Feb. 9, 1960 R. H. PETERSON 2,924,137

ELECTRONIC MUSICAL INSTRUMENT

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Fig. 1.

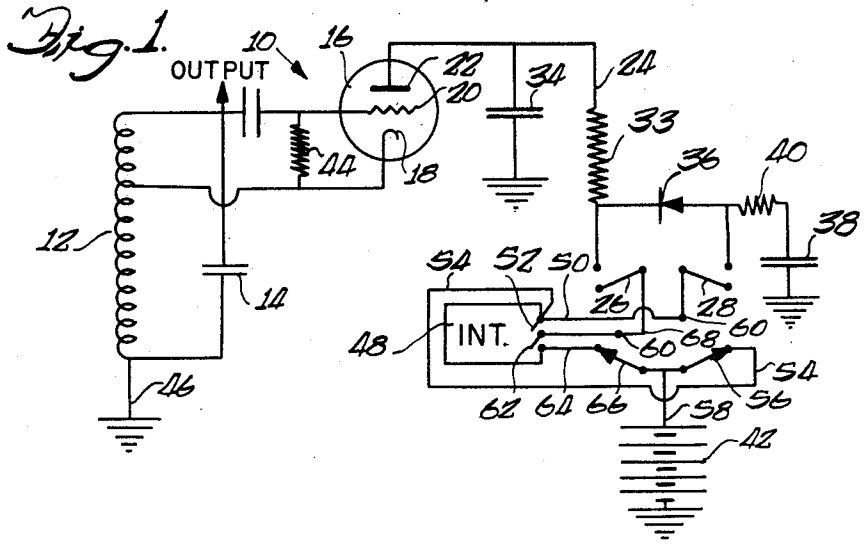
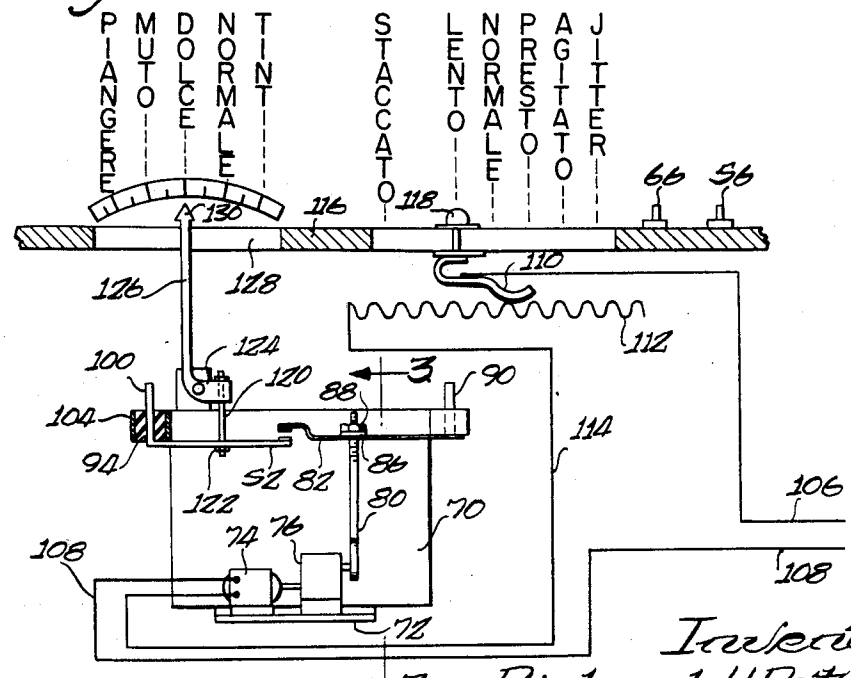


Fig. 2.



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Fig. 3.

