Jan. 22, 1963 J. H. RIGGS ETAL 3,074,306

PERCUSSION ARRANGEMENT FOR ELECTRONIC MUSICAL INSTRUMENT

Filed Feb. 29, 1960 4 Sheets-Sheet 1

Fig. 1.

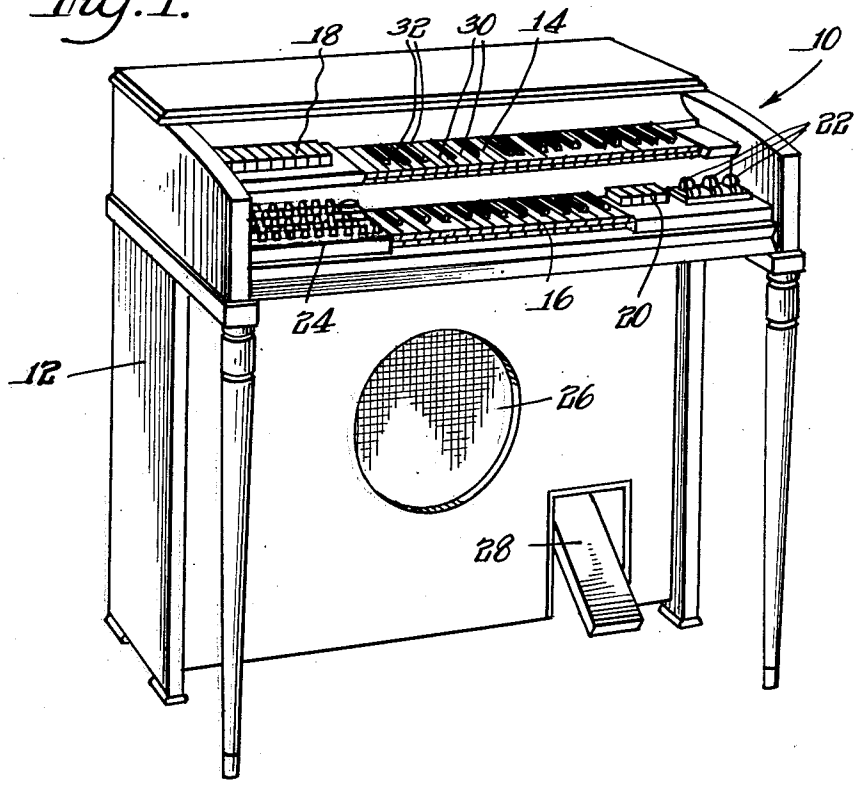
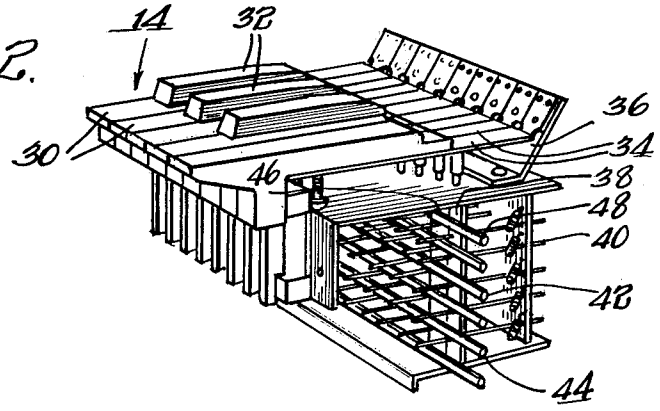


Fig. 2.



INVENTORS
John H. Riggs
Frank B. Lumney
Howard G. Bauer
By Olson & Trexler Attys.

Jan. 22, 1963 J. H. RIGGS ETAL 3,074,306

PERCUSSION ARRANGEMENT FOR ELECTRONIC MUSICAL INSTRUMENT

Filed Feb. 29, 1960

4 Sheets-Sheet 2

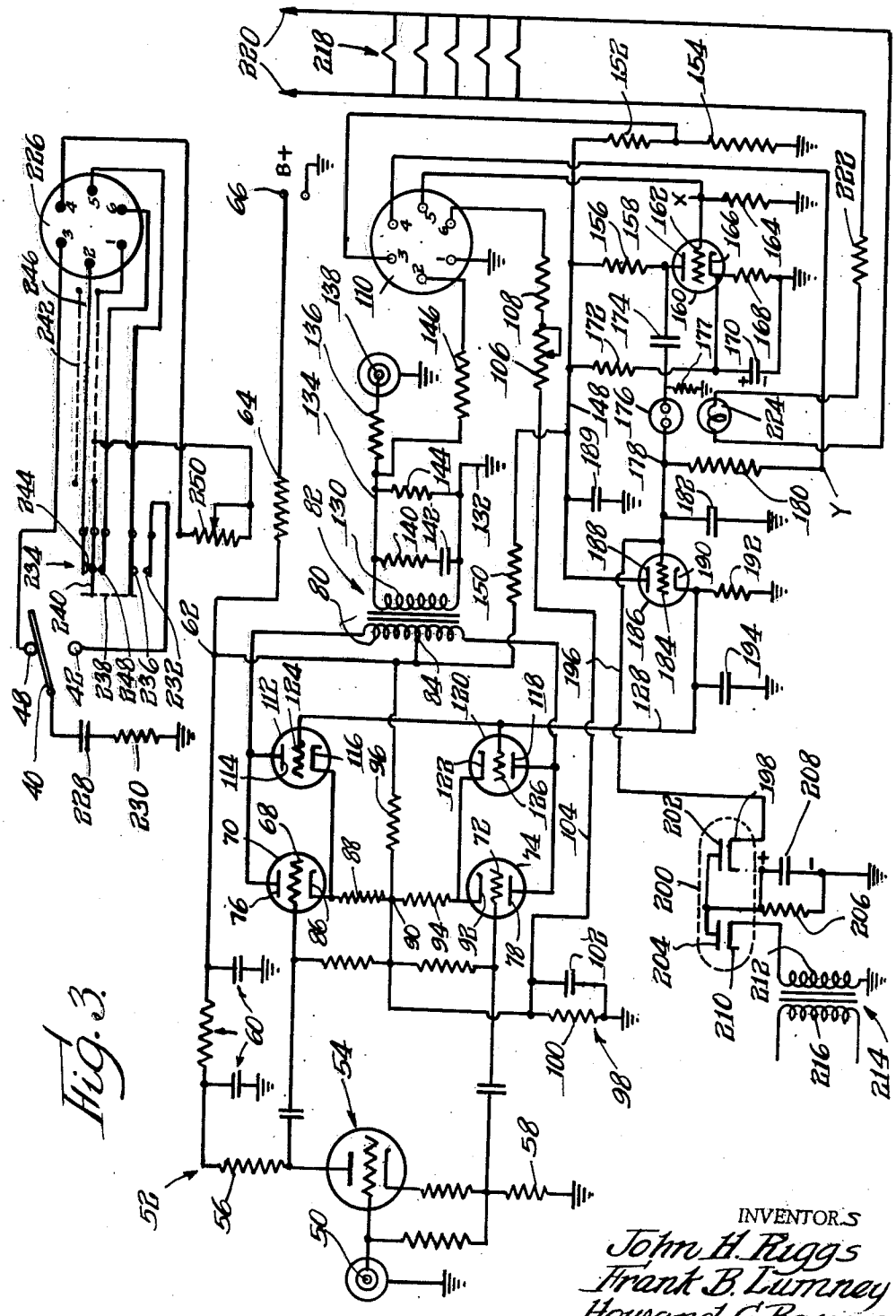


Fig. 3.

