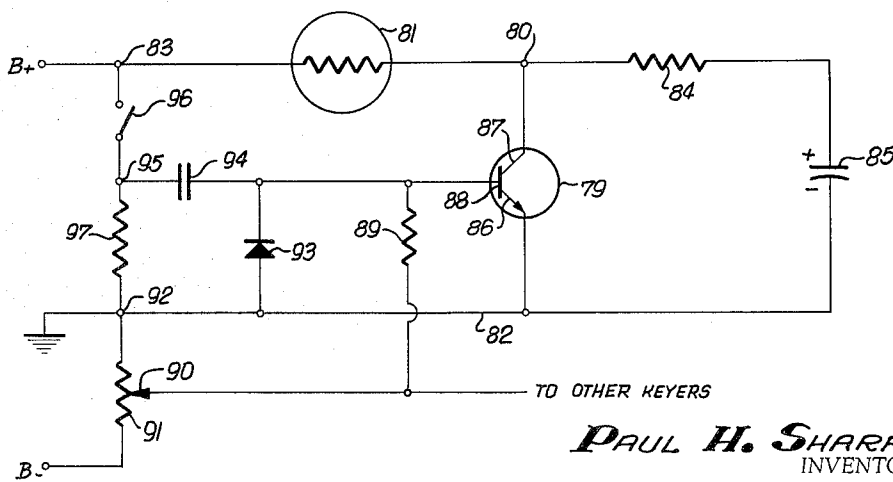


FIG. 8.



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PERCUSSION CIRCUIT UTILIZING A SINGLE-POLE KEY SWITCH

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FIG. 9.

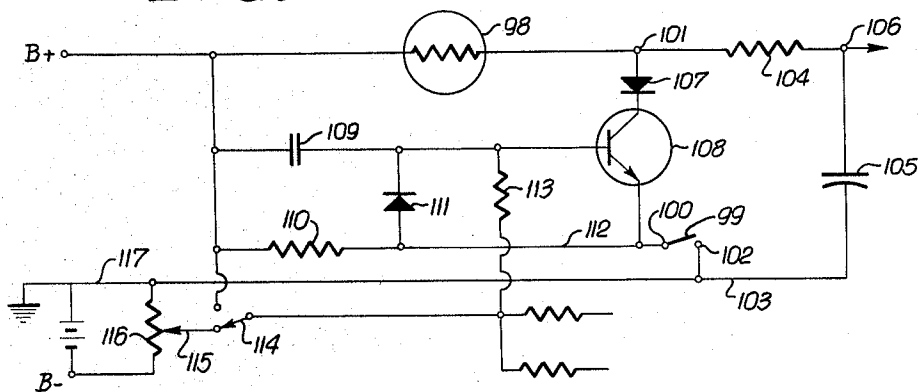


FIG. 10.

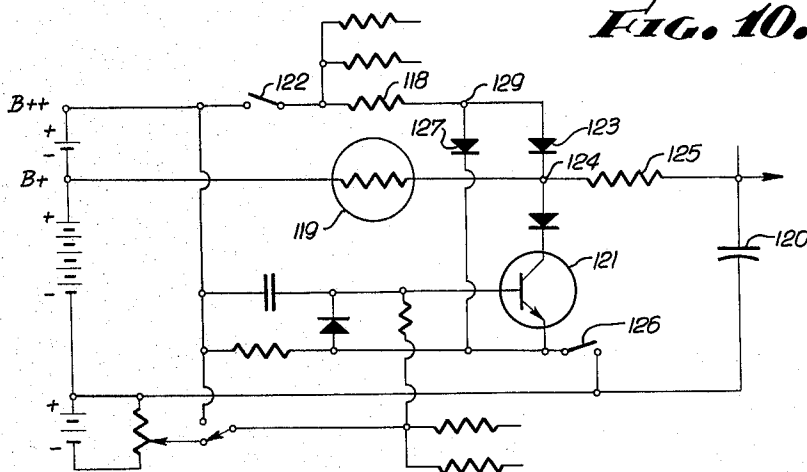
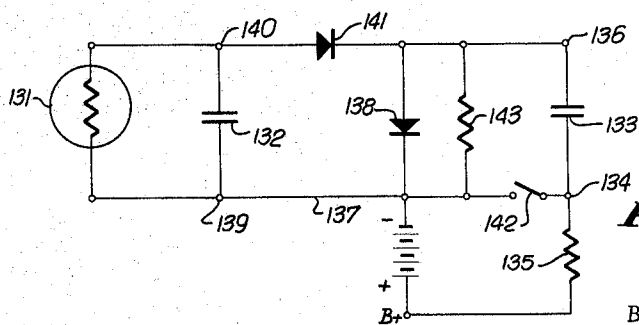


FIG. 11.



