June 7, 1966 S. HEYTOW 3,255,294

PERCUSSION CIRCUIT FOR ELECTRONIC MUSICAL INSTRUMENT

Filed June 7, 1961 2 Sheets-Sheet 1

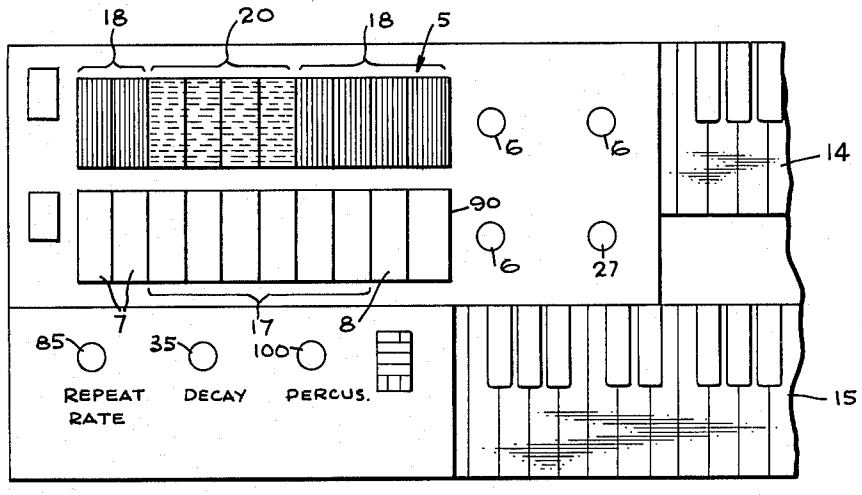



Fig. 1

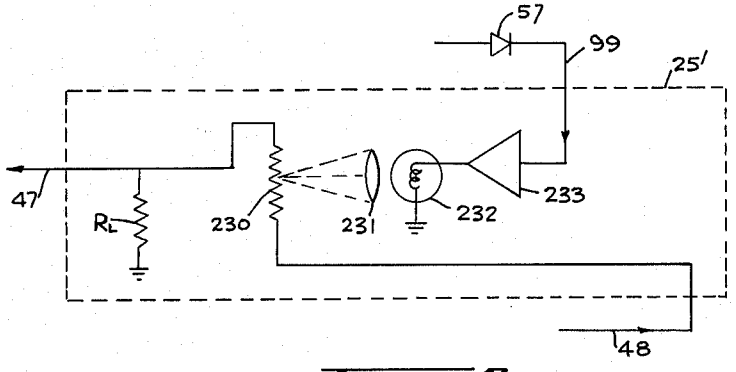



Fig. 3

SOLOMON HEYTOW

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BY Warren T. Jessup

ATTORNEY

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PERCUSSION CIRCUIT FOR ELECTRONIC MUSICAL INSTRUMENT

Filed June 7, 1961 2 Sheets-Sheet 2

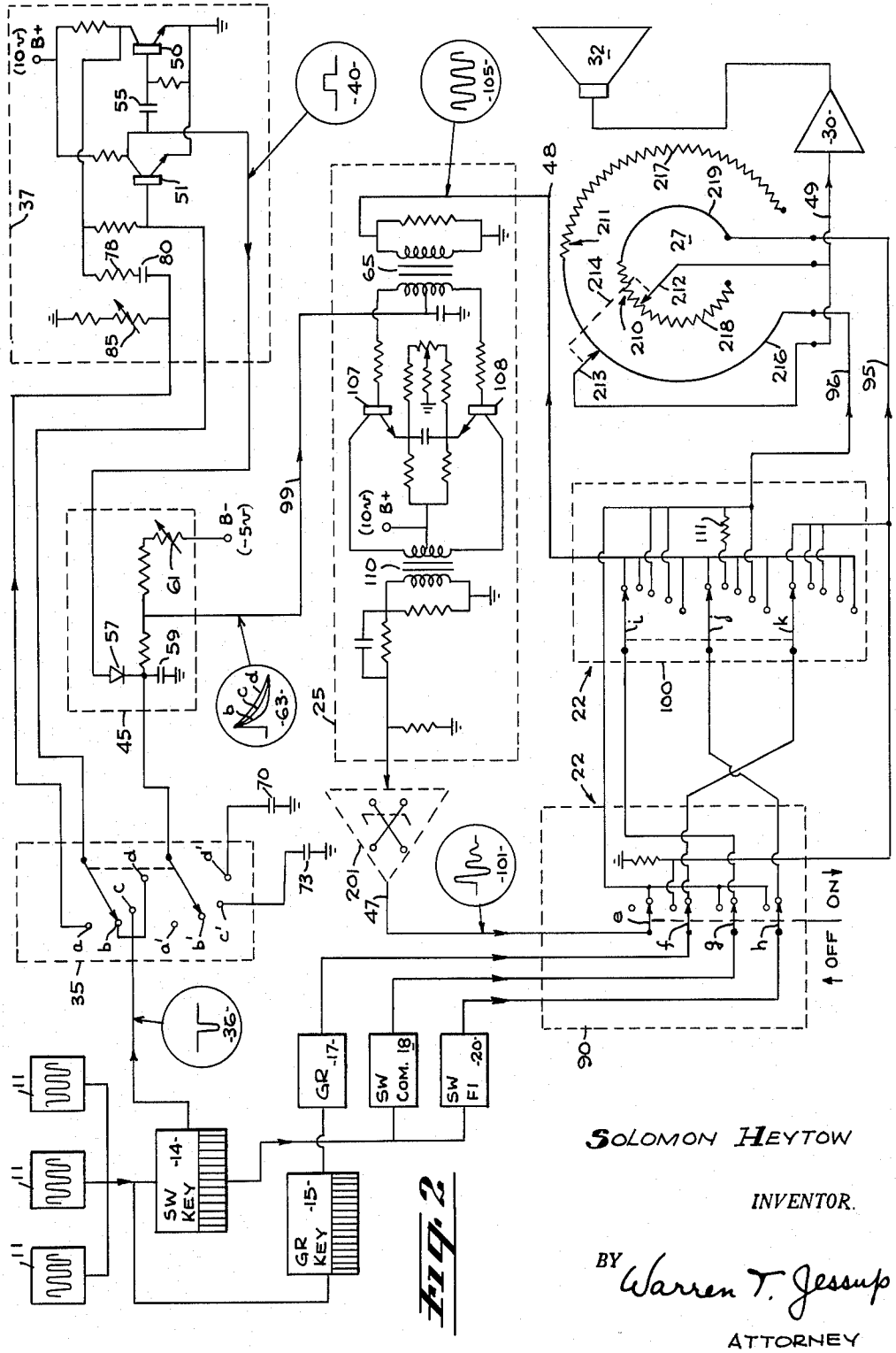



Fig. 2

SOLOMON HEYTOW

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United States Patent Office 3,255,294 Patented June 7, 1966



3,255,294

# PERCUSSION CIRCUIT FOR ELECTRONIC MUSICAL INSTRUMENT

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This invention relates to a percussion circuit for an electronic musical instrument such as an organ, and more particularly to such a circuit wherein a wide variety of tonal effects and combinations may be accomplished with percussion, both alone and in combination with unpercussed or sustained tones.

It is therefore an object of this invention to provide an improved percussion circuit.

It is another object of this invention to provide means whereby a very wide range of tonal effects involving percussion may be achieved.

It is another object of this invention to provide means for sounding percussion tones either upon each actuation of a key of a given keyboard or alternatively in a repeated manner at a regular but adjustable interval as set by the performer, and independent of the moment of key actuation.

It is another object of this invention to provide means whereby the performer or organist may, if desired, sound both a percussed tone and an unpercussed tone upon actuation of a single key, and wherein the two tones may be subjected to entirely different formant or voicing networks. By this means an electronic organ may be caused to sound like a wide variety of instruments, both domestic and exotic, with remarkable similitude.

It is another object of this invention to provide an improved balance means under the selective control and adjustment of the performer through which the volume of sound controlled by the swell keyboard of the organ and by the great keyboard of the organ may be relatively adjusted in the speaker or other transducing system; and wherein at the midpoint or mid region of such adjustment both keyboards apply substantially maximum volume output to the transducing system.

It is a further object of this invention to provide a simplified percussion modulating circuit wherein a percussion pulse activated by depression of a key may be caused to amplitude-modulate the tones emanating from the tone generators of the musical instrument such as an organ.

