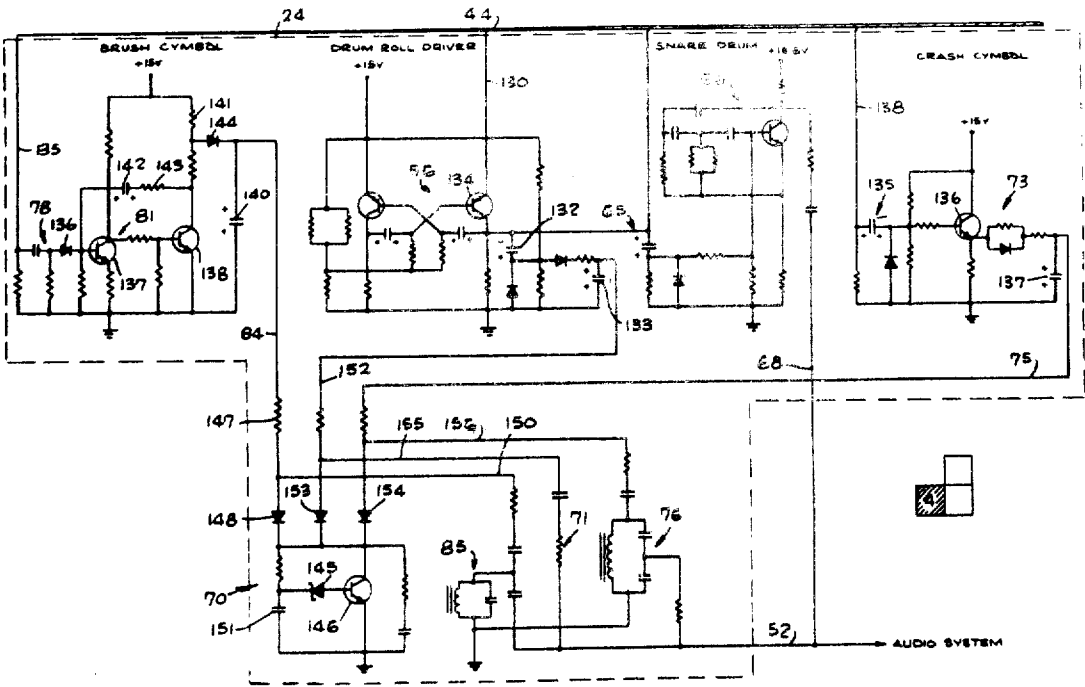


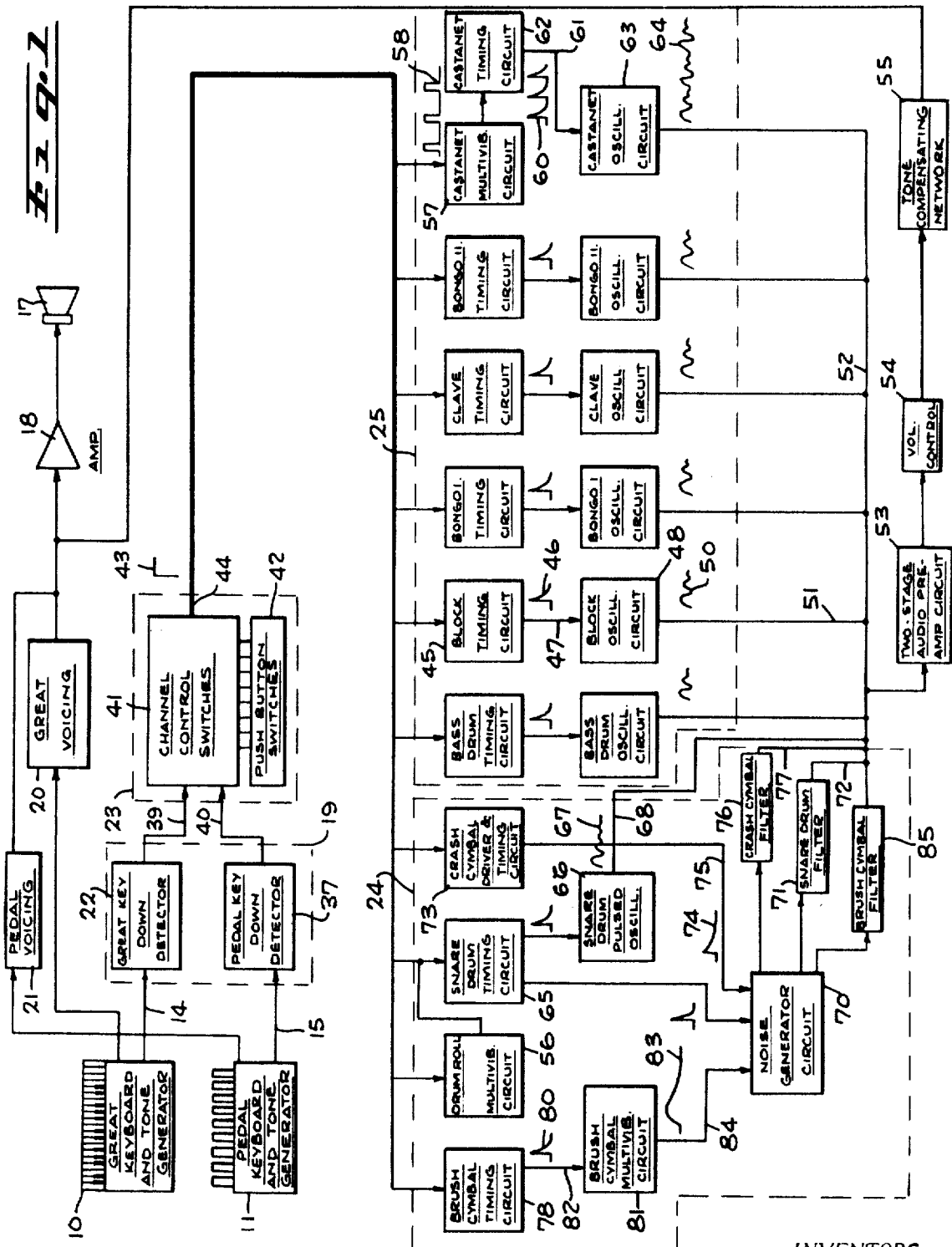
[72] Inventors **Ralph L. Dodds;**
Bradley J. Plunkett, both of Los Angeles,
Calif.
[21] Appl No **828,047**
[22] Filed **Mar. 21, 1969**
Division of Ser. No. 466,551, June 24, 1965,
Pat. No. 3,439,569
[45] Patented **July 13, 1971**
[73] Assignee **Warwick Electronics Inc.**
Chicago, Ill.

[56] **References Cited**
UNITED STATES PATENTS
3,165,707 1/1965 Ciapper 331/78
3,209,279 9/1965 Kanibouris 331/78
3,247,309 4/1966 Campbell 84/1.17
3,281,711 10/1966 Kees et al 331/78
Primary Examiner—Roy Lake
Assistant Examiner—Siegfried H. Grimm
Attorney—Roger A. Marrs

[54] **NOISE GENERATOR AND ACTUATING CIRCUIT**
FOR MUSICAL INSTRUMENTS
5 Claims, 4 Drawing Figs.
[52] U.S. Cl. 331/78,
84/1.24, 84/1.26, 331/46
[51] Int. Cl. H03b 29/00
[50] Field of Search 331/78;
1/46, 1.26, 84/1.24

ABSTRACT: A noise generator circuit is disclosed herein having a transistor amplifier operated by a noise diode connected to its base electrode. The noise diode is operated in response to a selected one of a plurality of decoupling diodes arranged in a network with respect to a plurality of voicing oscillators. A collector resistor couples the decoupling diode network to respective ones of the voicing oscillators. The oscillators may be of the phase shift or the multivibrator type.