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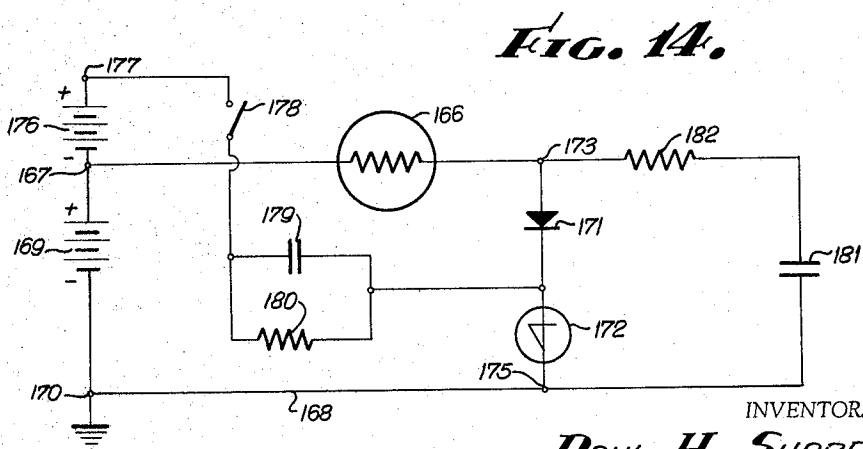
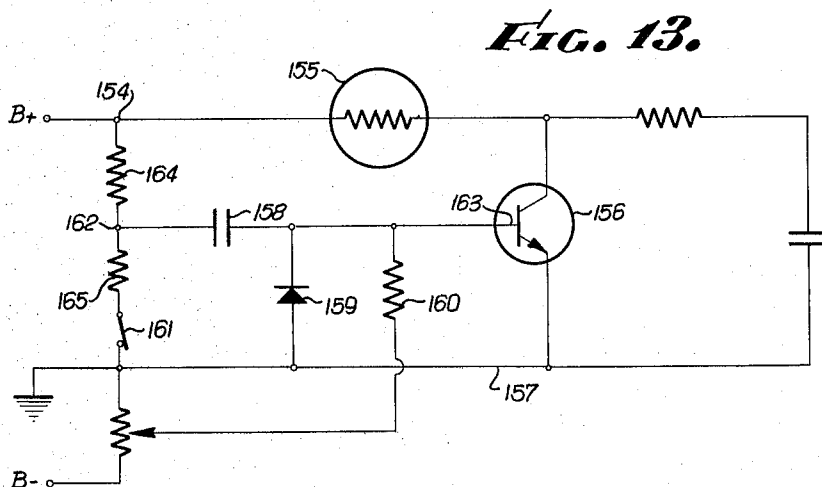
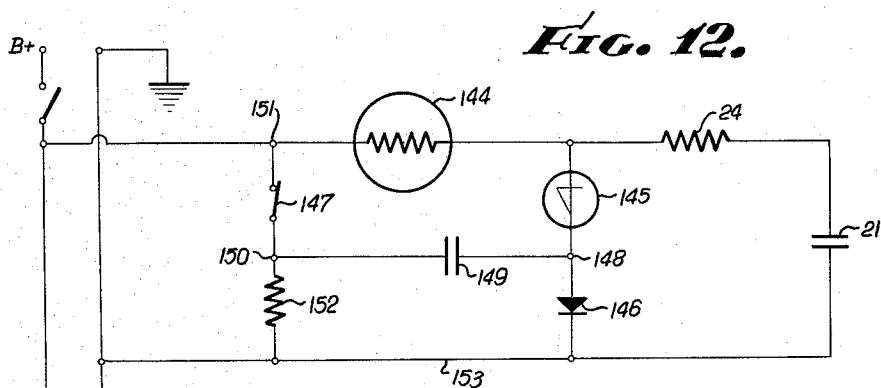
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PERCUSSION CIRCUIT UTILIZING A SINGLE-POLE KEY SWITCH

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5 Sheets-Sheet 5



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PERCUSSION CIRCUIT UTILIZING A SINGLE-POLE KEY SWITCH

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Filed Aug. 2, 1962, Ser. No. 214,331
29 Claims. (Cl. 84-1.13)

This invention relates to electronic organs, and particularly to electrical circuits for producing percussive effects for simulating bell, piano, marimba and other percussive tones.

Percussive effects can be crudely produced on a conventional electronic organ by depressing a key and immediately releasing it. Immediate release is required because, in the conventional organ circuit, the tone continues as long as the key is depressed. In contrast, a piano key can be held down or released without altering the tone. Thus percussive tones are produced by imparting a burst of energy to a vibrating body, rather than a continuous supply of energy. After the energy pulse is initially applied to a percussive tone generator, it decays at a rate determined by the damping characteristics of the generator.

Some electronic organs utilize circuits that require, for the production of percussive effects, continued depression of a key. This too is an unnatural operation as compared, for example, to the piano. Other electronic organs superimpose a percussion envelope on the entire organ output. This severely restricts versatility.

One of the primary objects of this invention is to provide improved circuitry for producing percussive effects in which the organ key, after depression, can be released or not without affecting the tone produced. Thus the action truly simulates that of a piano or equivalent percussive instrument.

Another object of this invention is to provide improved circuitry for producing percussive effects without alteration of the operation of other tone producing circuits. Thus percussion tones can be combined with other tones and add versatility to the organ.

In still other known organ circuits for producing percussive effects, a key operated switch has both a back contacting and a front contacting position. In such organizations, movement of the switch first disconnects a capacitor from a source, and then connects it to a tone generator. These circuits have proved impractical since they require major revisions in the conventional single pole switch assemblies used in electronic organs. Further, they require undue maintenance to ensure proper engagement of a switch arm with a back contact and a front contact. Such adjustments are ordinarily not required.

Accordingly, an important object of this invention is to provide means for producing percussive effects by the natural key manipulation described with the aid of a simple single pole switch. This means that existing switch assemblies can be utilized.

Still another object of this invention is to provide circuitry that makes it possible to add percussion to an existing electronic organ without reducing its existing capabilities, and without requiring extra key switches.

Still another object of this invention is to provide percussion circuitry of the type described that incorporates a single variable circuit element for the entire rank of generators whereby the frontal shape of the wave is controlled. A companion object is to provide a circuit means of this description that can be operated in conjunction with known means for varying the decay rate of the generators, whereby unusual pizzicato results, for example, can be achieved.

It is well known that various percussive instruments

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can be simulated by building harmonic structures. Thus, for example, a certain characteristic percussion tone may be produced by operating the 8' unison, the 5 1/3' coupler and the 2' coupler. Couplers ordinarily require extra key switches so that the borrowing connections can be made. An object of this invention is to provide novel circuit means whereby coupling can be accomplished for such purposes without requiring added key switches.

Another object of this invention is to provide unique, simple, selectively operable circuitry by the aid of which heavy damping to percussive tones can be applied just as soon as the key is released.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of several embodiments of the invention. For this purpose, there are shown a few forms in the drawings accompanying and forming part of the present specification. These forms will now be described in detail, illustrating the general principles of the invention; but it is to be understood that this detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

Referring to the drawings:

FIGURE 1 is a diagrammatic view illustrating one form of the present invention;

FIG. 2 is a trace showing current through the tone generator as a function of time;

FIGS. 3, 4, 5 and 6 are wiring diagrams, each illustrating modified forms of the present invention;

FIG. 7 is a wiring diagram showing the use of coupler circuitry in combination with a circuit structure similar to that shown in FIG. 6; and

FIGS. 8, 9, 10, 11, 12, 13 and 14 are wiring diagrams, each illustrating other modified forms of the present invention.

In the form of the invention illustrated in FIG. 1, there is disclosed a tone generator 10 that produces a signal corresponding to a specific note. The generator 10 may, for present purposes, be considered purely resistive; however, in practice, the generator ordinarily incorporates reactive elements. The generator 10 may represent the equivalent input resistance of an oscillator or a keyer for a continuously operating generator or the like. In any event, the signal produced by the device 10 has an intensity that is directly proportional to the applied voltage.

Excitation is provided by a lead B+ that connects to one terminal 11 of the generator 10. The other terminal 12 of the generator 10 is connected to ground 13 or the return lead for the source B+ via a switching device 14. When the switching device 14 is closed, the generator terminal 12 is connected to ground. The generator 10 is then active.