INVENTORS
John H. Riggs
Frank B. Lumney
Howard G. Bayer
By: Olson & Trueblood Atts.

Jan. 22, 1963 J. H. RIGGS ETAL 3,074,306

PERCUSSION ARRANGEMENT FOR ELECTRONIC MUSICAL INSTRUMENT

Filed Feb. 29, 1960 4 Sheets-Sheet 3

Fig. 4.

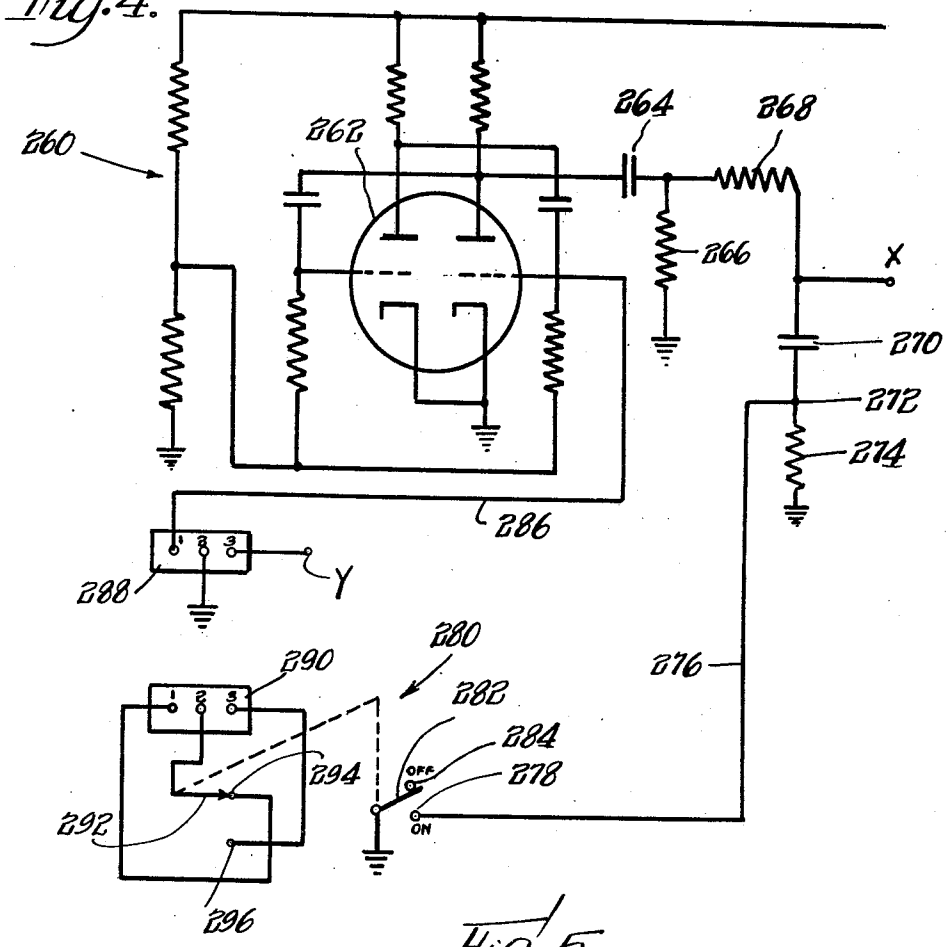
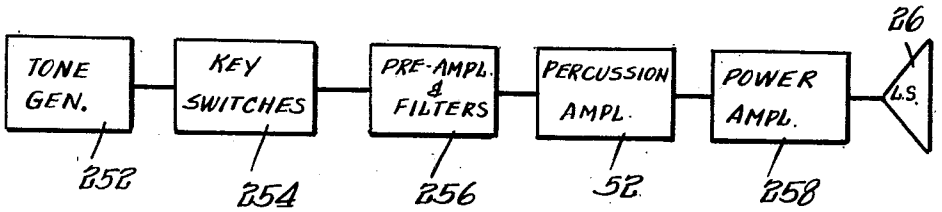


Fig. 5.



INVENTORS
John H. Riggs
Frank B. Lumney
Howard G. Bauer
By: Olson & Trexler attys

Jan. 22, 1963 J. H. RIGGS ETAL 3,074,306

PERCUSSION ARRANGEMENT FOR ELECTRONIC MUSICAL INSTRUMENT

Filed Feb. 29, 1960 4 Sheets-Sheet 4

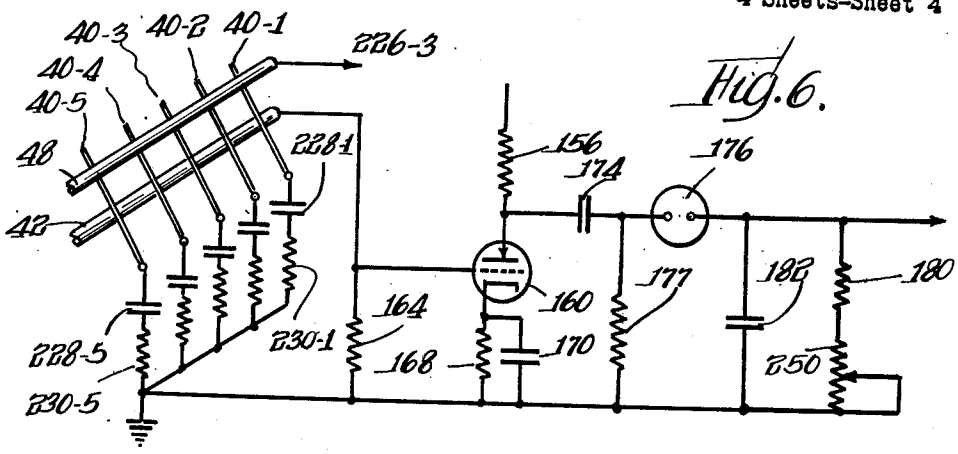


Fig. 6.

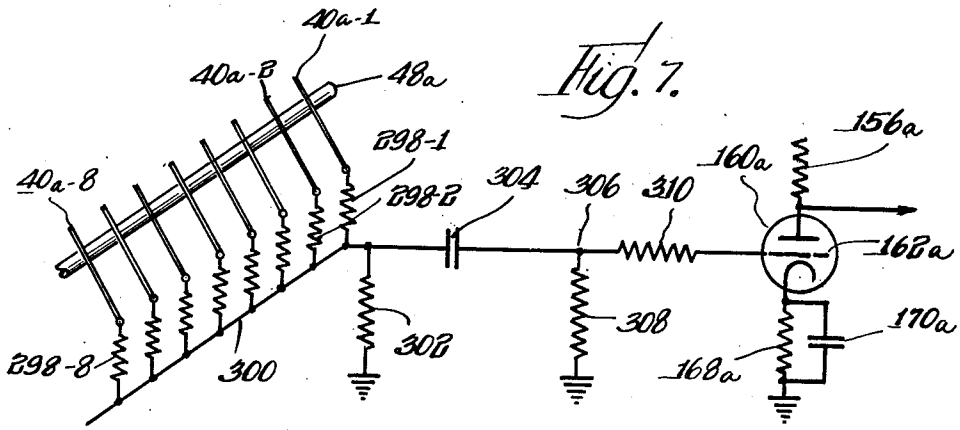


Fig. 7.