It is still another object of this invention to provide a percussion circuit for an electronic musical instrument, such as an electronic organ, which has improved versatility of operation, whereby some of the tones resulting from depression of a single key will be percussed while other tones activated by the same depression of the same key will sound in sustained form, as long as the key is held depressed.

It is a further object of this invention to provide a percussion circuit capable of alternatively producing an iterative percussion effect or a repetitive percussion effect.

It is still a further object of this invention to facilitate the operation of an electronic musical instrument by providing means for generating a percussive rhythm signal at a preselected rate.

The circuit of the present invention may be employed in an electronic organ having tone generators for producing the various pitches of a scale, such as a tempered scale. The audio frequencies from the tone generators are applied to keyboard switching circuits, illustrated in the present case as consisting of a swell keyboard and a great keyboard. From each of the keyboards the tones are fed to formant or voicing circuits wherein the timbre



of the tone is altered or selected in accordance with the voicing tabs, which are set at the console by the organist.

It is a feature of the present invention that one of the keyboards, in this case the swell keyboard, has its formant circuits divided into two major categories, one accommodating the flute or pure tones and the other accommodating the more complex tones, sometimes known as the string formants (although this also comprehends the various wind and percussion instruments which generate complex tones in contrast to the relatively pure tones of the flute family).

In accordance with the present invention the tones from the swell complex formant circuits and from the swell flute formant circuits may be conveyed over two separate tone paths to the tone output system, which usually consists of an amplifier and loudspeaker, but may consist of any transducing means such as a transmission line, recording head, or other suitable circuit or system for employing the tones received. The two paths are so arranged that one goes directly to the tone output system without percussion, while the other is sent through a modulating means which normally blocks transmission of the tones except when a modulating pulse is applied thereto from a suitable pulse means. The pulse means may be activated from triggering pulses received from the swell keyboard keys upon each actuation of a key. Such a percussive modulating circuit is illustrated by way of example in pending application Serial No. 669,112, filed July 1, 1957, entitled Percussion Circuit, Stanley Cutler et al., now abandoned, to which reference is made for enhanced understanding of the present specification.