Switch 14 in the present example is a four or other known multilayer diode having the characteristic that it takes a predetermined voltage differential to switch it to the on state, whereupon it will remain on providing a certain minimum holding current flows.

The circuit is so designed that the source voltage B+ is inadequate to turn the switch 14 to its on state; hence, the switch 14 is normally off.

In order to turn the switch on, a pulse generator is provided, that momentarily sends the cathode terminal 15 of the switching diode 14 to a negative value adequate to switch it on. The pulse generator in the present example is a simple circuit comprising a small condenser 16, a charging resistor 17, a normally open key switch 18 and a blocking diode 19.

The blocking diode 19 is interposed between the ground lead 13 and the cathode terminal 15 in order to permit the cathode terminal to swing to a potential lower than the ground lead.

The condenser 16, resistor 17 and key 18 have a common terminal 20. The other terminal of the resistor 17 is connected to the supply via terminal 11; the other side of the condenser is connected to the cathode terminal 15; and the other side of the key switch 18 is connected to the ground lead 13.

The condenser 16 is normally charged through resistor 17 to the voltage of the source B+. When the switch 18 is closed, the charge on the condenser 16 momentarily pulls the cathode terminal to a negative value adequate to fire the switching diode 14.

As soon as the switching diode 14 is switched to its conductive state, the generator 10 has its circuit completed, and the note is sounded. This corresponds to time t_0 shown in FIG. 2 where generator current is plotted as a function of time.

As soon as the diode 14 switches, the condenser 16, being very small, is virtually instantly discharged. Accordingly, no audible effect results from the control circuit itself.

The steady state current I_0 (FIG. 2) passing through the generator 10 is much less than the holding current I_h necessary to keep the switch 14 on. In order to sustain the current for a transient decay period corresponding to the characteristic percussive tone, a relatively large capacitor 21 is provided. The capacitor 21 has one terminal 22 connected to the ground lead 13 and its other terminal 23 connected via charging resistor 24 to the anode terminal 12 of the switching diode 14. Before the diode 14 is switched to its on state, the capacitor 21 has been charged from source B+ via generator 10. At the moment of firing of the diode 14, the condenser 21 discharges through it. The combined current from condenser 21 and source B+ via generator 10 is greater than the critical holding current for the switching diode 14. But the condenser current is transient; hence, after a designed time the holding current value is reached, and the diode 14 switches off. This is depicted at time t_1 in FIG. 2. Time t_1 may follow time t_0 by only a few milliseconds, the spacing between these times being exaggerated.

When the diode 14 has switched off, the condenser 21 has been more or less discharged. Hence current through the generator 10 from source B+ recharges the condenser 21, as depicted in FIG. 2. The charging circuit for the condenser 21 now has the combined impedance of the generator 10 and the resistor 24, whereas the resistance to flow of the current I_0 is approximately only that of the generator 10. Hence the current instantly falls to a value I_1 when the diode 14 is switched off. If the charging resistor 24 is small, the initial recharging current I_1 is about equal to the current I_0 .

If the key switch 18 is maintained closed by depression of the corresponding key, it will not affect the opening of the switching diode 14 at the time t_1 , nor will it matter that the key 18 is released. It requires reclosure of the switch 18 to apply the voltage to cathode terminal 15 adequate to turn it on, and it requires discharge of condenser 21 to turn it off. Opening of switch 18 does not affect the discharging characteristics of the condenser 21.

Change in the value of resistor 24 has two effects. First of all, if resistor 24 is decreased, then the condenser 21 discharges very rapidly. This means that the time t_1 falls closer to the time t_0 . Further, as the resistance I_2 is decreased, the drop in current from I_0 to I_1 on opening of the switching diode 14 is likewise reduced. The square top of the wave disappears. This corresponds to a smooth "klakless" tone, as might be produced by a rubber striker on a tone bar.

The resistor 24 also determines the residual charge on the condenser 21 at the moment that the switching diode 14 turns off; hence, the recharging part of the curve is modified somewhat. But since generator impedance remains, there must be a minimum recharging time. The resistor 24, of course, can not be increased in value to a

point where the combined current through the switching diode 14 is less than its holding value.

The key switch 18 will be understood by those skilled in the art as one of a group of normally open switches simultaneously operated by a playing key. The switch 18a operates similar circuitry for the generator 10a for a different note. There may be as many such circuits as there are playing keys in the organ manual, and all may be controlled by a common stop switch 25.

In the form of the invention illustrated in FIG. 3, the switching diode 26 requires a voltage to switch it greater than twice the value of the supply B+. Accordingly, in this instance a supplemental supply B- is provided through which the intermediate terminal 27 is switched by the key switch 28. Thus the circuit may be required in an organ that provides a B+ of nine volts when the switching diode 26 requires twenty volts. The operation of the system is otherwise the same.

In the form illustrated in FIG. 4 a supplemental power supply B++ is also used in order to supplement the output of the main supply B+ to ensure switching of the diode 29. But this supplemental supply can be remote from the switching assemblies. Thus, in the present example, the key 30 has one terminal common to the ground lead which is customarily accessible at the switching assembly. The charging resistor 31 for the small condenser 32 has its terminal connected to B++ rather than to B+. In this example the condenser 32 charges to a voltage corresponding to B++ which is higher than B+. Accordingly, upon operation of the key 30 the total voltage across the diode will be B+ plus B++. Other arrangements are also possible.

For example, the form shown in FIG. 5, the key switch 33 has one terminal connected to the positive terminal of the supply B+, which is customarily available at the switch assembly.

In place of the condensers switched by key switch, a small coil could be provided for momentary production of a negative pulse at the cathodes of the switching diodes. However, the simplest arrangement for generation of a negative voltage appears to be the condenser system described.

In the form of the invention illustrated in FIG. 6, the circuit is similar to that illustrated in FIG. 3 except that the condenser 35 normally has a zero potential. The condenser 35 extends from terminal 36 to one terminal 37 of the key switch 38. The other side of the key switch 38 connects to a source of negative potential designated as B-.

The key switch 38 as in the previous forms is normally open. A resistor 39 parallel the condenser 35 and thus normally prevents any steady state charge from being applied to condenser 35.