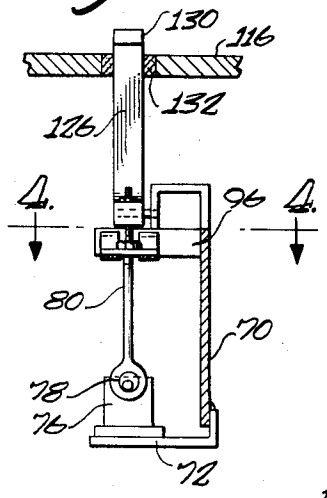


Fig. 4.

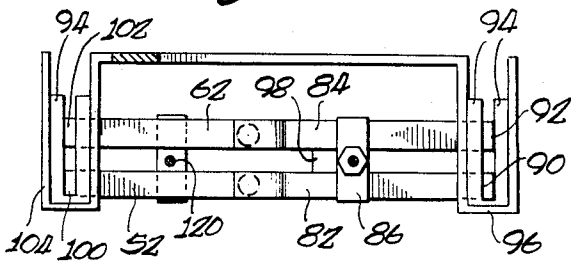


Fig. 5.

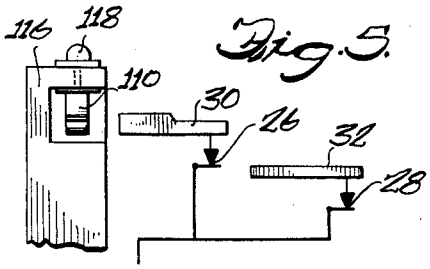
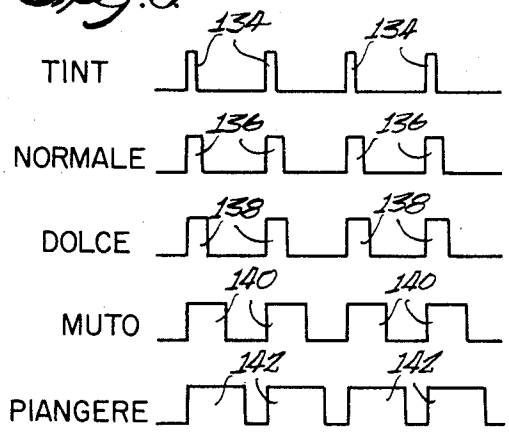


Fig. 6.



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Fig. 7.