In accordance with the present invention, the pulse means includes a multivibrator and shaper which pulse modulates the tones passing through the percussion path of the organ and which may be selectively adjusted by the performer to produce either iterative or reiterative percussion. By iterative percussion is meant a percussion wherein with each depression of the key in a keyboard (in this case the swell keyboard) the tones corresponding to all keys which are depressed at that particular moment, and which are applied to the modulator by the formant and other switching circuits, will be sounded in percussed form. To achieve this the multivibrator is connected so as to operate as a monostable or one shot device, delivering a single pulse for each triggering impulse applied thereto from the swell keyboard circuit. Reiterative percussion as used herein is achieved by connecting or switching the multivibrator so as to be an oscillator or free running device, which delivers repeated output pulses, completely independent of any input thereto. In accordance with the present invention the oscillator or repeat frequency of the reiterative percussion may be adjustably controlled by the performer.

Preferred forms of the present invention will now be described with reference to the accompanying drawings wherein;

FIG. 1 is a fragmentary plan view of an organ console showing particularly the voicing and percussion controls;

FIG. 2 is a wiring diagram partly schematic illustrating the circuitry of the present invention; and

FIG. 3 illustrates a modified form of a portion of the circuit of FIG. 2.

Referring to FIG. 1 the plan view of the console illustrates the left hand portion of a swell keyboard **14** and below it the left hand portion of a great keyboard **15**. Generally aligned with the swell keyboard **14** and lying immediately to the left are voice or timbre controls manually operable by the performer, some of which are conventional and some of which are unique to the present invention.

Numeral **5** represents rockable tabs which control, for

the most part, the various voicing or formant circuits, to apply the desired timbre to the tones applied to the speaker. The two groups of tabs represented by the numeral **18** control the complex voicing circuits of the swell manual **14**, while the tabs denominated **20** control flute voicing circuits of the swell manual. In accordance with the present invention, the flute tabs **20** are colored one distinctive color, for example gray, while the complex tabs **18** are colored another distinctive color, for example red.

In the second line of tabs, the group of tabs **17** control the voicing circuits for the great manual **15**.

Numeral **6** represents rotable knobs which control respectively vibrato rate, vibrato depth, and pedal volume including the on/off switch for the organ. Numeral **27** is a manual balance control for controlling the relative volume of sound applied to the speaker from the swell and great keyboards, respectively. A special balance control is employed in accordance with the present invention which will be described hereinafter.

Numeral **90** is a two position tab which simply determines whether or not percussion will be sounded. The tab **90** controls a multi-pole two position switch to selectively switch the tones delivered by the various voicing circuits and by the percussion modulator, as will be described hereinafter. Tabs **7** control the voicing of the pedal circuit, while tab **8** is an on/off switch controlling the use or non use of vibrato.

Aligned with and to the left of the great keyboard **15** is the control panel for the unique percussion combinations forming the principal subject matter of the present invention. Knob **85** serves to continuously vary the repeat rate or oscillation frequency of the multivibrator which produces the reiterative percussion, independent of any key actuation. This control becomes effective when the knob **35** is moved to its "repeat" position. The knob **35** controls a two-pole, four-position switch, one position of which is "repeat" as mentioned above, and the other three of which serve to control in discrete steps the decay time of the percussion pulse applied to the modulator means; this serves to control the duration of the pulse envelope. Knob **100** controls a three-pole, five-position switch, which selectively switches the tones from the tone generator and formant circuits, in various selected combinations, to the transducer or to the input of the percussive modulator. By judicious use of these five positions, the performer can achieve an extremely wide variety of tonal effects simulating not only individual instruments, but also a plurality of concurrent discrete instruments actuated by a single key of a keyboard, in this case the swell keyboard.

Referring to FIG. 2, a diagram illustrating the device of the invention as incorporated into an electronic organ is shown. Tone signals are generated in a tone generating system **11** which may comprise a plurality of electronic oscillators. The various tone signals are fed to respective associated switching circuits in the swell keyboard circuits **14** and the great keyboard circuits **15**. Tone signals are selectively fed from the great keyboard circuits **15** to the great voicing networks **17** in accordance with the actuation of the keys of the great keyboard. Similarly tone signals are fed from the swell keyboard circuits **14** to the swell complex voicing networks **18** and the swell flute voicing networks **20**, in accordance with actuation of the keys of the swell keyboard. The various voicing networks comprise electrical formant filters which are used to shape the tone signals by techniques well known in the art, to produce various timbres.

The variously filtered signals are fed from voicing networks **17**, **18** and **20** to selector switches **22**, and thence selectively to percussion modulator **25** and manual balance control **27**. The signals from selector switches **22** retain their voice identity as great and swell signals. Manual or keyboard balance control **27** comprises an attenuating and mixing pad which is used to mix the great and swell inputs and vary their relative amplitudes. The output of manual balance control **27** is fed to amplifier **30** where it is appropriately amplified and fed to loudspeaker **32**. Elements **30** and **32** are representative of any suitable tone output system which may include other transducers such as recording heads or may simply be a transmission line.

The keys of the swell keyboard are connected in a pulse generating circuit so that when any key is actuated, an output pulse is generated. Output pulses **36** from the swell keyboard circuits **14** are fed through switch **35**, when it is in the position shown, to a pulse means including a percussion multivibrator **37** and a shaping means **45**. Percussion multivibrator **37**, with switch **35** in the position indicated, operates as a mono stable or one shot device and generates a generally rectangular pulse **40**, in response to pulse input signals **36** from the swell keyboard circuits.