As the key switch 38 closes, the (zero) voltage of the condenser 35 is added to B- instantaneously to determine the voltage at terminal 36. The diode 40 accordingly fires as in the previous forms. As soon as the diode 40 fires, a charge on the condenser 35 builds up rapidly if the key is depressed. Upon conduction the terminal 36 moves to ground potential and the switching diode is now under the control of the condenser 41. When the key 38 is released, the resistor 39 quickly discharges the condenser 35 and the circuit is reconditioned.

The circuits just described are quite useful in combination with a coupler circuit whereby only one conventional single pole key switch is required for each playing key. The system of this character is shown in FIG. 7.

In FIG. 7 generators 42, 43 and 44 for the notes C, C1 and C2 are illustrated, together with diode circuitry similar to that shown in the form of FIG. 6. Of course, there are a number of other generators that are excited from the same battery or supply B+.

The key switch 45 has one terminal connected to B- terminal. The other terminal of the switch 45 is connected to the cathode terminal 46 of a switching diode

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47 for generator C through a condenser 48 (paralleled by resistor 49) as in the form shown in FIG. 6. A cross wiring isolating diode 50 is interposed between the cathode terminal 46 and the terminal 51 and the adjacent side of the RC circuit.

When the switch 45 is closed, negative potential is applied through blocking diode 50 to turn the switching diode 47 on. Diode 52 isolates this negative pulse from the more positive ground lead 53.

The diode 52 may selectively be shunted so that the key 45 is incapable of momentarily applying a voltage at the terminal 46 lower than that existing at the ground lead 53. The shunting circuit includes a common lead 54 and a double-pole switch 55 that connects the lead 54 either to the ground lead 53 via contact 56 or to the B— terminal via a lead 57 and the opposite contact 58.

A blocking diode 59 is connected between the common lead 54 and the terminal 51. Any negative pulse generated by the closure of the switch 45 then passes through the preferred path of the blocking diode 59 directly to ground 54 rather than to the terminal 46 which is isolated from ground. Accordingly, no negative potential is applied to the terminal 46 if the switch 56 is in the "off" position corresponding to grounding of the common lead 54.

When the switch 55 is moved to disengage the contact 56, the shunting circuit to ground is ineffective and the circuit operates as previously described. The back or "on" contact 58 of the switch 55 is connected to B— to ensure against thermally developed charges or the like from affecting the operation of the very small condenser 48. The diode 59 ensures that no current is drawn through this circuit.

The switch 55 may be labeled 8' or unison if so desired.

The switch 55 may also prevent the keys 60 and 61 from operating their corresponding generators C1 and C2. Thus, the common lead 54 connects via a diode 62 to an intermediate terminal 63 on one side of the corresponding RC circuit 64-65 for the key 60, and the common lead 54 is similarly connected to the generator circuit for C2. Thus when the switch 55 is operated, all of the keys 45, 60, 61, etc. are similarly incapable of generating unison or 8' tones.

The generator C also has a 4' coupling circuit and a 16' coupling circuit. Thus on operation of the key 60 (whose unison is C1) a coupling circuit may cause the generator for C to be operative irrespective of the operation of the key 45. A lead 66 from one side of the switch 60 connects to one side of a 16' RC circuit 67-68 that is similar to the RC circuit 49-48. The other side of the RC circuit 67-68 connects via a terminal 69 and a blocking diode 70 to the cathode terminal 46 of the switching diode 47. Accordingly, on closure of the key 60, the coupling circuit including the lead 66 transfers a negative pulse to the cathode of the switching device 47 and it switches on to cause appropriate operation.

The 16' circuit so described can be selectively shunted or disabled by a common ground lead 71. The common ground lead 71 is connected to the terminal 69 by a blocking diode 72 and it is controlled by a double-pole switch 73 that may be labeled 16'. In one position, the lead 71 is connected to ground, thereby making it impossible for the RC network 67-68 to transfer a negative pulse to the cathode 46. Other similar 16' circuits are illustrated. For example, a lead 74 provides a 16' coupling between the key 61 whose unison tone is C2 for operating the generator for C1.

Coupling circuits for a 4' tone are also illustrated in FIG. 7. Thus a lead 75 extends from one side of the key switch 45 whose unison tone is C to an RC circuit 76-77 that cooperates with the circuit for the generator C1. Another 4' coupling lead is shown at 78.

Diodes 50, 70, etc. ensure isolation of the coupling circuits. Thus, without these diodes, switching the 16' coupler switch to off would also prevent the negative

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pulse from RC circuit 49-48 from reaching the terminal 46.

It will be well understood to those skilled in the art that the three coupling circuits may represent a much larger number and it will be understood that as many different generators may be provided as convenient, desirable or necessary.

In the form of the invention illustrated in FIG. 8, a different type of switch is provided. In the present example, a transistor 79 is utilized for operation in switching service. As before, the switching transistor 79 when closed connects one terminal 80 of a generator 81 to a common lead 82. The other terminal 83 of the generator 81 is connected directly to a supply lead B+. A resistor 84 and a relatively large condenser 85 are serially connected in parallel across the switching device 79, as in the previous forms. However, this RC circuit is not required to supply any holding current for the switching device.

In the present example, an NPN type transistor is illustrated, but it will be understood that polarity reversals will require the use of other transistor types. The transistor 79 has its emitter 86 connected to the ground lead 82 and its collector 87 connected to the terminal 80. The base 88 of the transistor is biased to cut off by a circuit that includes a resistor 89 and a slider 90 that engages an intermediate point of a potentiometer resistor 91. The resistor 91 has one terminal connected to a B— supply and its other terminal, as at 92, connected to the ground lead 82. The reverse bias on the base 88 is limited by the voltage drop of a diode 93 that is connected between the ground lead 82 and the base 88. Thus under steady state conditions, a current circulates from the ground lead 82 via diode 93, resistor 89 and a section of the resistor 91 to the B— terminal.

A positive pulse adequate to turn the transistor 79 on is applied via a condenser 94 that is similar in some respects to the keying condensers of the previous forms. One terminal of the condenser 94 is connected to the base 88, and the other terminal 95 is connected to one side of a normally open key switch 96. The other side of the normally open key switch is connected to the terminal 83 and B+ supply. The condenser 94 has a normal discharge path to ground provided by a resistor 97. The resistor 97 is thus connected between the switch terminal 95 and the terminal 92 at the ground lead 82. Any positive charge accumulated at the terminal 95 is ultimately discharged through the loop including the condenser 94, discharging resistor 97 and diode 93.