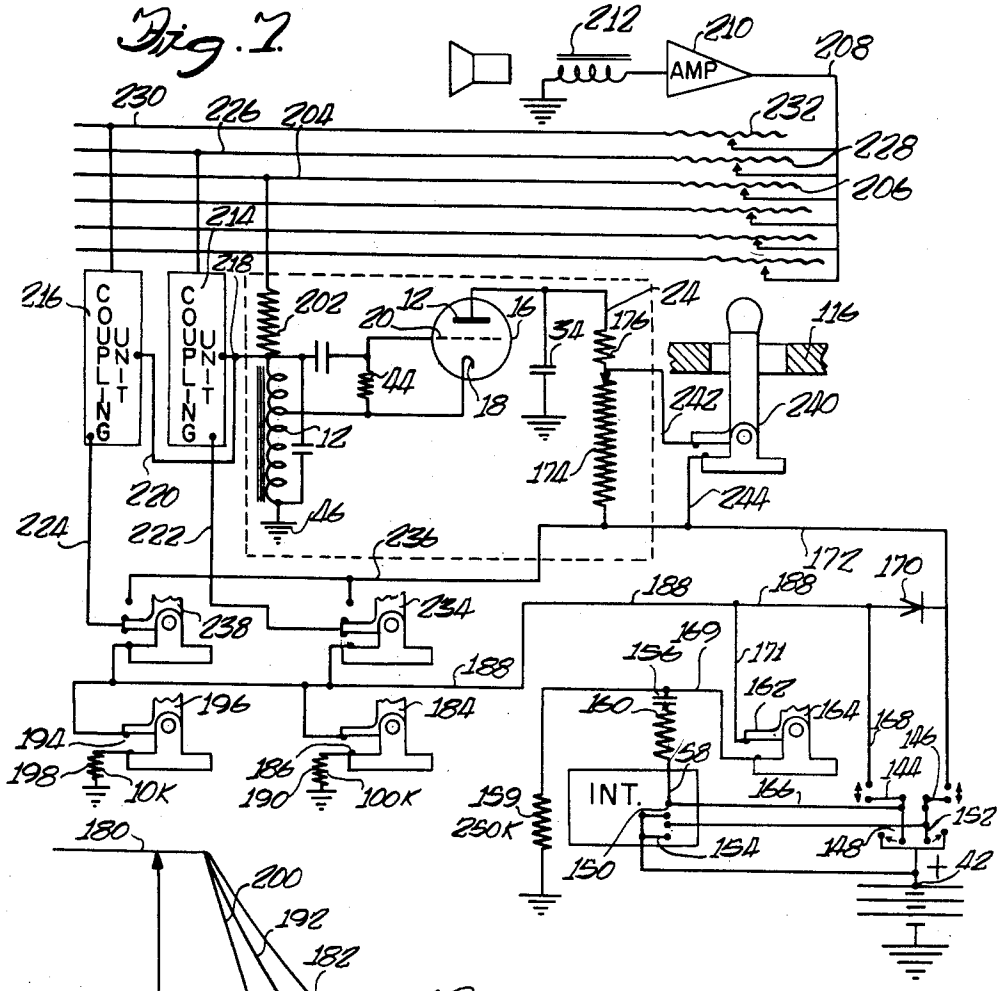
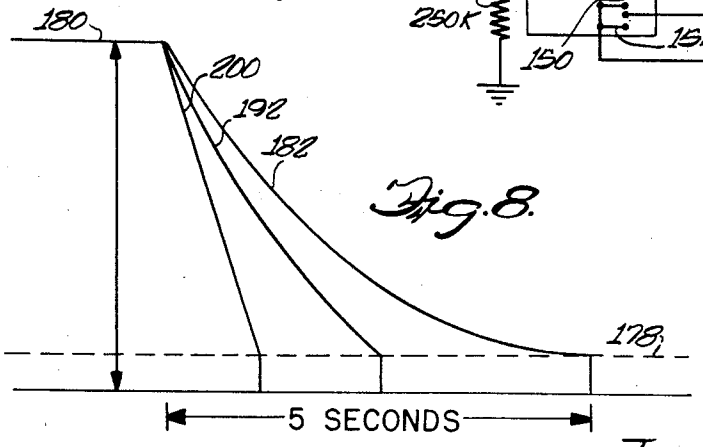


Fig. 8.



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United States Patent Office 2,924,137 Patented Feb. 9, 1960

2,924,137

ELECTRONIC MUSICAL INSTRUMENT

Richard H. Peterson, Oaklawn, Ill.

Application February 20, 1956, Serial No. 566,446

8 Claims. (Cl. 84—1.26)

This application is a continuation in part of my co-pending application Serial Number 503,104, filed April 22, 1955, and relates to a modification for securing percussion and multiple percussion effects according to the basic principles of said original application.

In the accompanying drawings:

Figure 1 is a schematic wiring diagram of a tone-producing unit according to the invention;

Figure 2 is a front elevation of an interrupter;

Figure 3 is a sectional view of the interrupter of Figure 2 on line 3—3 of Figures 2 and 4;

Figure 4 is a plan view of the interrupter, as on line 4—4 of Figures 2 and 3;

Figure 5 is a partial wiring diagram indicating the relation of the novel modification to the conventional keyboards;

Figure 6 is a diagram indicating the nature of the time sequences secured with different adjustment of the timer;

Figure 7 is a schematic wiring diagram indicating equipment for obtaining a wider variety of effects; and

Figure 8 is a diagram indicating the nature of the time sequences of decay obtainable with an instrument according to Figure 7.