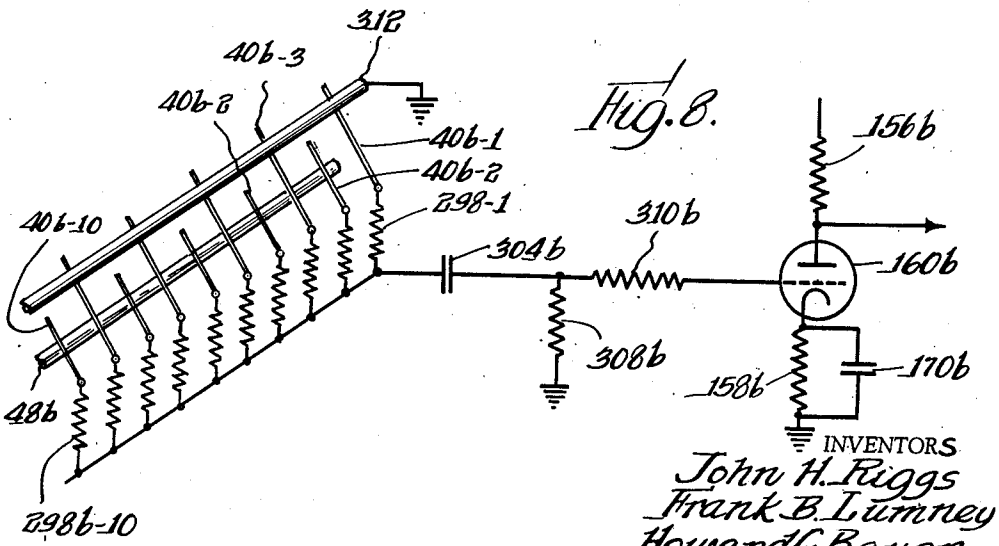


Fig. 8.

INVENTORS
John H. Riggs
Frank B. Lumney
Howard G. Bauer
By: Olson & Trexler Watts

United States Patent Office

3,074,306

Patented Jan. 22, 1963

1

3,074,306

PERCUSSION ARRANGEMENT FOR ELECTRONIC MUSICAL INSTRUMENT

John H. Riggs, Kenmore, and Frank B. Lumney and Howard G. Bauer, Tonawanda, N.Y., assignors to The Wurlitzer Company, Chicago, Ill., a corporation of Ohio

Filed Feb. 29, 1960, Ser. No. 11,691
26 Claims. (Cl. 84—1.26)

This invention is concerned generally with an electronic musical instrument, and more particularly with an improved percussion arrangement therein.

As is well known, there are many electronic musical instruments using electronic oscillators, such as tube oscillators, as tone generators. It is not particularly difficult to obtain percussive effects with such electronic oscillators by applying the percussion directly at the oscillators. However, this requires a separate circuit for each oscillator, and this renders the resulting instrument inordinately expensive. Application of percussion means to an amplifier or transmission circuit eliminates the need for a plurality of percussion means respectively at the oscillators. However, difficulties are encountered here. In a keyboard type of electronic musical instrument, such as an electronic organ, depression of the first key may be made to produce a percussion without too much difficulty. However, the amplifier soon tends to operate in a steady state, and a percussion effect cannot readily be obtained on a second note, when the first key is held down and a second key is depressed.

Accordingly, it is an object of this invention to provide, in a keyboard type electronic instrument, percussion means in the amplifier thereof, wherein percussion effects can be obtained on successive notes, irrespective of whether or not preceding notes are sustained.

A further object of this invention is to provide percussion means in the amplifier of an electronic musical instrument wherein the amplifier is operated in a more or less steady state, and the output thereof is varied by varying the loading of the amplifier, whereby to produce a percussive effect.

More specifically, it is an object of this invention to produce a percussive effect in the amplifier of an electronic musical instrument by means of a "variable loser" circuit.

It is yet another object of this invention to provide various improved pulsing circuits for producing percussion in the amplifier of an electronic musical instrument.

It is yet another object of this invention to provide novel electronic switch means for interconnecting a key operated pulsing means to the amplifier of an electronic musical instrument for producing percussive effects.

Another object of this invention is to provide a repeater percussion for providing plucked or banjo-like tones in an electronic organ.

Other and further objects and advantages of the present invention will be apparent from the following description when taken in connection with the accompanying drawings wherein:

FIG. 1 is a perspective view of an organ constructed in accordance with the principles of this invention;

FIG. 2 is a perspective view of a fragment of the keyboard and switching means thereof;

FIG. 3 is an electronic wiring diagram illustrating the essential electrical parts of the invention;

FIG. 4 is an "add-on" circuit for producing a plucking effect;

FIG. 5 is a block diagram of the organ;

FIG. 6 is a schematic wiring diagram illustrating a modification of a part of the circuit of FIG. 3;

2

FIG. 7 is another schematic wiring diagram somewhat along the lines of FIG. 4 illustrating another modification; and

FIG. 8 is another fragmentary electronic wiring diagram illustrating a further modification.

Referring now in greater particularity to the drawings, and first to FIG. 1, there is shown an organ 10 constructed in accordance with the principles of this invention and including a console 12. The console has two manuals or keyboards 14 and 16, having respective stop tablets 18 and 20 associated therewith. The organ includes various controls as indicated at 24 and also may include a chord unit 22, for playing chords. The console includes a loud speaker at 26, and a swell pedal at 28.

Each of the manuals or keyboards, for example the manual 14 (see also FIG. 2) includes a plurality of white keys 30 and a plurality of black keys 32. These keys are mounted on key bars 34 mounted on suitable pivot means, such as flexible springs, to a fixed plate or flange 36. The key bars are arranged to shift operating members 38 vertically, whereby to effect movement of a plurality of contact wires 40. The contact wires are aranged to contact conductive inserts 42 in transverse insulating supports 44, whereby to connect the oscillators to the amplifier, or to actuate the oscillators, for proper tone generation. The conducting inserts 42 generally correspond to different stops of the organ, as controlled by the stop tablets 18 and 20. In adidtion, there is preferably an additional transverse insulating support 46 having a conductive insert 48 on the bottom thereof. The adjacent wire contact 40 normally engages the overlying conductive insert 48, and all of the contact wires 40 are normally spaced from the conductive insert 42. Upon depression of a key, the corresponding wires 40 are deflected downwardly by the operator 38 into engagement with the underlying conductive inserts 42, the upper wires at the same time moving away from the conductive insert 48. The insulating supports 44, except for the top one, are pivotable about their own axes selectively to position the conductive inserts for engagement or non-engagement by the wires 40, according to whether a given stop is active or not.