Pulse **40** is fed from multivibrator **37** to the shaping circuit or network **45** where it is employed to charge an RC time constant network, having an adjustable decay time. The output pulse **63** from the network is applied as a modulating pulse to the modulator **25**. There it amplitude modulates the continuous tone **105** applied as a carrier to the input **48** of a modulator **25** and produces a shaped burst of percussed tone **101** at the output **47** thereof. The sustained tone **105** at the input to the modulator **25** is substantially blocked except when a pulse **63** is applied at **99** to pass the tone **101**. It will be noted that the envelope of the tone **101** substantially corresponds to the shape of the input pulse **63**. This burst **101** is a percussive pulse, in that it simulates quite closely the timbre of various and sundry percussive instruments, as will be explained more fully hereinafter.

The output **101** of modulator **25** is fed to selector switches **22** from where, with percussion in use, it is coupled to the swell line **96** running to manual balance control **27**.

Switch **35** may alternatively be placed in any of four positions, as shown, at the election of the operator. When switch **35** is in the first or upper position, percussion multivibrator **37** operates as an oscillator or free running device at a preselected repetition rate. In this position feedback is provided between the multivibrator stages to achieve the desired free running operation. The details of the operation of the multivibrator will be explained hereinafter. Switch **35** thus provides means for alternatively connecting the multivibrator as a mono stable or one shot device operating in response to keys in the swell keyboard circuits **14** or alternatively as a free running device, or oscillator.

Stages of multivibrator **37** are so biased that with switch **35** in the position indicated in FIG. 2, and with no output signal from the swell keyboard circuits **14**, transistor **51** will continually conduct while transistor **50** is cut off. With the actuation of any of the keys of the swell keyboard, a negative output pulse **36** is fed from the swell keyboard circuits **14** to fixed contacts *b*, *c* and *d* of switch **35**. With the upper movable contact arm of switch **35** in contact with fixed contact *b*, *c* or *d*, pulse **36** is fed to the base of transistor **51**, driving this transistor to cutoff. When transistor **51** is driven to cutoff the voltage at its collector rises to the B plus supply voltage (plus 10 volts). This positive going signal is fed through capacitor **55** to the base of transistor **50**, and drives this transistor into the conductive state. The positive going signal appearing at the collector of transistor **51** is also coupled through diode **57** to capacitor **59** in shaping network **45**. Across capacitor **59** is a resistive network which includes a bias control resistor **61** returned to B minus (minus 5 volts). With the arms of switch **35** in the *c* and *c'* position, capacitor **70** is added to the R/C discharge circuit to increase the time constant of the circuit and hence the time duration of the output pulse **63** to a "medium" range. The time duration of output pulse **63** may be increased to a "long"

range by switching the arms of switch **35** to the *d* and *d'* positions to connect capacitor **73** into the R/C discharge circuit. Capacitor **73**, of course, must have a substantially greater capacitance than capacitor **70** to achieve the desired end result. If desired the switch may be arranged so that the capacitance of **73** is added to that of **70**, at the *d* position, thereby reducing cost of components. This is done by well known switching techniques which are old in the art.

With the movable arms of switch **35** in the *a* and *a'* positions, a feedback path is provided from the collector of transistor **50** through resistor **78**, capacitor **80**, and switch **35** to the base of transistor **51**. This feedback causes the multivibrator to operate as a free running device or oscillator at a frequency determined by the R/C time constant of the circuit, the supply voltage and the characteristics of transistors **50** and **51**. This oscillation frequency can be varied by means of potentiometer **85**.

Switch **35** is thus utilized to operate the multivibrator as a single shot device in response to the pulse output **36** of the swell keyboard circuits **14** or as a free running device with a repetition rate which can be adjusted by means of potentiometer **85**. In the three lower positions of the switch **35** the one shot mode of operation is employed with three different pulse widths or durations for the pulse **63** delivered by the network **45**.

Tone input signals **105** are fed from selector switch **100** via line **48** to the primary winding of transformer **65** in modulator **25**. These signals are inductively coupled to the secondary winding of this transformer so that they appear at the bases of transistors **107** and **108**. The output pulse **63** from the pulse means **37**, **45** is fed via line **99** to the center tap of the secondary winding of transformer **65** so that it also appears at the bases of transistors **107** and **108**. Transistors **107** and **108** are so biased that they will only conduct when the modulator output pulse **63** appears at their bases. Transistors **107** and **108** thus act as gates which conduct only during the times when pulse **63** is present. The signals which are gated through transistors **107** and **108** are coupled from the primary of transformer **110** to its secondary. The output **101** of the percussion modulator **25**, which is a modulated tone signal having an envelope corresponding to the modulation pulse **63**, is fed via line **47** to movable arm *e* of percussion switch **90**. With the percussion switch in the "on" position, which is the position indicated in FIG. 2, the modulated output signals are fed via arm *e* to the swell output line **96** which runs to manual balance control **27**. The output of manual balance control **27** is amplified in amplifier **30** and then fed to loudspeaker **32**.

The multivibrator **37** and the pulse shaping network circuit **45** thus constitute in conjunction a pulse means for producing and delivering a suitable modulating pulse **63**, which "opens" the modulator **25** and forms the envelope for the tone output **101**.