Referring first to Figure 1, I have illustrated a conventional Hartley oscillator **10** having a tuned circuit, of highly constant frequency, including the inductance **12** and capacitor **14**. The activating triode is illustrated as a tube **16** with a cathode **18**, grid **20**, and plate **22**. During playing of the instrument, the cathode **18** is kept continuously operative by conventional heating means. There is one such oscillator for each pitch to be produced by the instrument, and each oscillator has its plate operatively connected with an individual D.C. conductor **24** adapted to receive potential from a conventional source **42** through switches **26** and **28** controlled by keys **30** and **32** (see Figure 3) manipulated by the fingers of the player, to start and stop the tone delivery.

The switch **26** activates the conductor **24** directly, through the resistor **33**. The capacitor **34** combines with the resistor **33** to constitute an R-C time delay circuit which controls the timing of the inception, or "attack," of the tone produced. The switch **28** activates the same conductor **24** through the same protective resistor **33**, but only through the rectifier **36**. When the circuit through switch **28** and rectifier **36** is employed, the capacitor **38** and its resistor **40** constitute an additional energy storage means, but the tube does not get its energy through the resistor **40**, and therefore, the attack will remain unchanged so long as the energy source at **42** is of ample capacity.

When the note is played with the key **26**, and the key is subsequently opened, the energy stored in capacitor **34** has to discharge through the tube **16** and part of the inductance **12**, to ground at **46**. This discharge determines the decay of the tone when the switch **26** is opened. However, if the tone was sounded with switch **28**, or if switch **28** was closed while the tone was being sounded with switch **26**, the much larger energy stored in capacitor **38** will also have to discharge through the same path, and the decay of the note will be correspondingly prolonged.

When the switches **26** and **28** receive energy direct from the source **42**, playing the instrument as above outlined with key **32** and switch **28** will cause it to simulate a bell, or a piano with the sustaining pedal held down, but playing it with key **30** and switch **26** will give the relatively abrupt decay characteristic of a piano with the sustaining pedal left up.

I have provided additional means for automatic repeated interruption of the D.C. activating circuit to enable the operator to simulate the music produced with a xylophone, banjo, mandolin, or the like.

As illustrated, the interrupter **48** is connected so that the operator can interpolate it between the source **42** and either or both of the switches **26** and **28**. For this purpose the switch **28** is connected through conductor **50** and contact **52** of the interrupter, and then through conductor **54** to the interrupter switch **56**, and through conductor **58** back to the source **42**. In Figure 1, switch **56** is shown in a position to render the interrupter operative. By turning the switch counterclockwise to engage the contact **60**, the interrupter is taken out of the circuit and a direct connection established to switch **28**.

Similarly, switch **26** is connected through conductor **60** to contact **62** of the interrupter, and from the interrupter through conductor **64** to switch **66**, and through the same conductor **58** to the source **42**. Switch **66** is also shown in position to render the interrupter operative, but rotation of the switch in a clockwise direction to engage contact **60** will take the interrupter out of the circuit and establish a direct D.C. connection to switch **26**.

It will be obvious that the interrupter can be either electronic or mechanical. In Figures 2, 3, and 4 I have illustrated a mechanical interrupter. The supporting panel **70** has a bottom shelf **72** supporting a miniature motor **74** connected through a speed reducer **76** to the eccentric **78**. The pitman **80** rises between the relatively movable contact arm **82** co-operating with the contact **52**, and contact arm **84** co-operating with the contact **62**. The cross-piece **86** overlies both contact arms **82** and **84**, and the connection may be adjusted by means of the adjusting nut **88**.

The contact arms **82** and **84** are resilient and terminate in upwardly directed extensions **90** and **92** clamped between insulating blocks **94** set in a U-shaped metal holder **96**, which may be integral with the panel **70**. An insulating spacer block **98** braces the arms **82** and **84**, and keeps them in good alignment. The contact arms **52** and **62** are also flexible but materially less so than the arms **82** and **84**. They terminate in upwardly directed extensions **100** and **102** clamped between insulating blocks **94** in the U-shaped receiver **104** at the upper left corner of the panel **70**. It will be obvious that, with the parts properly adjusted, actuation of the motor **74** will raise and lower the arms **82** and **84**, and open and close the effective connection between the source **42** and the switches **26** and **28**, with the frequency depending on the speed of the motor and the time cycle depending on the adjustment of the parts. But this will make no music except when the operator closes the switch **26** or the switch **28** to continue the connection through to the tone-generating unit.