When the key switch 96 is closed, the potential of the supply B+ is suddenly transferred by the condenser 94 to the base 88, and the transistor 79 conducts. The generator 81 conducts, and the condenser 85 discharges. In the present example, the switching device or transistor 79 does not depend upon a minimum holding current. Instead, the conduction time of the transistor 79 depends upon the effective duration of the positive pulse at the base 88 that provides current adequate to maintain the transistor 79 on. The biasing circuit for the transistor ultimately regains control and at a time dependent upon the setting of the slider 90. Thus if the slider 90 is moved to the negative end, then the net potential for absorbing any positive charge at the base 88 is greater and the conduction time is decreased. Conversely, if the slider 90 is moved toward the opposite end of the resistor 91, the positive charge dissipates more slowly. This is true even though the base itself conducts a portion of this charge to the emitter 86 and ground 82. The slider 90 accordingly controls the width of the rectangular top of the wave and as depicted in FIG. 2.

One side of the condenser 94 is immediately brought to the B+ potential as soon as the key 96 is closed. Keeping the switch 96 closed has no further effect on the input circuit at the other side of the condenser. When the key

is released, the positive charge on one side of the condenser 94 is discharged through the resistor 97, and the other side of the condenser is relatively unaffected since the discharge is relatively slow.

The slider 90 and the resistor 91, together with the supply terminal B—, can be made common to any number of generators. Accordingly, a single control can be utilized to determine the attack characteristics of the signal, that is, the shape of the current through the generators at the initial portion of the pulse.

The biasing circuit 89-90 serves to absorb the minimum collector current so that thermal activity is ineffective to turn the transistor on.

In the form of the invention illustrated in FIG. 9, a circuit similar to that shown in FIG. 8 is disclosed, except that key switches already in use can be adapted for production of percussive tones. For example, the generator 98 may be a tibia generator controlled by a key switch 99 associated with an upper manual of the organ. Ordinarily, one terminal 100 of the key switch 99 is connected to one terminal 101 of the generator, and the other terminal 102 of the key switch is connected to a ground lead 103. Decay characteristics of the generator 98 are normally controlled by an RC circuit including a resistor 104 and a condenser 105. An adjustable voltage source affecting the decay characteristics of all of the generators may be connected to a terminal 106.

For adding percussion, the switch terminal 100 is separated from the terminal 101 and circuit elements added. A diode 107 and the collector-emitter terminals of a transistor 108 are connected between the terminals 101 and 100, and a switching condenser 109 is connected between the B+ terminal and the base of the transistor 108. A resistor 110 and biasing diode 111 shunt the condenser 109, and a lead 112 connects the emitter of the transistor 108 to the positive side of the diode 111 and to the resistor 110.

A biasing resistor 113 is connected between the transistor base and a selector switch 114. In the position shown, conductive engagement is established to a slider 115 similar to the slider 90 of the previous form. The slider 115 engages a resistor 116 that is connected between the ground lead 117 and a B— terminal.

In the position of switch 114 illustrated, the operation of the circuit is similar to that of the form shown in FIG. 8. Thus, the transistor 108 is reverse biased but by an amount limited by the diode 111. The condenser 109, in the present example, is normally charged to a voltage corresponding to the drop across the diode 111 and resistor 110. Thus a conduction path exists from the terminal B+ through the resistor 110, diode 111, resistor 113, to the B— terminal via selector switch 114, slider 115 and a section of the resistor 116.

The resistor 110 has an ohmic value small in comparison to that of the resistor 113. The emitter of the transistor 108 is thus slightly more positive than the base, and both are at a potential nearly approaching that of the terminal B+.

When the key 99 is depressed, the voltage at the emitter is substantially reduced, namely, to the potential of the ground lead 103. Accordingly, base current flows and the transistor 108 is switched on. Current also flows from the now grounded lead 112 via diode 111 and resistor 113 to the B— terminal until the voltage of the base returns to a cut-off value.

In order to restore the circuit for normal tibia or other operation of the generator 98, the selector switch 114 is moved from the position illustrated to a position in which the resistor 113 and corresponding resistors are permanently connected to the B+ terminal. This means that whenever the key 99 and corresponding keys are depressed, a continuous supply of base current is provided. Accordingly, the generator 98 continues to sound as long as the key 99 is depressed and corresponding to normal

organ type operation. A single selector switch 114 is all that is required.

The diode 107 ensures that, when the transistor 108 is turned off, current to recharge the condenser 105 flows through the generator 98. Thus a current path would otherwise exist from the B+ terminal to the resistor 110, diode 111, the base and the collector of the transistor 108 to resistor 104. The condenser 105 would thus immediately recharge without flow of current through the generator 98, and a damping effect would be achieved.

However, in some circumstances, it may be desirable selectively to add the damping feature. Such a circuit is illustrated in FIG. 10. In this circuit, a resistor 118 is shown that provides a path independent of the generator 119 for recharging the condenser 120 as switching transistor 121 turns off. The shunting path may be traced as follows: B+ terminal, a supplemental supply to a B++ terminal, a selector switch 122, resistor 118, a diode 123, to the terminal 124 on the negative (—) side of generator 119. This damping circuit is intended to shunt the generator 119 only when a key switch 126 is released so that a normal decay pattern results when the key is kept depressed. In order to disable this shunting circuit only when the key switch 126 is closed, a shunting circuit is provided. The shunting circuit is provided by a diode 127 having its cathode connected to the side of the key switch 126 remote from the ground lead 128. The anode of the diode 127 is connected to the side of the damping resistor 118 remote from the source. When the key switch 126 closes, the terminal 129 is pulled to ground and the current that might otherwise recharge the condenser 120 via damping resistor 118 is now shunted directly to ground. Thus the condenser 120 can not recharge through resistor 118. The damper 118, during closure of the switch 126, is ineffective.

The diode 123 ensures that the switching transistor is not shunted when the key switch 126 is closed.

In summary, if the key 126 is maintained in a depressed condition, the transistor 121 conducts for a period depending upon the input circuit of the transistor and the operation is as described in the previous form. However, when the key switch 126 is released, current through the damping resistor 118 now passes through the diode 123 paralleling the generator 119, quickly to recharge the condenser 120. The signal produced by the generator 120 very rapidly decays. Most unusual interpretative effects can be added by the simplified damper circuit illustrated.

All of the damper circuits can be rendered ineffective simply by opening the selector switch 122.

The supplemental supply B++ compensates for the drop across the diode 123, thereby ensuring that the condenser 120 approaches at least the potential of the terminal B+ on its recharge cycle. If the switch 122 were directly connected to the B+ terminal instead, the effective voltage of the damping circuit would be reduced, especially near the terminal portion of the recharge cycle.