The outputs of the great voicing network **17**, the swell complex voicing network **18**, and the swell flute voicing network **20** are fed to movable arms *f*, *g* and *h* respectively of percussion switch **90**. With percussion switch **90** in the "on" position, the movable arms *e*, *f*, *g* and *h* of the switch are connected as shown in FIG. 2 to feed the output of great voicing network **17**, swell complex voicing network **18**, and swell flute voicing network **20** to movable arms *k*, *i* and *j* respectively of selector switch **100**.

With the percussion switch **90** in the "on" (down) position, movable arm *e* feeds the output **101** of modulator **25** to swell output line **96** which is connected to the swell input terminal of manual balance control **27**. With percussion switch **90** in the "off" (up) position, the output **101** of the modulator is dead ended at switch arm *e*; the output of the great voicing network **17** is fed through arm *f* to the great output line **95** which runs to manual balance control **27**, and the outputs of the swell complex voicing network **18** and the swell flute voicing network **20** are both fed to the swell output line **96** which runs to manual balance control **27**.

With switch **90** in the "off" position, the switch **100** is ineffective and its postion is of no moment.

With the percussion switch **90** in the "on" position, the movable arms *i*, *j* and *k* of selector switch **100**, which are ganged together, may be positioned to any one of the five contact positions as shown in FIG. 2 to selectively couple the great voicing network, swell complex voicing network, and the swell flute voicing network and various combinations thereof to either the input winding of transformer **65** in modulator **25** or to the great and swell output lines **95** and **96**. Thus, a great variety of percussive and unpercussive signals can be produced.

It will be noted that the percussion control switch **100** has five positions selective at the will of the performer. In FIG. 2, starting from the top, the first position is denominated "All swell." This signifies that both the complex and the flute tones from the swell manual will be percussed by being directed through the modulator **25**, while the great manual will be unpercussed. This is confirmed by noting that tones from the swell complex and swell flute formant circuits **18** and **20** pass through the switch arms *g* and *h*, thence to the arms *i* and *j*, respectively, and thence to the input line **48** of the modulator **25**. Tones from the great manual circuit **17** on the other hand go through the switch arm *f* to the switch arm *k* and thence to the great output line **95**. The percussed swell tones emerge from the modulator **25** on the line **47**, pass through the arm *e* and thence to the swell output line **96**. Tones on the lines **95** and **96** are then applied to the manual balance control **27** and thence to the common output line **49** feeding the amplifier **30**.

The second position of the switch **100** is denominated "Swell red." This indicates that only the "red" or complex tones of the swell manual will be percussed. The "grey" or flute tones of the swell manual will be unpercussed; and the great manual will also be unpercussed. Thus it is seen that in this position the swell flute tones from **20** pass through arms *h* and *j*, thence through attenuating resistor **111** and to the swell output line **96**. Swell complex tones from **18** pass through arms *j* and *i* to the modulator line **48**, thence through the modulator and to the arm *e* and swell output line **96**.

The third position of the switch **100** is denominated "Swell grey." In this position, the grey or flute tones from the swell manual are percussed, while the red or complex tones are unpercussed. The great manual is, as before, unpercussed. This may be readily seen by tracing the switch positions in the manner exemplified above.

The fourth position of the switch **100** is denominated "Great to Swell." In this position of the switch very unique effects can be achieved in that the modulator **25** receives only tones from the great voicing network **17**, but since the pulsed output **101** of the modulator **25** is under the control of the output pulse **36** from the swell keyboard **14**, it follows that percussed great tones will appear at the output, but only at the moment of depression of a key in the swell keyboard **14**. This assumes, of course, that the switch **35** is in one of its three "iterative" positions. If the switch **35** is in its reiterative or repeat position *a*, then the percussive pulses **40** and **63** are independent of the keyboard **14** and run freely as explained hereinbefore. Assuming that the switch **35** is set for one of the three iterative percussion positions, the performer may hold a note or chord depressed in the great keyboard but no sound will emanate except when a key in the swell keyboard is depressed. When such occurs, the depressed notes of the great keyboard will sound percussively through the output system, and simultaneously whatever tones from the swell keyboard as have been selected by the swell voicing tabs **18**, **20** will be sounded in sustained fashion.

Finally the fifth position of the switch **100** is denominated "Great and Swell." In this position all tones from

all of the voicing circuits **17**, **18** and **20** will be percussed and no sustained tones will be applied to the output circuit. Here again, however, the application of the percussive envelope will be dependent on the depression of a swell key **14** (assuming switch **35** in iterative position), so that the mere depression of a note or chord in the great keyboard will not necessarily sound those particular tones; the actual sounding of great tones is dependent upon the coincidence of depression (sustained or momentary) of the desired key in the great keyboard plus any key in the swell keyboard.

It will be noted that in the last two positions of switch **100**, since the tones of the great keyboard pass through modulator **25**, they do not appear on the great output line **95**, but instead appear, along with any swell tones, on the swell output line **96**. This renders the control **27** ineffective as a balance control or mixer and makes it a simple attenuator for the swell line **96**.