Means are provided for varying both the speed of the motor **74** and the nature of the contact cycle. From one power line the circuit is through switch contact **110** (see Figure 2), a portion of control resistor **112**, conductor **114**, and the motor **74** to the other line **108**. The switch **110** may be slidably mounted on the shelf **116** where the operator can slide it back and forth to vary the speed of the motor. Conveniently, switches **56** and

66 may be mounted on the same shelf close beside the adjusting button 118 for the switch 110.

To vary the portion of the cycle during which the contacts 52 and 62 will remain closed, I provide a tension riser 120 carrying a cross-piece 122 underlying the contacts 52 and 62. The upper end of the riser 120 is connected to the short arm 124 of a bell crank lever having a long arm 126. The long arm 126 extends upward through a slot 128 in the shelf 116 and carries a pointer 130. The arm 126 and pointer 130 may be frictionally held in adjusted position by suitable means such as felting 132 having a light friction engagement with the arm 126.

It will be apparent that raising and lowering the riser 120 will increase or decrease that portion of the time cycle represented by one revolution of the eccentric 78, during which the circuit will be closed. For convenience in discussing the acoustics involved, Figure 6 indicates five different conditions of adjustment for the contacts 52 and 62. The lowest position of the contacts will produce the uppermost curve of Figure 6, indicating very short closure periods at 134 amounting to about one-twelveth of the total time cycle. This condition is identifiable by the indicia "Tint." The next condition of adjustment is identifiable as "Normale." In this condition the contact periods 136 are about one-eighth of the total time cycle. Similarly, the next adjustment identifiable as "Dolce" has longer contact periods 138; the next condition "Muto" has longer contact periods 140 amounting to almost one-half the time cycle, and the last condition identifiable as "Piangere" has contact periods 142 amounting to more than one-half the cycle.

With the attack of the tone generator adjusted so that it will build up to full intensity during the time interval represented by the contact period 136, that condition of adjustment will generate the normal tone quality for which the generating unit is designed. This may be any of the tone qualities identified in U.S. Patent 2,649,006, issued August 18, 1953, or such other acoustical tone qualities as may be desired.

During the attack period of such a tone-generating unit the higher frequency overtones appear more quickly than the fundamental frequency, and if it takes the unit the entirety of time interval 136 to build its fundamental to full intensity, the much shorter time interval 134 will build the overtones to full intensity and come to an end before the fundamental has risen to more than about one-half its normal relative intensity. This will produce the tinny or tintinnabulating quality characteristic of a mandolin or similar instrument when the plectrum is shifted close to the bridge, commonly only about one-half as far from the bridge as the normal position.

It is well known that shifting the plectrum abnormally away from the bridge is also possible, even to a position substantially in the middle of the free length of the vibrating string, although the extreme central position requires great delicacy of touch for effectiveness. Such shifting away from the bridge materially reduces the higher overtones in playing such an instrument with a plectrum. The time interval 138 is long enough to build the fundamental to full intensity and hold it there for some time, and will produce a softer tone quality closely resembling the softer tone quality produced by striking with the plectrum at a point abnormally far from the bridge.

Similarly, the time interval identified as "Muto" will bear a resemblance to that relatively difficult plectrum manipulation which involves striking substantially at the middle of the free length of the string.

The acoustical quality identified as "Piangere" probably can not be produced with a plectrum on an instrument of the mandolin type, but with the electronic instrument adjusted to the right intensity it can provide an imitation of a feeble voice choked with sorrowful emotion.