Reference now should be made to FIG. 3 wherein the percussion amplifier is shown in deail. A jack 50 is provided for tone input to the percussion amplifier hereinafter identified generally by the numeral 52. The tone input is from the key switches, preferably through a preamplifier and through wave shaping filters, and conventionally also including various organ stop switches. The input at the jack 50 is conventionally connected to a triode phase inverter 54 having the usual equal value plate and cathode resistors 56 and 58 respectively. The plate resistor 56 is connected through the usual resistance-capacitance decoupling or smoothing resistance-capacitance filter 60 to a junction 62, and thence through a resistor 64 to a B+ supply line as indicated at 66. The B+ voltage preferably is obtained from a power amplifier in the usual fashion. The plate output of the phase inverter 54 is conventionally resistance-capacitance coupled to the grid 68 of a triode vacuum tube 70. The cathode output is resistance-capacitance coupled to the grid 72 of a triode vacuum tube 74.

The tubes 70 and 74 are push-pull connected, the respective plates 76 and 78 thereof being connected to the opposite ends of the input winding 80 of a transformer 82. The input winding is provided with a center tap 84, and this is connected to the junction 62 leading to the B+ supply line.

The cathode 86 of the tube 70 is connected through a cathode resistor 88 to a junction 90. The cathode 92 of the tube 74 is similarly connected through a cathode resistor 94 to the junction 90. This junction is connected

through a resistor 96 to the center tap of the transformer, and is also connected to a bias determining filter 98 comprising a grounded resistor 100, and a capacitor 102 in parallel therewith. The resistor 100 is quite small relative to the resistor 96 representative values being 3900 and 150,000 ohms respectively. The capacitor 102 is a power supply capacitor, for example 25 mfd. The top of the filter 98 is connected through a line 104 to a series connected potentiometer 106 and a fixed resistor 108. The potentiometer is somewhat smaller than the fixed resistor, for example being on the order of 1000 ohms, with the fixed resistor 168 being on the order of 1500 ohms. The fixed resistor is connected to terminal number 6 of a percussion socket 110. The significance of this connection will be brought out hereinafter.

A triode tube 112 has its plate 114 connected directly to the plate 76 of the tube 70. Furthermore, the cathode 116 of the tube 112 is directly connected to the cathode 86 of the tube 70.

Similarly, the plate 118 of a triode tube 120 is directly connected to the plate 78, while the cathode 122 thereof is directly connected to the cathode 92. The grids 124 and 126 of the respective tubes 112 and 120 are connected in parallel to a line 128. Further connection of this line will be set forth hereinafter.

The phase inverter 54, the tubes 70 and 74, the tubes 112 and 120, and associated circuit parts will be recognized as being a "variable losser" circuit of the type sometimes used for volume expansion. The tubes 112 and 120 variable load the tubes 70 and 74. When the grids of the tubes 112 and 120 are biased for cutoff, the plate resistance of the tubes 112 and 120 is so high as to throw very little load on the tubes 70 and 74, the output thereof accordingly being at a maximum. However, when the tubes 112 and 120 are biased for conduction, the plate resistance thereof drops, and the tubes 70 and 74 are loaded, whereby the output thereof as applied to the transformer 82 is reduced. As will be brought out more clearly hereinafter, the grid bias of the tubes 112 and 120, as effected through the line 128, is varied to produce a percussive effect.

The secondary winding 130 of the transformer 82 is grounded at one end as indicated at 132. The opposite end of the transformer is connected to a wire 134 leading through a resistor 136 of relatively high value, for example 2.2 megohms to an output plug or jack 138. The transformer secondary is bypassed by a series combination of a resisotr 140 and capacitor 142, with an additional resistor 144 also connected across the transformer secondary. A connection also is made from the wire or line 134 through a resistor 146 of relatively low value, for example 22,000 ohms, to contact number 2 of the percussion socket 110.

In the lower right hand portion of FIG. 3, there will be seen a subsidiary B+ line 148 connected through a resistor 150 to the junction 62 leading to the B+ supply at 66. Connected to the line 148 is a voltage divider comprising a resistor 152 in series with a grounded resistor 154. The two resistors 152 and 154 are of equal value, for example 100,000 ohms. The junction between these two resistors is connected to contact number 3 of the percussion socket 110.

The B+ line 148 further is connected through a plate load resistor 156 to the plate 158 of a triode vacuum tube 160. The grid 162 of this tube is shunted by a grid resistor 164 and is connected to contact number 5 of the percussion socket 110.

The cathoed of the tube 160, as indicated at 166, is connected through a resistor 168 to ground. The resistor 168 is paralleled by a capacitor 170 of rather high value, for example 25 mfd. The cathode also is connected through a resistor 172 to the B+ line 148. The resistor 172 is much larger than the resistor 168. For example, the resistor 172 may be 100,000 ohms, while the resistor 168 may be 2700 ohms.

The plate 158 also is connected through a capacitor 174 to one electrode of a neon bulb 176. The capacitor 174 is of significant size, for example being .47 mfd. The opposite electrode of the neon bulb is connected at a junction 178 to a resistor 180 leading to contact number 4 of the percussion socket 110. This resistor, for example may be 150,000 ohms. The junction 178 is grounded through a capacitor 182 of larger capacity than the capacitor 174. For example, the capacitor may be 1 mfd. The junction is also connected to the grid 184 of a triode 186. The plate 188 of this tube is connected to the B+ line 148. A smoothing capacitor 189, for example of 20 mfd., is connected from the plate to ground.

The cathode 190 of the tube 186 is connected through a cathode resistor 192 to ground. The resistor is paralleled by a capacitor 194 of significant size, for example 0.1 mfd. The cathode further is connected to the line 128 leading to the grids 124 and 126 of the loading tubes 112 and 120.

Connection is made from the grid 184 of the triode 186 through a wire 196 to one cathode 198 of a dual diode 200. The corresponding plate 202 is connected to the plate 204 of the other diode, and both plates are connected across a network comprising a resistor 206 and a capacitor 208 in parallel with one another, and connected to ground. The resistor, for example may be 10,000 ohms, while the capacitor, for example may be 25 mfd. The remain cathode 210 is connected to a 12 volt secondary winding 212 of a transformer 214 having a 110 volt input winding 216. If desired, the secondary winding 212 may be incorporated in the main power transformer of the electronic organ.

Some of the triodes shown may be triode sections of dual tubes. Thus, for example, the tubes 70 and 74 may be the two halves of a 12AX7. Similarly, the triodes 112 and 120 may be the two sections of another 12AX7 tube, while the two triodes 160 and 186 may be the two halves of a 12AU7 tube. As previously indicated, the tube 200 comprises a dual diode, for example a 6AL5 tube. The filaments of all of the tubes are conventionally shown at 218 connected across the 6.3 volt A.C. filament winding as indicated at 220.

As will be understood, the normally 12 volt tubes have their filaments connected for 6 volt operation. Also connected across the filament winding through a small resistor 222, for example of 27 ohms, is a light bulb 224. The light bulb physically is in close proximity to the neon bulb 176 and conveniently is placed in a small housing therewith. The reason for this is that neon bulbs, type NE2 for example, are somewhat photosensitive, and are much more reliable in operation when exposed to light.