The circuit shown in FIG. 10 provides a most versatile operation utilizing existing key switches.

In the form of the invention illustrated in FIG. 11, a tone generator 131 is driven by charge accumulated on a condenser 132. The generator 131 directly parallels the condenser 131 to form a discharge circuit therefor.

Charge for the condenser 132 is transferred to it by the aid of a storage condenser 133. The storage condenser 133 in turn is charged from a suitable source. One terminal 134 of the condenser 133 connects to a B+ terminal via a charging resistor 135. The other terminal 136 of the condenser 133 is connected to a ground lead 137 through a reverse blocking diode 138. This charging circuit is a fast one since resistor 135 is of small ohmic value.

One side of the operating condenser 132 at terminal 139 is connected to the ground lead 137, and the other

side at terminal 140 is connected through a blocking diode 141 to the condenser terminal 136 and blocking diode 138 to ground lead 137. Normally the storage condenser 133 is charged and the operating condenser discharged.

A key switch 142 has one side connected to the condenser terminal 134 and the other side connected to the ground lead 137. When the key switch 142 is closed, the condenser 133 instantly transfers a portion of its charge to the operating condenser 132. The condenser 132 then discharges through the generator 131 and the generator is operated.

At the moment after key switch closure, the generator 131 forms a discharge path for the condenser 133 as well as for the condenser 132. But the condenser 133 has an additional discharge path that is not provided for the condenser 132. This is provided by a resistor 143 that is connected across the diode 138. The other diode 141 makes it impossible for the operating condenser 132 to discharge through the resistor 143, but does not affect the storage condenser 133.

Since the condenser 133 has an additional discharge path, its voltage drops more quickly than the voltage on the condenser 132. This means that the cathode side of the blocking diode 141 is less negative, that is, more positive, than its anode side. Thus the blocking diode 141 isolates the circuit that includes the generator 131 and the operating condenser 132 almost immediately after charge is transferred to the condenser 132. Accordingly, the decay characteristic of the generator 131 is unaffected by movement of the switch 142 away from closed position. Thus when the switch 142 moves away from closed position and assuming that the operating condenser 132 has not yet fully discharged, then the anode side of the blocking diode 141 remains more negative than the cathode side, and decay continues uninterrupted.

The diode 138 shunts the resistor 143 in order to ensure a rapid recharge of the condenser 133 for subsequent operation.

The form of the invention illustrated in FIG. 12 is generally similar to that illustrated in FIG. 1. A generator 144, a switching device 145 and blocking diode 146 are provided in the same arrangement as the generator 10, switching device 14 and blocking diode 19 in the form shown in FIG. 1. However, a normally closed key switch 147 rather than the normally open switch is utilized for applying a switching voltage at the terminal 148.

A condenser 149, corresponding to the condenser 16, has one side connected to the cathode terminal 148. The switch 147 is interposed between a terminal 150 on the other side of the condenser 149 and a terminal 151 that is directly connected to the source B+. A small resistor 152 is connected between the terminal 150 and the ground lead 153.

When the switch 147 is in its normally closed position, the terminal 150 is at the positive potential of the source. But when the key switch 147 is opened, the terminal 150 now assumes the potential of the ground lead 153 via the small resistor 152. Accordingly, the cathode terminal 148 is transiently pulled to a negative value and conduction through the switching device is established.

Continuance of conduction through the switching device 145 depends, of course, upon a current and hence is virtually independent of subsequent closure of the normally open switch 147. The operation parallels that of FIG. 1.

The circuit illustrated in FIG. 13 is similar to that illustrated in FIG. 8. A source terminal 154, generating device 155, transistor 156 and ground lead 157 are provided in the same arrangement as the source terminal 83, generating device 81, transistor 79 and ground lead 82 of the form illustrated in FIG. 8. A switching condenser 158, diode 159 and biasing resistor 160 are provided for the base or input circuit of the transistor 156 in the same re-

lationship that the condenser 94, diode 93, and biasing resistor 89 are provided in the form of FIG. 8.

A normally closed key switch 161, in place of the resistor 97 of the form shown in FIG. 8, normally places the condenser terminal 162 remote from the transistor base 163 at the potential of the ground lead 157. When the switch 161 is opened, a small resistor 164 is effective to communicate to the terminal 162 the potential of the source via terminal 154. The source potential is transiently applied to base 163, pending acquisition of charge by condenser 158. Operation accordingly parallels that of FIG. 8, but with a slightly different attack characteristic due to the presence of the resistor 164 in the condenser circuit.

A very small resistor 165 is serially associated with the switch 161. This resistor 165 protects the diode 159 from passing excessive current at the instant of reclosure of the switch 161.

In the form of the invention illustrated in FIG. 14, a reiteration effect is achieved by a circuit similar in some respects to that illustrated in FIG. 6. A generating device 166 has one side connected to a source terminal 167 that is positive relative to a ground lead 168. The source potential 167 is illustrated as being a battery 169, one side of which provides the B+ terminal 167. The other side of the battery 169 provides a terminal 170 connected to the ground lead 168.

The generating device 166 has its circuit completed via a blocking diode 171 and a four-layer diode or other suitable or comparable switching device 172. Thus the energization circuit for the generating device 166 may be traced from the terminal 167, generating device 168, a terminal 173, blocking diode 171, an anode terminal 174 for the switching device 172, switching device 172 to a cathode terminal 175 at the ground lead 168.

The potential of the battery 169 is inadequate to cause the switching device 172 to turn on. In order to turn it on, a supplementary supply, illustrated as a battery 176, is provided. One side of the battery connects to the B+ terminal 167, and the other side of the battery provides a terminal 177, the potential of which relative to ground lead 168 is adequate to cause firing of the switching device 172.

The voltage of the terminal 177 is communicated to the anode terminal 174 via a normally open key switch 178 and a small condenser 179. The condenser 179 is paralleled by a discharge resistor 180. When the key switch 178 is closed, the anode terminal 174 is immediately brought to the potential of the terminal 177, the condenser 179 being normally discharged. Conduction occurs and the circuit for generator 166 is completed. The blocking diode 171 makes it possible for the anode terminal 174 to acquire a potential greater than that of the source terminal 167. Also completed is a circuit for the large condenser 181 that corresponds to the condenser 141 of the form illustrated in FIG. 6. The condenser 181, as in forms previously described, supplements the current through the generating device 166 to maintain the switching device 172 on. A resistor 182 determines the time constant of the circuit for the condenser 181.