The speed of the eccentric 78 may correspond with the frequency of plucking with an ordinary plectrum. I prefer to provide an adjustment at the extremely slow end, slow enough to permit a skillful and experienced player to manipulate the keys 30 or 32 in synchronism with the rotations of the eccentric 78, and perform staccato runs or arpeggios with just one impact for each note, but this will be an exceptional and unusual use of the instrument. The common use will be with the adjustment labeled "Normale" corresponding to the common trill frequency in mandolin play. This frequency can be reduced about twenty-five percent or increased about fifty percent by the player at will, corresponding to the positions identified as "Lento," "Presto," and "Agitato." The final condition identified as "Jitter" may be a frequency that is probably higher than the human hand can achieve with an ordinary plectrum and will be used for effects that will be bizarre, if not perhaps better called "crazy." It is possible to adjust the inertia of the moving parts of the mechanical interrupter so that when the motor is operating at "Jitter" speed, their own inertia will give them an erratic jumping action in addition to the normal movement corresponding to the position of the eccentric 78. The cracked quaver of a senile voice can be closely approximated in this way.

In the embodiment of Figure 7 the same prolonged decay is obtained by the charging of the large capacitor, rather than the discharging. This is advantageous when the large capacitor is an electrolytic capacitor because the capacitor can remain normally charged. The key switches 144 may be associated with keys 30, and the key switches 146 with keys 32. When reiterating is desired, switch 148 is left open, and keys 30 will deliver interrupted activating D.C. voltage through the contacts 150 of the interrupter. If reiteration is desired from keys 32, switch 152 is left open, and contacts 154 in the interrupter will deliver reiterated potential to switches 146.

The percussion effect is available only on keys 30, which actuate switches 144. The large capacitor 156 is electrolytic, and is normally in a charged condition because of potential from source 42 coming constantly through switch 148 or frequently through contacts 150. In either instance, the current comes through conductor 158 and resistor 160 to one terminal of the capacitor 156. The other terminal is returned to ground through resistor 159.

When the key switch 144 closes, the capacitor 156 is completely discharged through conductor 169, the closed contacts 162 of the percussion cut-out control lever 164, conductors 171, 188 and 168 to switch 144, conductors 166 and 158 back to resistor 160 and capacitor 156. When the switch 144 is subsequently opened, the capacitor 156 must charge again in the circuit consisting of conductors 166 and 158, resistor 160, capacitor 156, conductor 169, contacts 162, conductors 171 and 188, rectifier 170, conductor 172, resistors 174 and 176, conductor 24, tube 16, and inductance 12 to ground at 46. Resistors 174, 176, tube 16 and inductance 12 are in parallel with resistor 159 during this charging, but resistor 159 has much higher resistance than the other branch of the circuit. This provides a continued supply of energy to keep the tube active and the generating unit oscillating for a length of time dependent on the capacity of the capacitor 156.

Referring to the diagram of Figure 8, I have indicated time on the horizontal axis with a maximum decay period of five seconds. The dotted line 178 indicates the relatively low potential at which the tube 16 will break down and the circuit will stop oscillating. The sustained volume of sound is indicated by the horizontal line 180, and when the circuit is manipulated as last described, the long deeply curved line 182 represents a close approximation to the rate at which the volume of sound will decrease during the decay period.

Means are provided under the control of the player for causing the decay to take place more rapidly. The

player-controlled adjustment lever **184** may be rotated counterclockwise from the position shown in the drawings to close contacts **186** and connect the negative side of the capacitor **156** to ground through conductor **188**, contacts **186**, and resistor **190**. With the contacts **186** closed, the additional path to ground through resistor **190** increases the rate of charge and decay when the switch **144** is opened, and shortens the decay period. When the player-controlled contacts **186** are closed, the decay will be of the type indicated by full line **192** on Figure 8. The duration of the entire decay period is about cut in half, and the rate of decay during the period is much more nearly constant.

To provide a third and less prolonged decay period, it is only necessary to provide another similar set of contacts **194** (one pair for each tone-generating unit) which can all be closed through player-controlled lever **196** to connect the negative side of capacitor **156** to ground through the resistor **198** having a value less than that of resistor **190**. This will accelerate the decay to some such curve as line **200** in Figure 8, where the total decay period is again approximately cut in half, and the decay is so rapid that the curvature of line **200** is imperceptible.