Reference now should be had to the upper portion of FIG. 3 wherein there is shown the percussion plug 26 cooperable with the socket 110. Pin number 3, carrying B+ from contact number 3 of the socket, is connected to the common bus 48 previously referred to in connection with FIG. 2. This bus is normally engaged by all of the whisker percussion contacts. Each of these contacts is connected to a capacitor 228 in series with a grounded resistor 230. By way of example, the capacitor may be .047 mfd., and the resistor may be 2200 ohms. As will be understood, there is one whisker contact 40, and the corresponding capacitor 228 and resistor 230, for each key of the organ. When the key corresponding to any given whisker contact 40 is depressed, that contact 40 is moved away from the fixed bus 48 into engagement with the bus 42 immediately therebeneath. As will be understood, there is only one bus 42 cooperable with all of the whisker contacts 40 for the percussion, and similarly there is only one bus 48. The bus 42 is connected to a fixed contact 232 of a percussion switch, the switch being shown in off posiiton.

Operation of the percussion circuit is effected by closing of the percussion switch, hereinafter identified by the numeral 234, to bring movable contact 236 into engage-

ment with the fixed contact 232, whereby to apply the B+ charge on capacitor 228 to pin 5 of the plug 226, and hence to the grid 162 of the triode 160.

The movable switch arm 236 is ganged as indicated at 238 with a movable switch arm 240. This movable switch arm is connected to the braid or shielding 242 of a cable or wire. The braid is connected to pin number 1 of the plug 226, and hence is grounded. The movable contact 240 normally engages an upper fixed contact 244, connected through the shielded wire 246 to pin 2 of the plug 226. Hence, with the switch in normal "off" position pin 2 is grounded, and resistor 146 shunts the output of the circuit. When the switch is moved to "on" position, the movable contact 240 engages a lower fixed contact 248. This contact is connected to pin number 6 of the percussion plug 226.

Operation of the percussion circuit is as follows: With the percussion switch 234 in the "on" or lowered position, whenever the whisker 40 of any key switch is lowered from the B+ bus 48 to the collector bus 42, the charge on condenser 228 associated therewith applies a positive potential through the switch contacts 232 and 236, and through the pin 5 and contact 5 of the plug 226 and socket 110 to the grid 162 of the triode 160. The tube 160 is normally cut off. However, since the capacitor 228 is normally charged to 100 volts, the tube 160 is suddenly biased to conduction. However, the capacitor 228 discharges through the resistors 230 and 164, whereby conduction of the tube 160 quickly decays.

The neon bulb 176 is normally non-conducting, and the side of the capacitor 174 toward this bulb is at substantially ground potential. A resistor 177 on the same order of size as the resistor 156, say 100,000 ohms, shunts the first mentioned electrode of the neon bulb 176 to ground. The opposite side of the capacitor 174 is at approximately 200 volts above ground. The neon bulb 176 will become conductive with about 90 volts potential across it, and will stop conducting when the voltage across it drops to about 60 volts. Normally, as noted above, it is non-conducting. However, when the tube 160 is pulsed, the plate potential thereof drops rather markedly, and the potential of the plate of the capacitor 174 which is connected to the neon bulb 176 provides a negative pulse of about 140 volts below ground to the neon bulb. This bulb then becomes conductive. The capacitor 182 is charged negatively, and the neon bulb 176 stops conducting when this charge has built up to a sufficient potential. Hence, the neon bulb functions as any electronic switch, and the tube 160 may be considered to be a trigger tube.

The charge on the capacitor 182 leaks off through the resistor 180, and through a potentiometer 250 connected in series therewith and adjacent the percussion switch 234, the connection being made through pins 4 and 1 of the plug 226 and the corresponding contacts of the socket 110. A negative pulse is thus applied to the grid 184 of the triode 186, either cutting off this tube, or substantially reducing its conduction. This markedly lowers the bias on line 128 and hence the grid bias of the loading triodes 112 and 120.

Normally, the triodes 112 and 120 are conducting. When they are in this condition, they load the tubes 70 and 74 to a greater or lesser extent. When the negative potential is suddenly applied to the grids, the tubes 112 and 120 are suddenly cut off, and the tubes 70 and 74 are not loaded. Hence, the electrical tone oscillations applied at the input at 50 are simply passed through to the output at 138 with some degree of amplification. However, as soon as the neon bulb 176 has extinguished, the charge on the capacitor 182 leaks off through the resistor 180 and the potentiometer 250, and the tube 186 thus becomes progressively more conductive. The potential of the cathode 190 rises accordingly, as does the potential on the line 128. Hence, the grids 124 and 126 become progressively more positive, and the tubes 112 and 120 become progressively more conductive, whereby to place an ever increasing load on the tubes 70 and 74 and thereby to diminish the output at 138. The tones thus produced are started quite rapidly, and decay at a rate controlled by the setting of the potentiometer 250. Hence, a variable percussion is produced.

The dual diode 200 serves as a clamp tube and limiter to prevent the capacitor 182 from being charged beyond a predetermined value. This is of importance when successive notes are played percussively, as the succession of charges on the capacitor 174 transferred through the switching neon bulb 176 would charge the capacitor 182 to a sufficiently high potential that the tube 186 would remain cut off for a considerable time, whereby the output of the circuit would remain at a constant level for some time before beginning to decay, whereas the decay should desirably start substantially instantaneously. With the clamp tube-limiter 200, any voltage over the desired value is discharged to ground through the power supply. The rectifier section of the diode applies a predetermined D.C. bias from the power supply to the clamp section of the diode to control the cut in point of its action.

The grids of the loading or control tubes 112 and 120 have a normal positive potential of 12 volts from the cathode of the tube 186. This requires that the cathode circuit of the control tubes 112 and 120 and of the output tubes 70 and 74 be raised to 12.8 volts to establish the correct operating bias for these tubes. Due to tube variations and component variations, this operating point would be difficult to maintain. Accordingly, the 1,000 ohm potentiometer 106 is included to give some adjustment to this operating point. For proper adjustment, the percussion is turned on, stops are drawn on the organ, a chord is played, and is held. When the signal diminishes, a certain amount of signal will still pass through the percussion amplifier. The potentiometer 106 is then adjusted until the signal is substantially biased off.

The resistor 146 shunts the output when the sustain switch is in "off" position. It does not shunt the output when the switch is in "on" position. This is done to prevent an apparent drop in output when percussion is used, especially with short sustain for the percussion, as adjusted by the potentiometer 250.

Besides loading the tubes 70 and 74, the tubes 112 and 120 when conducting reduce the conduction of tubes 70 and 74 due to the common cathode resistors which raise the cathode bias when the tubes 112 and 120 conduct.

Reference has been made heretofore to incorporation of the percussion amplifier 52 in the organ, and this may be seen more clearly with reference to the block diagram of FIG. 5. Thus, the tone generators are indicated at 252. These generators may be of any desired type to produce electrical oscillations corresponding to musical tones. The tone generators are connected to the key switches 254, including the various whisker contacts 40 and the collectors or busses 42. The output from the key switches, except for the one whisker contact 40 controlling the percussion, is connected to a preamplifier unit 256 including wave shaping filters. The properly preamplified and shaped tones at 256 are then applied to the percussion amplifier 52, by means of the input jack 50. The output from the jack 138 of the percussion amplifier is applied to a power amplifier 258, and the output of the power amplifier is connected to the loudspeaker 26.