As the current to the condenser 181 passes through the switching device 172, the switching condenser 179 comes up to charge, the anode terminal 174 being substantially at the potential of the ground lead 168.

As soon as the current from the condenser 181 is inadequate to maintain conduction, the current through the generator 166 now begins to charge the condenser 181, and the tone decays. Since the anode terminal 174 is no longer at ground potential, the switching condenser 179 discharges through the resistor 180. But if the key switch 178 is held in its closed position, the condenser 179, as soon as it reaches an adequate condition of discharge, will again communicate the potential of the terminal 177 to the anode terminal 174, and the switching device 172 will again operate. A reiteration effect accordingly is achieved

and at a rate corresponding to the time constants determined by the resistors 180 and 182.

The reiteration effect is not superimposed upon the entire output of the organ but, instead, is produced individually for each generating device 166. Thus, each note begins to reiterate as it is sounded and at a rate that might differ slightly from that of other generators. A chorus-type effect characteristic of pipe organs is thus produced.

The inventor claims:

1. In an electrical musical instrument: an electrically operated generating device that produces a signal corresponding to a musical tone with an intensity related directly to the intensity of electrical energization; a two state key switch; means initiated only upon movement of the switch from one state to its other state for energizing said generating device; and circuits means determining a transient period of energization of said generating device from a time immediately following movement of the switch to its other state; said circuit means determining said transient period independently of the said switch remaining in its said other state.

2. In an electrical musical instrument: an electrically operated generating device that produces a signal corresponding to a musical tone with an intensity directly related to the intensity of electrical energization; a normally open switching device for completing an energization circuit for the generating device; a two state key switch; and circuit means initiated only upon movement of said key switch from one state to its other state for transiently operating said switching device, and reconditioned for subsequent operation by movement of said key switch back to its said one state.

3. The combination as set forth in claim 2, in which said switching device closes upon the application of a critical voltage thereto, and opens when the current therethrough is less than a critical value; said circuit means including means for generating a pulse of electrical energy for closing said switching device; the current through said generating device being inadequate to maintain said switching device on; and means for storing electrical energy when said switching device is open for discharge through said switching device when closed for transiently supplementing the generating device current for holding the switching device on for a period of time.

4. The combination as set forth in claim 3 in which said energy storing means has a charging circuit that includes said generating device.

5. The combination as set forth in claim 2 together with: means providing a source of voltage for operating said generating device in series with said switching device; said switching device requiring for closure, the application of a voltage greater than that of the said voltage source means, and requiring for continued closure the existence of a predetermined holding current that is greater than that provided by said voltage source means; said circuit means including a condenser connected at one end to a source of voltage greater than that of said voltage source means, and at the other to said switching device in dependence upon said key switch; and transient circuit means for providing sustaining current through said switching device upon closure of said switching device.

6. The combination as set forth in claim 2 together with: terminals cooperable with a source of voltage for operating said generating device in series with said switching device; said devices being connected in series across said terminals; said switching device requiring for closure, the application of a voltage greater than that of the said voltage source, and requiring for continued closure, the existence of a predetermined holding current that is greater than that provided by said voltage source; said circuit means including a blocking diode connected between one of the devices and its corresponding terminal, said circuit means further including a condenser having one side connected between said blocking

diode and the said one of the said devices, the other side of said condenser being connected to said key switch for suddenly subjecting said condenser to a voltage adequate to close said switching device.

7. The combination as set forth in claim 2, in which said switching device is a transistor having an emitter, collector and base; said circuit means normally biasing the transistor to cutoff, said circuit means including a series RC circuit between the base and emitter, the condenser thereof having one side connected to the base, the other side of the condenser being connected to the key switch for suddenly subjecting said condenser to a voltage adequate transiently to saturate said transistor.

8. The combination as set forth in claim 7 together with means for adjusting the biasing means for determining the on-time of the transistor.

9. The combination as set forth in claim 2 in which said switching device closes upon the application of a critical voltage thereto, and opens when the current therethrough is less than a critical value; said circuit means comprising a transient control circuit which includes said two state key switch for momentarily providing the requisite voltage for closing of said switching device when the key switch is in its said other state, said transient control circuit including elements for resetting upon opening of said switching device whereby a reiteration effect is achieved upon maintaining said key switch in its said other state.

10. The combination as set forth in claim 9 in which the current through the generating device is inadequate to hold the switching device closed, together with means for storing electrical energy when the switching device is open for discharge through said switching device when closed for transiently supplementing the generating device current for holding the switching device on for a period of time.

11. In an electrical musical instrument: an electrically operated generating device that produces a signal corresponding to a musical tone with an intensity directly related to the intensity of electrical energization; a normally open switching device for completing an energization circuit for the generating device; a two state key switch; circuit means initiated only upon movement of said key switch from one state to its other state for transiently operating said switching device, and reconditioned for subsequent operation by movement of said key switch back to its said one state; and means storing and discharging electrical energy in accordance with the state of said switching device, said energy storing means having a circuit that includes said generating device when the switching device is open for sustaining the operation of said generating device.

12. In an electrical musical instrument: an electrically operated generating device that produces a signal corresponding to a musical tone with an intensity directly related to the intensity of electrical energization; a normally open switching device for completing an energization circuit for the generating device; a two state key switch; circuit means initiated only upon movement of said key switch from one state to its other state for transiently operating said switching device, and reconditioned for subsequent operation by movement of said key switch back to its said one state; means storing and discharging electrical energy in accordance with the state of said switching device, said energy storing means having a circuit that includes said generating device when the switching device is open for sustaining the operation of said generating device; and means operable upon movement of the key switch back to its said one state for providing an alternate circuit for said energy storing means independent of said generating device.

13. In an electrical musical instrument: an electrically operated generating device that produces a signal corresponding to a musical tone with an intensity directly re-

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lated to the intensity of electrical energization; a normally open switching device for completing an energization circuit for the generating device; said switching device being controlled by an input current; a two state key switch; and means for generating a pulse of current for closing said switching device for an interval of time, and upon movement of said key switch from one state to its other state.

14. In an electrical musical instrument: an electrically operated generating device that produces a signal corresponding to a musical tone with an intensity directly related to the intensity of electrical energization; a normally open switching device for completing an energization circuit for the generating device; said switching device being controlled by an input current; a two state key switch; means for generating a pulse of current for closing said switching device for an interval of time, and upon movement of said key switch from one state to its other state; and adjustable biasing means for determining the dwell period of the current pulse.