These differences have their counterparts in the psychology of the listener. With a decay according to curve **182**, the effect may be similar to that of an organ harp or vibra-harp. When the tone decays along line **200**, the effect resembles that of a glockenspiel.

As in the parent application, Serial Number 503,104, filed April 22, 1955, the signal from the oscillator may be transmitted directly through resistor **202** to bus **204**, which collects the signal from all the oscillators that are functioning and delivers it through the volume selector control **206** to the output bus **208**, from which it goes through a conventional amplifier **210** and a conventional loud-speaker **212**. Coupling units **214** and **216** may correspond to those described in detail in the parent application, and may change either the volume or the wave shape of the signal, or both, as desired. They receive the same signal from the oscillator through conductors **218** and **220**, but are inoperative unless they receive activating D.C. potential through conductors **222** and **224** respectively. When couplings **214** are employed, the modified oscillations from all the **214** couplings are assembled by bus bar **226** and transmitted through volume control **228** to the output bus bar **208**. Similarly, when couplings **216** are operative, their output signals are assembled on collecting bus bar **230** and transmitted to delivery bus bar **208** through volume control **232**.

Means are provided for selectively connecting all the couplings **214** or all the couplings **216** either to the switches **146** from which they can receive continuous or reiterated signal, or to the switches **144** from which they can receive signal that is either continuous or reiterated, and either percussion or not depending on the player's adjustment of the stops actuating control levers **164**, **184**, and **196**. I have illustrated a similar multiple contact control lever **234** in neutral position, so that coupling unit **214** does not function. Conductor **222** from coupling unit **214** leads to a double contact on control lever **234**, and it will be obvious that displacement of the control lever clockwise will move the central contact up and connect coupling unit **214** through conductor **236** to conductor **172** controlled by switches **146**. Similarly, counterclockwise displacement of control lever **234** will move the contact down and connect it to wire **188**, so that percussion quality can be given to the signal from coupling unit **214**.

Coupling unit **216** is controlled identically through player-controlled lever **238**. While I have only illustrated two coupling units, it will be obvious that an indefinite number of similar coupling units can be provided in a more complete instrument, by mere addition of the coupling units and duplication of the control levers.

The normal attack, when activating potential is initially delivered, depends on the time constant of capacitor **34** and the resistors **174** and **176**. For certain bizarre effects with an attack that verges on an explosive effect, it is necessary to have a much more abrupt attack. I have illustrated an operator-controlled multiple switch lever **240** projecting upward through the panel **116**, and conductors **242** and **244** arranged to bypass or short circuit resistor **174**, but not resistor **176**. It will be obvious that rotation of the control stop **240** counterclockwise will close this short circuit and give the abrupt attack just mentioned.

Others may readily adapt the invention for use under various conditions of service by employing one or more of the novel features disclosed or equivalents thereof. As at present advised with respect to the apparent scope of my invention, I desire to claim the following subject matter:

1. In an electronic organ, in combination: an audio-frequency oscillator having the frequency of a musical note to be produced; loud speaker means for translating the vibrations of said oscillator into sound waves; said oscillator having a first and a second terminal; a first and a second key switch for delivering energizing voltage to sound said oscillator; a first circuit completed by said first key switch through said first terminal for sounding said oscillator and transferring a predetermined amount of energy other than that delivered to the oscillator; connections operative when energizing voltage is withdrawn by opening said first key switch, for restoring the open-key condition of said first circuit by current through said oscillator to produce a predetermined, relatively short decay period immediately after the voltage is withdrawn; a second circuit completed by said second key switch through said second terminal for sounding said oscillator and transferring a different, larger, predetermined amount of energy other than that delivered to said oscillator; connections operative when energizing voltage is withdrawn by opening said second key switch, for restoring the open-key condition of said second circuit by current through said oscillator to produce a second, relatively long decay period immediately after energizing voltage is withdrawn.