A circuit is shown in FIG. 4 which is usable in cooperation with the percussive circuit to produce a plucking effect, as with a guitar. The circuit of FIG. 4 comprises mainly a free running multi-vibrator 260 of generally conventional construction and including a dual triode vacuum tube 262. One plate of this tube is coupled by a capacitor 264, a shunting resistor 266 of large value, and a large value resistor 268 to a terminal identified at *x*. The terminal *x* is connected through a coupling capacitor 270 to a junction 272, the latter being grounded through a resistor 274. The junction 272 is connected by a wire 276 to a fixed "on" contact 278 of a foot switch

identified generally by the numeral 280. The foot switch further includes a grounded movable contact 282 engageable with the fixed contact 278, and also engageable with a fixed "off" contact 284 which is not connected to anything.

The corresponding grid of the dual triode 262 is directly connected by a wire 286 to terminal No. 1 of a socket 288. Terminal No. 2 of the socket is grounded, while terminal No. 3 is connected to another terminal or junction identified at Y.

A plug 290 cooperates with the socket 288. Pin No. 2 of the plug is connected to a second movable contact 292 of the foot switch 280, ganged for movement with the movable contact 282. In the "off" position shown, the movable contact 292 engages a fixed contact 294 which is directly connected to terminal No. 1 of the plug 290. Terminal No. 3 of the plug is directly connected to a fixed contact 296 with which the movable contact 292 is engageable when the latter is moved to the "on" position.

When the repeater or plucker circuit of FIG. 4 is incorporated in the organ, point *x* of the circuit is connected to point *x* in the circuit of FIG. 3 leading to the grid 162 of the trigger tube 160. Similarly point *y* is connected to point *y* of FIG. 3, this being in the discharge path for the capacitor 182 and specifically, between the single resistor 180 and potentiometer 250.

The movable switch contact 292 when on the "off" contact 294, as illustrated, grounds one grid of the multivibrator tube 262 through the line 286 whereby the multivibrator is kept from operating. When the switch contact 292 is moved down to the fixed contact 296, ground is connected to the bottom of the resistor 180, thereby removing ground from the multi-vibrator grid which then proceeds to run freely, and shorting out the potentiometer 250, thereby adjusting the time constant for the capacitor 182 and its discharge path. Simultaneously, the switch arm 282 is moved to the fixed contact 278. Pulses to the trigger tube 160 thus are shunted to ground, thereby preventing the normal operation of the percussion. The percussion is repeated at a predetermined rate by the multi-vibrator 260. A plucked type of tone thus is produced, and in particular, a banjo can be readily simulated.

Various modifications for keying of the percussion amplifier are shown in FIGS. 6–8. The original form disclosed in connection with FIG. 3, particularly including the capacitor 228, works extremely well. However, it requires one capacitor for each note, and capacitors are rather expensive. This may be seen particularly well with reference to FIG. 6. Thus, there will be seen certain of the parts previously described, including the common bus bar 48 for cooperation with all of the whisker contacts of which five are shown in FIG. 6, these five being identified as 40–1 to 40–5. All of these whisker contacts 40–1 etc. are selectively cooperable with the collector 42 which is connected as heretofore described to the trigger tube 160, and to the ensuing parts associated therewith.

Although only five whisker contacts have been shown, it will be understood that the actual number in an organ would be much larger and equal to the number of keys. With each of these whisker contacts there is associated one of the capacitors 228, shown in FIG. 6 as 228–1 through 228–5, and corresponding resistors 230–1 through 230–5. The expense of the resistors 230–1 etc. is not great, but the expense of the several capacitors 228–1 etc. is rather substantial.

A circuit is shown in FIG. 7 wherein the capacitors 228–1 etc. are eliminated thereby materially reducing the cost. In this embodiment of the invention, similar parts are identified by numerals similar to those used heretofore with the addition of the suffix *a*. In this embodiment, there is still a plurality of whisker contacts, herein shown as 40*a*–1 through 40*a*–8, it being understood that the actual organ embodies a great many more of these contacts. A common B+ bus bar 48*a* is provided for engagement with all of the whisker contacts 40*a*–1 etc., and charged to, for example, 300 volts. The whisker contacts normally are not in engagement with the bus bar 48*a*. Each of the whisker contacts has connected thereto a resistor, herein shown as 298–1 through 298–8, all of the resistors being connected to a common wire 300. This wire is shunted to ground through a resistor 302, and is connected through a capacitor 304 to the junction 306 between a grounded resistor 308 and a resistor 310 leading to the grid 162*a* of the trigger tube 160*a*.

Relative values of the components in the circuit of FIG. 7 are important. Thus, by way of example, the key switch resistors 298–1 etc., each have a value of one megohm. The common resistor 302 has a value of 150,000 ohms. The capacitor 304 has a value of .0082 mfd. while the grid resistor 308 has the value of one megohm. The value of the resistor 310 is less critical but may be taken as 100,000 ohms.

When the first key is depressed, a 300 volt D.C. voltage is picked up from the bus 48*a* by the corresponding whisker contact 40*a*. This is divided by approximately 10 to 1 and charges the capacitor 304 through the grid resistor 308, providing a positive pulse to the grid 162*a* of the trigger tube 160*a*. From this point, the percussion circuit is the same as, and operates the same as the circuits previously described in connection with FIG. 3.

Each time an additional key is depressed, the one megohm resistor 298 associated with the corresponding whisker contact is connected in parallel with the previous resistor 298, assuming the first key remains depressed. This decreases the resistance of the upper part of the voltage divider, and thus raises the voltage at the top of the common resistor 302. This causes the capacitor 304 to be charged to the new voltage at the top of the resistor 302, thus providing another pulse to the grid of the trigger tube 160*a*. Each time another key is depressed, another pulse is applied in the same manner. However, subsequent pulses become smaller and smaller because of the paralleling of the resistors 298 until the charging circuits will no longer be actuated. With 300 volts on the bus bar 48*a*, it is possible to hold six keys down, and to obtain percussion upon depression of the seventh. However, this requires 300 volts on the B+ bus, as opposed to 100 volts in the previously described circuit.

A further variation of the key switches of FIG. 7 is shown in FIG. 8, operation being generally the same, and similar parts being identified by similar numerals, with the addition of the suffix *b*. In this instance, there is provided a common grounded bus 312. This bus is engaged normally by some of the whisker contacts and not by others. By way of example, the alternate contacts 40*b*–1, 40*b*–3 etc. engage the grounded bus 312 with the keys in rest position, while the whisker contacts 40*b*–2, 40*b*–4 etc. do not engage anything. When any key is depressed, its corresponding whisker contact 40*b* is moved into engagement with a B+ bus 48*b* charged to 300 volts.

As wil be seen, upon actuation of successive keys, resistors are connected in parallel to the B+ side of the voltage divider, while resistors are also removed from the parallel combination on the ground side of the voltage divider. By this means, the voltage steps used in charging the capacitor 304*b* are controlled so that the pulses produced are more nearly uniform. Correspondingly, the range over which the percussion can be produced, i.e. the number of keys that can be held down and yet still have another key produce percussion, is greatly extended.

It will be understood that the various examples of the invention as herein shown and described are set forth by way of illustration only. Various changes in structure will no doubt occur to those skilled in the art and will be understood as forming a part of this invention insofar as they fall within the spirit and scope of the appended claims.