From the above description it will be noted that in positions two and three of switch **100**, depression of a single key in the swell keyboard **14** may cause the sounding of a percussed tone of one timbre and an unpercussed or sustained tone of another timbre. While both of these tones will correspond to and be actuated by the particular swell key depressed, they need not necessarily be of the same pitch. This will depend on the swell tabs **18** and **20** which are actuated at the time. For example, if among the tabs **20**, there is in the "on" position, the swell flute quint 5⅓′, and among the tabs **18**, the clarinet 8′, and if the switch **100** is in the second position, the 8′ clarinet note will come through with clarinet timbre and percussed, while the 5⅓′ flute note will come through unpercussed. The 8′ note is of the pitch corresponding exactly to the depressed key; however, the 5⅓′ note is (in accordance with regular organ practice) of a higher pitch, being a fifth interval above the pitch of the depressed key. Both notes however will be sounded simultaneously, one unpercussed and the other percussed, upon depression of a single given key in the swell keyboard.

The manual balance control **27** is comprised of a pair of attenuators in the form of impedances or resistors **210** and **211**, made adjustable by sliders **212** and **213** respectively. The resistors are shown in circular form because as a practical matter it is simpler to provide a rotatable adjusting knot than a linearly slidable tab; but the physical disposition on the parts is immaterial to the function. In terms of the path of movement or adjustment of the sliders **212** and **213**, which are ganged together as shown at **214**, each attenuating impedance consists of two portions. The first portion of the impedance **211**, which is in the swell circuit line **96**, consists of a negligible impedance conductor **216**; it is connected to and followed by an appreciable resistance portion **217**, which forms the second portion. Thus, in the first half or portion of its clockwise movement, the slider **213** does not markedly change the impedance or attenuation introduced into the swell line **96**. It is only when the slider **213** engages the portion **217**, that the attenuation begins to steadily increase.

The impedance **210** in the great keyboard line **96** is arranged in opposite fashion. That is to say, in the first portion of the clockwise movement of its slider **212**, the resistance **210** has an appreciable value illustrated at **218**, while in the last or second portion of the movement of the slider **212**, there is substantially a very low impedance conductor **219**. It will be noted that this is exactly the complement of the arrangement for the impedance **211**. It will be further noted that since the sliders **213** and **212** are ganged together, at one point (substantially the mid point in the adjustment thereof) the impedance introduced into the line **96**, is negligible as is also the impedance introduced into the line **95**. Thus at the mid point of the manual balance control **27**, substantially the full volume output from both the swell line **96** and the great line **95** is applied to the amplifier **30**. From this point, moving clockwise, there is introduced a steadily increasing attenuation or impedance into the swell line **96**, as the slider **213** traverses and encompasses an increasing portion of the resistor **217**, while substantially no attenuation is introduced into the great line **95**, since the slider **212** slides over the negligible resistance conductor **219**. Conversely, moving counter clockwise from the mid point introduces steadily increasing impedance and attenuation into the great line **95** as the slider **212** encompasses an increasing portion of resistor **218**, while substantially no attenuation is introduced during this traverse into the swell line **96**.

The advantage of this structure is that while the full range of balance between the two manuals is available to the performer, he also has available, at the mid point of the adjustment, the full volume output of both manuals.

The circuit described makes possible a wide variety of instruments and instrument combinations, with remarkable similitude, for example, banjo, bagpipe, harpsichord, vibraharp, calliope, zither, marimba, chimes, Hawaiian guitar, piano and glockenspeil, piano and celeste, musette and temple blocks, clarinet and marimba, flute and mandolin, boogy woogy, calliope and banjo.

One of the more striking effects—Hawaiian guitar—is to be found, for example, by placing switch **100** in the second or swell red position, with the decay **35** set to medium or long (*c* or *d*). The effect produced is the sharp (percussive) twang of the plucked strings, which dies away while the smooth melody of the flute lingers on. This transition of tones gives the illusion of the familiar slur of this guitar. As reference to FIG. 2 will show, this is done by causing a flute tone, for example, the 4′ flute, from the network **20**, to pass unpercussed to the output line **96**, while complex tones, for example, the 8′ clarinet and 8′ oboe, are percussed through the modulator **25** before application to the output line **96**.

This effect may, if desired, be enhanced by inserting in the output line **47** from the modulator **25**, a phase invertor **201**, which simply inverts the phase of the percussed tones before they are recombined with the unpercussed tones at the output line **96**. The initial attack volume of the percussed tone, may be set appreciably greater than the volume of the unpercussed tone. Thus as the percussed tone dies out, and approaches the volume of the unpercussed tone, the phase inversion actually causes a substantial cancellation of the fundamental of the tone, with a resulting apparent momentary lowering of the volume, before it comes back up and continues with the drawn out slur effected through the flute alone. This simulates strikingly the Hawaiian guitar effect achieved by the bar in the hands of a skilled guitar player.

Other interesting effects derivable from the swell manual alone and by actuation of a single key are as follows. Mandolin combined with flute is achieved by setting the voice tabs **20** for the 8′ flute and the voice tabs **18** for the 8′ oboe and 8′ violin. Switch **100** is set in the second or swell red position while the decay switch **25** is set at the first or repeat percussion position. The repeated percussion simulates the mandolin, since the red tabs **18** are percussed, while the 8′ flute comes through unpercussed.