2. A combination according to claim 1 in which each of said energy transfer means includes a capacitor connected to change its condition of charge or discharge in one direction when its key switch is closed and in the opposite direction when voltage is withdrawn.

3. A combination according to claim 2 in which both capacitors are in branch circuits parallel with said oscillator and in charged condition when energizing voltage is present; said branches being in series with said oscillator when said key switches are open, to compel the capacitor charge to pass through said oscillator and energize it temporarily and with progressively decreasing potential.

4. An electronic organ comprising, in combination: a single set of oscillators according to claim 1; there being only one oscillator for each musical pitch within the range of the instrument; two sets of playing keys and key switches; and player-controlled stop switch means for connecting all the keys of either set to the first terminals or to the second terminals of the corresponding oscillators.

5. A combination according to claim 2 in which a diode isolates the capacitor of said second energy-transfer circuit from said oscillator, when energizing voltage is supplied to said first circuit only; whereby energizing of said second circuit causes the capacitors of both the first and the second circuits to experience an energy transfer.

6. An electronic organ comprising, in combination: a series of independently tuned LC oscillators; each oscillator generating signal of predetermined wave shape corresponding to the signal to be translated into sound; there being a separate independent oscillator for each

semi-tone within the range of the instrument; a source of D.C. activating voltage; player controlled key-switch means for delivering D.C. activating voltage to preselected oscillators only as long a the player holds the key down; each oscillator having its own characteristic decay rate in its oscillation when activating voltage is cut off by opening the key switch; ancillary energy transfer means for each oscillator, for rendering any one of a plurality of different amounts of energy available to continue the activating voltage on a decreasing scale after source voltage is cut off by opening the key switch; and quick-adjustable on-and-off stop switch means accesible to the player for selecting the amount of energy to be supplied from said transfer means; said transfer means comprising a capacitance connected to experience an energy transfer in one direction when a key switch is closed, and in the other direction when a key switch is opened; said stop switch means operating to vary the time rate at which said capacitance is restored to open-key condition.

7. An organ according to claim 1 in which the variation in time rate is secured by varying the resistance through which current flows during return to open-key condition.

8. In an electronic organ, in combination: tone-producing means including a normally inactive audio-frequency oscillator having the frequency of a musical note to be produced; loud speaker means for translating the vibrations of said tone-producing means into sound waves; said tone-producing means having predetermined

characteristic attack and decay periods; said tone-producing means having a first and second terminal; a first and a second key switch for delivering energizing voltage to sound said tone-producing means; a first circuit completed by said first key switch through said first terminal for sounding said tone-producing means; a second circuit completed by said second key switch through said second terminal for sounding said tone-producing means and transferring a predetermined amount of energy other than that delivered to said tone-producing means; and connections operative when energizing voltage is withdrawn by opening said second key switch, for restoring the open-key condition of said second circuit by current through said tone-producing means to prolong the predetermined decay period of said tone-producing means and produce a slower dying away of the signal.

References Cited in the file of this patent

UNITED STATES PATENTS

2,099,511	Caesar	Nov. 16, 1937
2,221,188	Hammond et al.	Nov. 12, 1940
2,245,354	Mroz	June 10, 1941
2,294,178	Hanert	Aug. 25, 1942
2,401,372	Reinstra	June 4, 1946
2,483,823	George	Oct. 4, 1949
2,486,208	Reinstra	Oct. 25, 1949
2,542,065	Van Wye	Feb. 20, 1951
2,577,753	Hanert	Dec. 11, 1951
2,764,683	Paust et al.	Sept. 25, 1956
2,790,906	Hammond	Apr. 30, 1957

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,924,137

February 9, 1960

Richard H. Peterson

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 7, line 4, for "as long a the" read -- as long as the --; line 21, for the claim reference numeral "1" read -- 6 --; column 8, line 2, for "a first and second" read -- a first and a second --.

Signed and sealed this 2nd day of August 1960.

(SEAL)
Attest:

KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents

UNITED STATES PATENT OFFICE

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