The invention is claimed as follows:

1. Percussion means for an electronic musical instrument having electro-acoustic translating means and tone generating means for producing electric oscillations corresponding to musical tones and further having a plurality of keys and key switches for controlling said oscillations, comprising amplifier means having input means connected to said key switch means and tone generating means and further having output means connected to said electro-acoustic translating means, means providing a variable load across said amplifying means output means, a plurality of percussion switches connected to and selectively operable by said keys, electric means connected to said percussion switches and operable by any thereof to produce a pulse, and means electrically interconnecting said pulse producing means and said variable load for varying the load thereof across said amplifying means output means as a pulse to produce a percussion effect in the electronic oscillations applied to said electro-acoustic translating means.

2. Percussion means as set forth in claim 1 wherein the means providing the variable load comprises means providing an impedance varying with applied bias, and wherein the interconnecting means comprises means biasing said impedance in accordance with the pulses produced.

3. Percussion means as set forth in claim 2 wherein the impedance comprises the anode to cathode resistance of an electronic valve.

4. Percussion means as set forth in claim 2 wherein the impedance comprises the plate resistance of an electronic discharge tube.

5. Percussion means for an electronic musical instrument having electro-acoustic translating means and tone generating means for producing electric oscillations corresponding to musical tones and further having a plurality of keys and key switch means for controlling said oscillations, comprising amplifier means connected from said key switch means and tone generating means to said electro-acoustic translating means, said amplifier means including a push-pull stage having a pair of electron tubes each with a plate, a control grid and a cathode, a pair of push-pull connected electron tubes comprising a variable load across the push-pull stage of the amplifier means, said pair of tubes each having a plate, a grid and a cathode, the plates of the load tubes being connected in parallel with the plates of the push-pull amplifier stage and the cathodes of said load tubes being connected in common with the cathodes of the push-pull amplifier tubes, the grids of the load tubes being connected in parallel with one another and independent of the grids of the push-pull amplifier tubes, a plurality of percussion switches connected to and selectively operable by said keys, means connected to said percussion means and operable by any thereof to produce a pulse, and means electrically interconnecting said pulse producing means and the grids of said load tubes for varying the load imposed by said load tubes on the push-pull amplifier stage as a pulse to produce a percussion effect in the electric oscillations applied to said electro-acoustic translating means.

6. Percussion means for an electronic musical instrument having electro-acoustic translating means and tone generating means for producing electric oscillations corresponding to musical tones and further having a plurality of keys and key switch means for controlling said oscillations, comprising amplifier means connected from said tone generating means and said key switch means to said electro-acoustic translating means, means providing a variable load across said amplifier means, means operated by said keys and key switches for producing pulses, means for producing a succession of pulses independently of operation of said keys, means connected to said pulse providing means and to said variable load for varying the load thereof across said amplifier means as a pulse to produce a percussion effect in the electrical oscillation applied to said electro-acoustic translating means.

7. Percussion means as set forth in claim 6 and further including a plurality of percussion switches connected to and selectively operably by said keys, and manual switch means for disabling the key operated percussion switches and for connecting the successive pulse producing means to the variable load.

8. Percussion means for an electronic musical instrument having electro-acoustic translating means and tone generating means for producing electric oscillations corresponding to musical tones and further having a plurality of keys and key switches for controlling said oscillations, comprising amplifier means connected from said key switches and said tone generating means to said electro-acoustic translating means, said amplifier means having means therein for varying the gain of said amplifier according to the bias applied thereto, a plurality of movable percussion switch contacts respectively connected to and selectively movable by said keys, capacitor means, a common D.C. bus with which all of said movable percussive switch contacts are alternatively engageable and non-engageable, means connecting said capacitor means to said movable percussion switch contacts whereby the potential on said capacitor means is changed as the condition of engagement and non-engagement of said movable percussion switch contacts with said bus is selectively changed to produce pulses, and means connecting said capacitor means to said amplifier gain varying means whereby the gain of said amplifier is increased and decreased by said pulses to provide a percussive effect.

9. Percussion means as set forth in claim 8 wherein all of the movable percussion switch contacts normally engage the common D.C. bus, wherein the capacitor means comprises a plurality of capacitors respectively connected to said movable switch contacts, and further including a common collector bus selectively engageable by said movable percussion switch contacts, a common discharge resistor connected to said last mentioned bus, said common discharge resistor comprising a part of the means connecting the capacitor means to the amplifier gain varying means.

10. Percussion means as set forth in claim 8 and further including means including a plurality of resistors respectively connected to each movable percussion switch contact, means forming with the percussion switch contact resistors a voltage divider having an output junction, the potential at said output junction changing as the condition of engagement of said movable percussion switch contacts with said common D.C. bus is varied, said voltage divider output junction being connected to said capacitor means.

11. Percussion means for an electronic musical instrument as set forth in claim 8 and further including a plurality of resistors respectively connected to said movable percussion switch contacts, all of said resistors being connected to a common point, a common resistor connected from said common point to ground and forming with said plurality of resistors a voltage divider, said capacitor means comprising a single capacitor connected from said common point, all of said movable percussion switch contacts normally being out of engagement with the common D.C. bus and selectively brought into engagement therewith to vary the resistance in one portion of the voltage divider, whereby to vary the potential at said common point.

12. Percussion means as set forth in claim 8 and further including a common ground bus with which at least some of said movable percussion contacts are normally in engagement, a plurality of resistors respectively connected to said movable percussion switch contacts, and a common bus to which all of said resistors are connected, said capacitor means comprising a single capacitor connected in series between said last mentioned common bus and the means connecting the capacitor means to the amplifier gain varying means.

13. Percussion means for an electronic musical instrument having electro-acoustic translating means and tone

generating means for producing electric oscillations corresponding to musical tones and further having a plurality of keys and key switches for controlling said oscillations, comprising amplifier means connected from said tone generating means and said key switches to said translating means, said amplifying means incorporating means for varying the gain of said amplifying means according to an electric potential applied to said gain controlling means, percussion switch means operated by said keys for producing electric pulses, and electric circuit means connecting said percussion switch means to said gain controlling means and including a normally open on-off electronic switch normally off automatically on momentarily upon application of a pulse thereto.

14. Percussion means as set forth in claim 13 wherein the electronic switch means comprises a gas diode.

15. Percussion means for an electronic musical instrument having electro-acoustic translating means and tone generating means for producing electric oscillations corresponding to musical tones and further having a plurality of keys and key switches for controlling said oscillations, comprising amplifier means connected from said tone generating means and key switches to said translating means, said amplifier means incorporating means for varying the gain of said amplifier means according to an electrical potential applied to said gain controlling means, means including percussion switch means operated by said keys for producing electric pulses, a normally cut off electron tube connected to said pulse producing means and momentarily rendered conductive by said pulses, and circuit means connecting said electron tube to said gain varying means and including a normally open on-off electronic switch automatically closing momentarily upon conduction of said tube.

16. Percussion means as set forth in claim 15 wherein the pulse producing means comprises capacitor means connected to said percussion switch means, the potential on said capacitor means being varied by manipulation of said percussion switch means.