Wood blocks with clarinets is achieved by setting the grey (flute) tabs **20** at 4′ flute and 5⅓′ flute and the red (complex) tabs **18** at 8′ clarinet. Switch **100** is set at the third or swell grey position and the decay switch **35** is set at the short decay position *b*. Each depression of a single key in the swell keyboard **14** causes the two flute tones (4′ and 5⅓′) to be percussed with short time decay, while the 8′ clarinet tone comes through unpercussed and is sustained as long as the note is depressed. A striking duet between wood block and clarinet is thus achieved entirely from the swell manual. This is an excellent example of where the two tone paths, one percussed and the other unpercussed, do not even carry notes of the same pitch, in view of the fact that the two flute tones

are respectively an octave and a fifth above the pitch of the sustained clarinet tone.

Calliope with banjo is achieved by employing the 8′ flute and the 8′ oboe, with switch **100** in the second or swell red position, and switch **35** in the *a* or repeat position. The 8′ oboe is passed through the percussive tone path at a fairly rapid repeat rate to simulate a banjo, while the 8′ flute is passed through the unpercussed or sustained tone path to simulate the calliope.

In FIG. 3 there is shown an alternative form which the modulator may take. This is shown at **25′** wherein the input **48** and output **47** lines are coupled simply by a light sensitive resistor **230** having the property that when not illuminated, the resistance or impedance is very high, dropping markedly in response to illumination thereon. A suitable optical system, represented schematically by the lens **231**, is used to illuminate the resistor **230** from a source of illumination such as a light bulb **232**. The light bulb is energized by the modulating pulse **63** applied to the input line **99** and preferably amplified as shown at **233**.

In this form of modulator the resistance of **230** is caused to change inversely with the magnitude of the pulse **63** and thus in effect open the gate between the input and output lines **48** and **47**, in substantially the same way as the modulator **25** shown in FIG. 2.

The impedance **230** is a type known in the art generally as a light sensitive impedance or light determining impedance and having the properties set forth hereinbefore.

The device of this invention thus provides a simple yet highly effective percussion circuit having a versatility of operation and incorporating a capability of producing a repetitive percussion signal at a preselected repetition rate. The repetitive percussion signal can be used to produce a strumming effect at a precise and regular rate. This can be used both to instill a sense of rhythm in the novice and to facilitate the playing of accompaniment and solo effects for a more experienced musician.

While the instant invention has been shown and described herein in what is conceived to be the most practical and preferred embodiments, it is recognized that departures may be made therefrom within the scope of the invention which is therefore not to be limited to the details disclosed herein but is to be afforded the full scope of the claims.

What is claimed is:

**1.** In an electronic musical instrument, a great keyboard circuit, a swell keyboard circuit having a pulse output signal, a multivibrator normally connected for single shot operation, first switch means for alternatively connecting the pulse output of said swell keyboard circuit to the input of said multivibrator or connecting said multivibrator for free running operation, a plurality of signal generating means for generating electrical tone signals, the outputs of said signal generating means being fed to said great and swell keyboard circuits, great and swell voicing networks connected to respectively receive the outputs of said great and swell keyboard circuits, a modulator for applying a percussive modulating envelope to tone signals delivered by said voicing networks, circuit means for connecting the output of said multivibrator to said modulator as a modulating signal, an amplfier, a loudspeaker connected to receive the output of said amplifier, second switch means for alternatively coupling the output of said modulator or selected outputs of said great and swell voicing networks to said amplifier, and third switch means for selectively connecting the outputs of said great and swell voicing networks to the input of said modulator when the output of said modulator is coupled to said amplifier.

**2.** The instrument as recited in claim **1** and additionally comprising keyboard balance means interposed between said voicing networks and said amplifier for varying the relative amplitudes of said great and swell voicing network outputs applied to said amplifier.

**3.** In an electronic organ having a plurality of tone generators, a keyboard having a plurality of keys for actuating said tone generators and a tone output system for receiving tones from said tone generators, the combination of means for applying to said tone output system a tone of one timbre, corresponding to a given key, for so long as said key is depressed, pulse means for producing percussion pulses, switch means for selectively coupling an output of said keyboard to actuate said pulse means upon each actuation of a key irrespective of the position of other keys or alternatively coupling said pulse means as a free running oscillator, modulator means, circuit means for applying a tone of another timbre, but corresponding to said given key to said modulator means as a carrier to be modulated, and circuit means for applying the output of said pulse means to said modulator means as a percussive, amplitude-modulating pulse.

**4.** In an electronic musical instrument having a plurality of tone generating means, a keyboard for selectively activating said tone generating means, and a transducer for transducing the tones from said tone generating means, the combination of modulator means, first tone path means for applying a given note, controlled by the depression of a key of said keyboard, through said modulator means and thence to said transducer, second tone path means for simultaneously applying said note directly to said transducer, voicing means in at least of one of said tone path means for modifying the timbre of the tone passing therethrough, means for producing at least one percussive pulse, means for applying said percussive pulse to said modulator means as a modulating pulse, thereby to amplitude modulate the tone applied to said modulator means, whereby upon depression of a given key of said keyboard, said transducer receives simultaneously a percussed tone of one voice corresponding to a given key and a tone of different voice unpercussed, and corresponding to said same key.