15. In an electrical musical instrument: a set of electrically operated generating devices each producing signals corresponding to musical tones with an intensity directly related to the intensity of electrical energization; a two state key switch for each generating device; a switching device for each generating device for completing an energization circuit therefor; each switching device being controlled by an input current; pulse generating means for each switching device for closing the corresponding switching device for an interval of time and upon movement of the corresponding key switch from one state to its other state; and adjustable biasing means common to all of the switching devices for determining the dwell period of the operating pulses.

16. The combination as set forth in claim 15 together with a transient circuit for each generating device operated by the corresponding switching device for sustaining the operation of the corresponding generating device after the switching device opens; and adjustable means common to all of said transient circuits for determining the decay rate of sustained operation.

17. In an electrical musical instrument: a set of electrically operated generating devices each producing signals corresponding to musical tones with an intensity directly related to the intensity of electrical energization; a two state key switch for each generating device; a switching device for each generating device for completing an energization circuit therefor; each switching device being controlled by an input current; pulse generating means for each switching device for closing the corresponding switching device for an interval of time and upon movement of the corresponding key switch from one state to its other state; means for producing for each switching device, control current when the corresponding key switch is in its said other state; and a selector switch common to all of the generating devices for determining operation of said control current producing means or said pulse generating means.

18. In an electrical musical instrument: a set of electrically operated generating devices each producing signals corresponding to musical tones with an intensity directly related to the intensity of electrical energization; a two state key switch for each generating device; a switching device for each generating device for completing an energization circuit therefor; each switching device being controlled by an input current; pulse generating means for each switching device for closing the corresponding switching device for an interval of time and upon movement of the corresponding key switch from one state to its other state; adjustable biasing means common to all of the switching devices for determining the dwell period of the operating pulses; and selectively operable means for switching said biasing means to an alternate source whereby the switching devices remain operative when the corresponding key switches are in their said other states.

19. In an electrical musical instrument: an electrically

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operated generating device that produces a signal corresponding to a musical tone with an intensity directly related to the intensity of electrical energization; a normally open switching device for completing an energization circuit for the generating device; said switching device being a transistor having a base, a collector terminal and an emitter terminal; said terminals being serially arranged with said generating device; a condenser having one side connected to the base; a circuit for the condenser determining a normal voltage thereof; a two state key switch having a first position and movable to another position for abruptly altering the voltage on one side of the condenser whereby a pulse is applied to the base for turning the transistor on; return of said switch to its first position for reconditioning the condenser for subsequent pulse production.

20. In an electrical musical instrument: an electrically operated generating device that produces a signal corresponding to a musical tone with an intensity directly related to the intensity of electrical energization; a normally open switching device for completing an energization circuit for the generating device; said switching device being a transistor having an emitter, collector and base; a diode between the emitter and base for normally biasing the transistor to cutoff; a series RC circuit between the base and emitter, the condenser having one side connected to the base; and a normally open key switch serially associated with the emitter for connecting the emitter to a voltage source adequate to saturate the transistor by passage of charge stored in the condenser through the base and emitter.

21. The combination as set forth in claim 20 together with a transient circuit for sustaining the current through the generating device when the power circuit therefor is interrupted.

22. The combination as set forth in claim 20 together with a transient circuit for sustaining the current through the generating device when the power circuit therefor is interrupted; a shunt circuit for the generating device operable upon movement of said key switch away from closed position.

23. The combination as set forth in claim 20 together with a transient circuit for sustaining the current through the generating device when the power circuit therefor is interrupted; a shunt circuit for the generating device operable upon movement of said key switch away from closed position, said shunt circuit including an impedance element and a first diode permitting flow of current for shunting purposes, there being a second diode between the key switch and the first diode for reverse biasing the first diode only when the key switch is closed.

24. In an electrical musical instrument: an electrically operated generating device that produces a signal corresponding to a musical tone with an intensity directly related to the intensity of electrical energization; a normally open switching device for completing an energization circuit for the generating device; said switching device being a transistor having an emitter, collector and base; a diode between the emitter and base for normally biasing the transistor to cutoff; a series RC circuit between the base and emitter, the condenser having one side connected to the base; a normally open key switch serially associated with the emitter for connecting the emitter to a voltage source adequate to saturate the transistor by passage of charge stored in the condenser through the base and emitter; and adjustable reverse biasing means for absorbing the pulse produced upon closure of said key switch for altering the on-time of the transistor.

25. In an electrical musical instrument: an electrically operated generating device that produces a signal corresponding to a musical tone with an intensity directly related to the intensity of electrical energization; a normally open switching device for completing an energization circuit for the generating device; a two state key switch; a first transient circuit operated by movement of the key

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switch from one state to its other state for closing said switching device only during a transient period; a second transient circuit for sustaining current through the generating device after opening of the switching device; a shunt circuit paralleling the generating device for bypassing the sustaining current; and means for rendering the shunt circuit ineffective until the key switch is opened.

26. In an electrical musical instrument: an electrically operated generating device that produces a signal corresponding to a musical tone with an intensity directly related to the intensity of electrical energization; a normally open switching device for completing an energization circuit for the generating device; a transient circuit for sustaining current through the generating device after opening of the switching device; a shunt circuit paralleling the generating device for bypassing the sustaining current comprising a diode and a resistor; and a circuit operable upon closure of the switching device for reverse biasing the diode.

27. In an electrical musical instrument: an electrically operated generating device that produces a signal corresponding to a musical tone with an intensity directly related to the intensity of electrical energization; a normally open switching device for completing an energization circuit for the generating device; a transient circuit for sustaining current through the generating device after opening of the switching device; a shunt circuit paralleling the generating device for bypassing the sustaining current comprising a diode, a voltage source for counterbalancing the diode drop, and a resistor; and a circuit operable upon closure of the switching device for reverse biasing the diode.

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28. In an electrical musical instrument: an electrically operated generating device that produces a signal corresponding to a musical tone with an intensity directly related to the intensity of electrical energization; a normally open switching device for completing an energization circuit for the generating device; said switching device requiring an energy condition for turning it on; a generator for providing the energy condition for said switching device; and a key switch having two states for operating the generator only in response to movement of said key switch from one state to its other state.

29. In an electrical musical instrument: an electrically operated generating device that produces a signal corresponding to a musical tone with an intensity directly related to the intensity of electrical energization; a normally open switching device for completing an energization circuit for the generating device; said switching device requiring an energy condition for turning it on; a generator for providing the energy condition for said switching device; and a normally open key switch for operating the generator only in response to movement of said key switch from open position to closed position.

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