17. Percussion means for an electronic musical instrument having electro-acoustic translating means and tone generating means for producing electric oscillations corresponding to musical tones and further having a plurality of keys and key switches for controlling said oscillations, comprising amplifier means connected from said tone generating means and key switches to said translating means, said amplifier means having means for varying the gain of said amplifier means according to an electric potential applied to said gain controlling means, capacitor means, means for charging said capacitor means, normally open on-off electronic switch means connected from said capacitor means to said gain varying means, and means including percussion switch means connected to and selectively operable by said keys for closing said electronic switch means and for simultaneously discharging said capacitor means to vary the potential applied through said electronic switch means to said gain varying means to produce a decaying tone characteristic.

18. Percussion means as set forth in claim 17 wherein the electronic switch means comprises a gas diode.

19. Percussion means as set forth in claim 17 and further including an electronic valve having an input and output, the output thereof being connected to said electronic switch, a second capacitor connected to the input of said electronic valve, said electronic valve being normally cut off, and means including the pulse producing means for momentarily rendering said electronic valve conductive and thereby rapidly changing the potential on the first mentioned capacitor to operate the electronic switch.

20. Percussion means as set forth in claim 19 wherein the electronic switch comprises a gas diode, and whereby the change in potential on the first mentioned capacitor causes the gas diode to break down, discharging said first mentioned capacitor and extinguishing said gas diode.

21. Percussion means for an electronic musical instrument having electro-acoustic translating means and tone generating means for producing electric oscillations corresponding to musical tones and further having a plurality of keys and key switches for controlling said oscillations, comprising amplifier means connected from said tone generating means and key switches to said translating means, amplifier means incorporating means for varying the gain of said amplifier means according to an electric potential applied to said gain controlling means, means including percussion switch means connected to and operated by said keys for producing electric pulses, an electronic valve normally biased substantially to cut off and connected to said pulse producing means, said valve being rendered conductive upon said pulses being applied thereto, said electronic valve having an anode connection, a dropping resistor supplying potential to said anode connection, a capacitor connected to said anode connection and normally charged through said dropping resistor, the opposite side of said capacitor having a terminal, a gas diode connected to said terminal and a resistor shunting said terminal to ground, said gas diode being normally non-conductive, and circuit means connecting said gas diode to the potential varying means of the amplifier means, the potential applied to said anode connection through said dropping resistor changing quite markedly upon application of a pulse to said electronic valve and thereby causing said capacitor to raise the potential of said gas diode to cause said gas diode to fire, said capacitor discharging through said shunt resistor and said gas diode subsequently becoming extinguished, conduction of said gas diode causing transmission of a pulse to the gain varying means of the amplifier.

22. Percussion means as set forth in claim 21 and including an additional capacitor connected to said gas diode on the opposite side of the previously mentioned capacitor and charged through said gas diode when said gas diode conducts, a discharge path for the additional capacitor, an electronic valve normally biased substantially to cut off and rendered conductive upon charging of said additional capacitor and subsequently decaying to substantial non-conduction as said additional capacitor discharges, and means connecting the last mentioned electronic valve to the gain varying means of the amplifier for varying the gain of the amplifier as the conduction of said valve changes.

23. Percussion means as set forth in claim 22 and including an additional capacitor connected from ground to the side of the gas diode opposite the first mentioned capacitor, a discharge path for said additional capacitor, said additional capacitor being charged from the first mentioned capacitor through said gas diode upon conduction of said gas diode, and wherein the circuit means connects the additional capacitor to the gain varying means of the amplifier to vary the gain thereof according to the charge on the additional capacitor.

24. Percussion means as set forth in claim 23 and further including means limiting the charge applied to the additional capacitor to a predetermined value.

25. Percussion means for an electronic musical instrument having electro-acoustic translating means and tone generating means for producing electronic oscillations corresponding to musical tones and further having a plurality of keys and key switches for controlling said oscillatiions, comprising amplifier means connected from said tone generating means and key switches to said translating means, said amplifier means including a push-pull stage having two electron discharge tubes each having a plate, a cathode and a control grid, a cathode resistor connected to each cathode, the cathode resistors having a common ground return, the grids being similarly energized 180 degrees out of phase, positive voltage supply means for said plates, variable load means for said push-pull state comprising a pair of electron discharge tubes each having a plate, a cathode and a control grid, the plates respectively being connected to the plates of the first mentioned electron dis-

charge tubes, and the cathodes of the loading tubes being directly connected to the corresponding cathodes of the push-pull tubes, the grids of the loading tubes being connected in parallel with one another and independent of the push-pull tubes, circuit means connecting the plates of the push-pull tubes to the translating device, means including percussion key switch means and capacitor means connected in circuit therewith for producing pulses, said percussion key switch means being connected to and selectively operable by said keys, a normally cut off trigger tube having a plate, a cathode and a control grid, means connecting the pulse producing means to the control grid of the trigger tube to render said trigger tube conductive in pulses, a resistor connected to the plate of the trigger tube for supplying voltage thereto, a capacitor having one side thereof connected to the plate of the trigger tube, a resistor shunting the opposite side of the capacitor to ground, said capacitor being charged through the aforementioned resistor, a gas diode connected to the opposite side of the capacitor, a second capacitor connected to the other side of the gas diode, a discharge path for said second capacitor, said gas diode normally being non-conductive but conducting when the trigger tube conducts in pulses, thereby changing the voltage on the plate of the trigger tube and hence the voltage on the first mentioned capacitor, said second capacitor thereby being charged and subsequently discharging through its discharge path upon extinction of the gas diode, a control grid being connected to the second capacitor and biased thereby, said control tube being normally substantially cut off and rendered suddenly conductive and having the conduction thereof subsequently decay as the second capacitor is charged and subsequently discharges, and cathode coupling means from said control tube to the grids of the amplifier loading tubes whereby to vary the conduction and hence the plate resistance of the loading tube, thus varying the loading of the push-pull tubes and producing a percussion in the output of the amplifier.

26. Percussion means for an electronic musical instrument having electro-acoustic translating means and tone generating means for producing electric oscillations corresponding to musical tones and further having a plurality of keys and key switches for controlling said oscillations, comprising tone transmission means connected between said tone generating means and said translating means, said toe transmission means having means for varying the efficiency of tone transmission therethrough according to an electric potential applied to said efficiency controlling means, said key switches including a plurality of percussion switches each comprising a pair of fixed contacts and a movable contact alternatively engageable with said two fixed contacts, at least one of each of said fixed contacts having a predetermined potential applied thereto, and electric circuit means connected to one of the two remaining contacts of each percussion switch and to said efficiency controlling means and including a gas diode normally biassed to non-conduction with the movable contacts engaging the biassed fixed contacts and rendered conductive upon movement of at least one of the percussion switch movable contacts away from the corresponding biassed fixed contact to the other fixed contact thereby to vary the efficiency of transmision of said tone transmission means.

References Cited in the file of this patent

UNITED STATES PATENTS

2,695,386	Schmidt	Nov. 23, 1954
2,712,040	Heytow	June 28, 1955
2,823,310	Anderson	Feb. 11, 1958
2,846,914	Wolgast	Aug. 12, 1958
2,848,919	Hanert	Aug. 26, 1958
2,916,957	Hanert	Dec. 15, 1959
2,918,576	Munch	Dec. 22, 1959
2,953,055	Hanert	Sept. 20, 1960
3,003,383	Williams	Oct. 10, 1961