**5.** In an electronic musical instrument having tone generators, a keyboard for selectively activating said tone generators, and a tone output system for receiving tones from said tone generators, the combination of radiant energy sensitive impedance means, the impedance of which varies inversely with the radiant energy applied thereto, means for applying the output of said tone generators as activated by said keyboard to the input of said impedance means, means for applying the output of said impedance means to said tone output system, means for producing a pulse in response to actuation of a key of said keyboard, radiant energy producing means positioned to apply radiant energy to said impedance means, and means for applying pulses produced by said pulse producing means to said radiant energy producing means, thereby to apply a pulse of radiant energy to said impedance means with consequent passage of a percussive modulated tone through said impedance means from said tone generators to said tone output system.

**6.** In an electric organ,

a first keyboard circuit

a first keyboard having a plurality of keys for actuating said first keyboard circuit

a second keyboard circuit

a second keyboard having a plurality of keys for actuating said second keyboard circuit

pulse circuits means for delivering a pulse output signal in response to actuation of the keys of said second keyboard

a plurality of tone signal means for delivering electrical tone signals in response to actuation of said keyboard circuits

modulating means for amplitude modulating said tone signals in response to said pulse output signal

circuit means for connecting tone signals responsive to said first keyboard circuit to the input of said modulating means

circuit means for connecting said pulse output signal to

said modulating means, whereby tone signals applied to the input of said modulator may be selectively passed as bursts of percussive tones in response to said pulse output signals and

output circuit means for delivering the output of said modulating means to an electro acoustic transducing means.

**7.** The combination of claim **6** including in addition:

circuit means for applying tone signals responsive to said second keyboard circuit to the input of said modulating means.

**8.** The combination of claim **7** including in addition:

circuit means for selectively bypassing said modulating means and applying tone signals responsive to said first keyboard circuit to said output circuit means.

**9.** The combination of claim **7** including in addition:

circuit means for selectively bypassing said modulating means and applying tone signals responsive to said second keyboard circuit to said output circuit means.

**10.** The combination of claim **7** including in addition circuit means having switch means for effecting any of the following:

(a) passing tone signals responsive to said first keyboard circuit to said output circuit means and bypassing said modulating means, while also passing tone signals responsive to said second keyboard circuit to said output circuit means and bypassing said modulating means;

(b) passing tone signals responsive to said first keyboard circuit to said output circuit means and bypassing said modulating means, while passing tone signals responsive to said second circuit to and through said modulating means thereby to be percussed in bursts of tone;

(c) passing tone signals responsive to said first keyboard circuit through said modulating means thereby to be percussed, while passing tone signals responsive to said second keyboard circuit to said output circuit means and bypassing said modulating means;

(d) passing tone signals responsive to said first keyboard means through said modulating means thereby to be percussed, while also passing tone signals responsive to said second keyboard circuit through said modulating means thereby to be percussed.

**11.** The combination of claim **6** wherein said pulse circuit means comprises:

multivibrator means for delivering a single pulse output in response to each pulse applied to the input thereof,

circuit means for applying the pulse output signal from said second keyboard circuit to the input of said multivibrator, and

circuit means for applying the output of said multivibrator to said modulating means as a percussive modulating signal.

**12.** The combination of claim **11** including selectively operable means for causing said multivibrator to oscillate and deliver freely repeating output pulses independent of input pulses applied thereto.

**13.** In an electric organ having a plurality of tone sources, a keyboard for selectively actuating said tone sources, and output circuit means for applying tones to an electro acoustic transducer; the combination of:



first tone path means for applying tones from said tone sources to said output circuit,

second tone path means for applying tones from said tone sources to said output circuit,

modulator means in one of said tone path means for percussively amplitude modulating the tones passing through said one tone path means,

pulse means for delivering a percussive pulse,

means for applying said percussive pulse to said modulator means as a modulating pulse, thereby to amplitude-modulate tones passing through said modulator means

and phase inversion means in one of said tone path means for inverting tones passing therethrough, whereby said output circuit receives a percussed tone and a sustained unpercussed tone in out-of-phase relation.

**14.** The combination of claim **13** including in addition voicing means in at least one of said tone path means for modifying the timbre of the tone passing therethrough.

**15.** In an electric organ having a plurality of tone generating means, a keyboard for selectively activating said tone generating means, and a transducer for transducing the tones from said tone generating means, the combination of:

modulator means,

first tone path means for applying a given note, controlled by the depression of a key of said keyboard, through said modulator means and thence to said transducer,

second tone path means for simultaneously applying said note directly to said transducer,

means for producing at least one percussive pulse,

means for applying said percussive pulse to said modulator means as a modulating pulse, thereby to amplitude-modulate the tone applied to said modulator means, whereby upon depression of a given key of said keyboard, said transducer receives simultaneously a percussed tone corresponding to a given key and a tone unpercussed and corresponding to said same key, and

phase inversion means in one of said tone path means for inverting the tone passing therethrough, thereby to enhance the musical effect resulting upon blending of said tones.


**References Cited by the Examiner**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| 2,585,357 | 2/1952 | Wayne | 84—1.17 |
| 2,916,957 | 12/1959 | Hanert | 84—1.26 |
| 2,937,556 | 5/1960 | Hanert | 84—1.26 |
| 2,953,055 | 9/1960 | Hanert | 84—1.26 |
| 2,967,951 | 1/1961 | Brown. | |
| 2,989,887 | 6/1961 | Markowitz | 84—1.24 |
| 3,039,347 | 6/1962 | Krauss et al. | 84—1.26 |
| 3,049,959 | 8/1962 | Meyer | 84—1.24 |


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