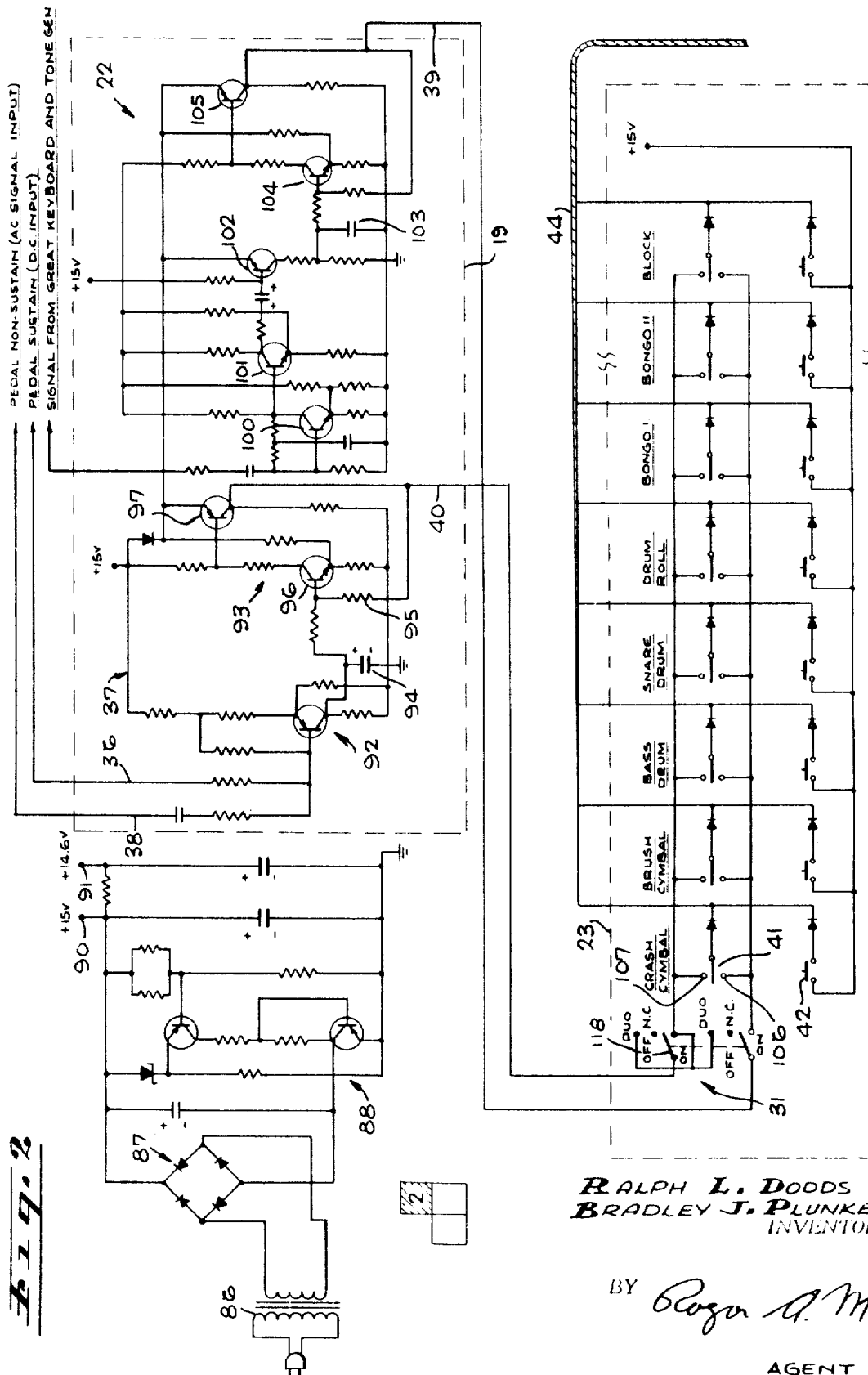


INVENTORS
RALPH L. DODDS
BRADLEY J. PLUNKETT

BY

Raymond G. Morris

AGENT

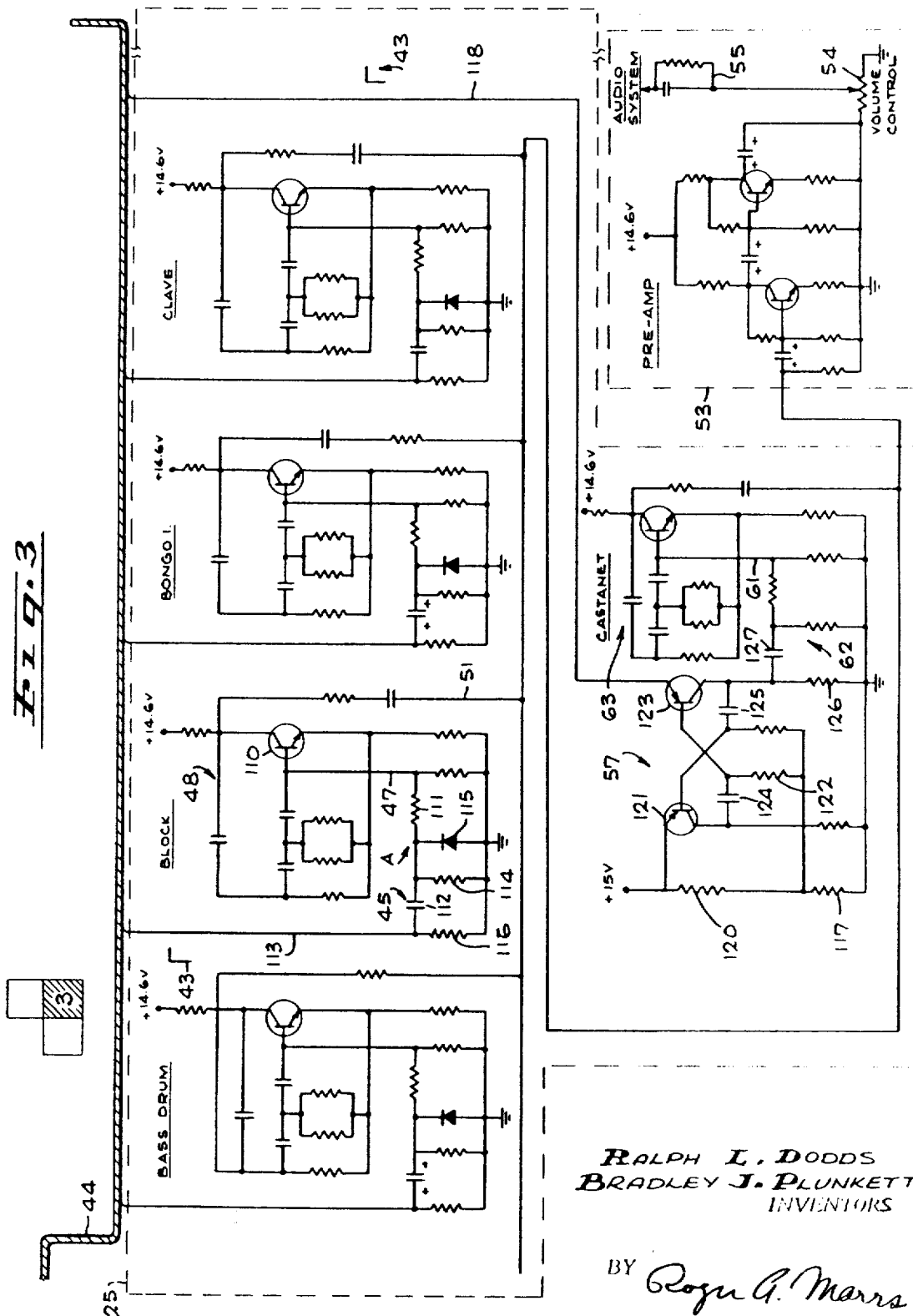


RALPH L. DODDS
BRADLEY J. PLUNKETT
 INVENTORS

BY *Roger A. Murre*

AGENT

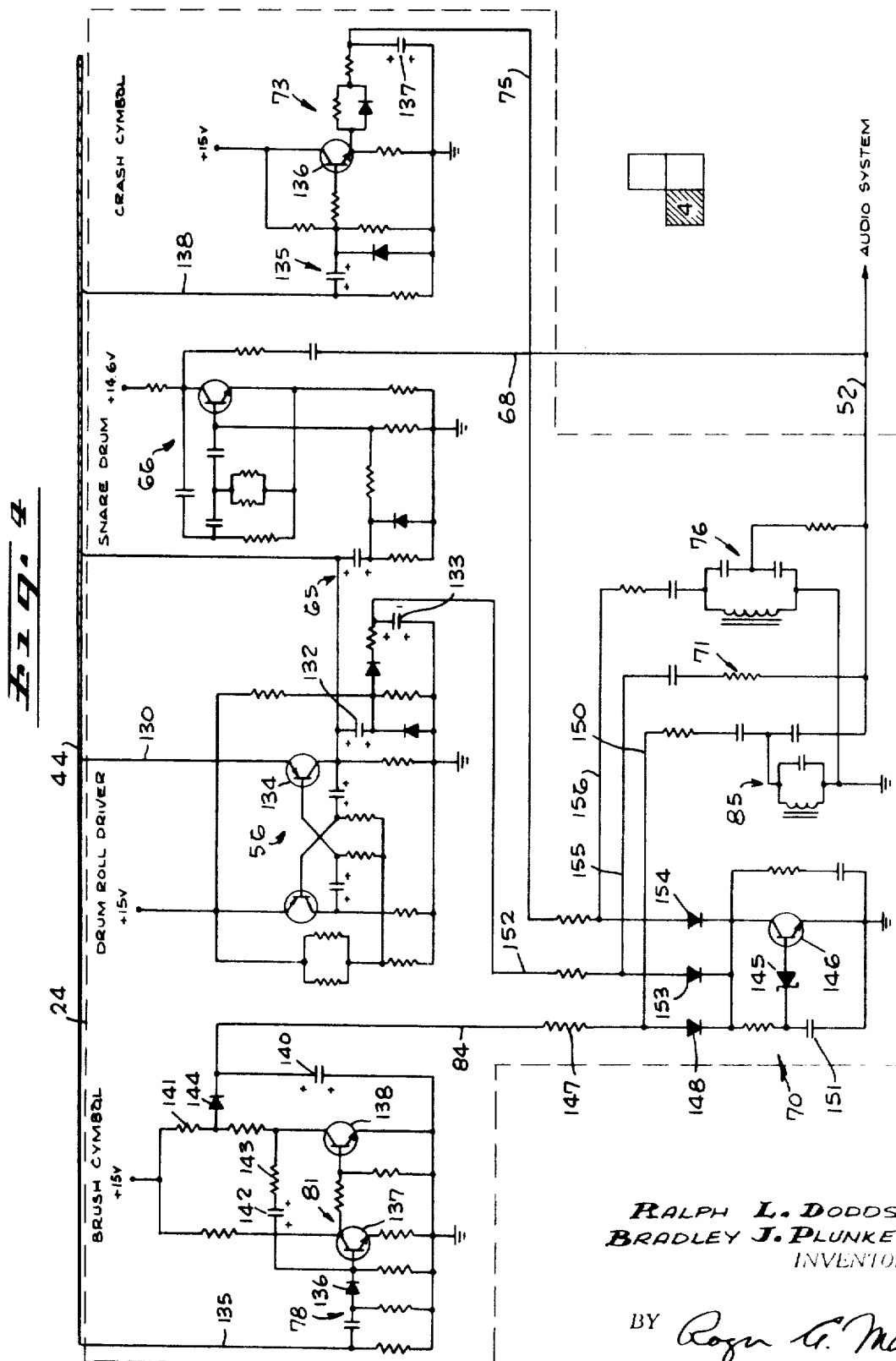
Fig. 3



RALPH L. DODDS
BRADLEY J. PLUNKETT
 INVENTORS

BY *Roger A. Morris*

AGENT



RALPH L. DODDS
BRADLEY J. PLUNKETT
INVENTORS

BY Roger G. Marra

AGENT

NOISE GENERATOR AND ACTUATING CIRCUIT FOR MUSICAL INSTRUMENTS

This is a division of application Ser. No. 466,551, filed June 24, 1965, entitled "Electrical Musical Instrument," having U.S. Pat. No. 3,439,569.

This invention relates to electrical musical instruments, and more particularly to such an instrument which may be operated as an accessory with another musical instrument or independently thereof for producing selected tonal pitches determined by the depression of various keys operated by a musician.

Electronic and electrical musical instruments are well known in the prior art which are capable of imitating the tones of various instruments. However, in playing such conventional instruments such as organs, for example, the rhythm accompaniment to the musical selection being played is usually dependent upon the quality of touch of the musician who is playing the instrument. Some rhythms are extremely difficult to sustain without undue fatigue and concentration being encountered by the musician. One system which provides automatic rhythm accompaniment for the manual keyboard and the pedal keyboard of a conventional electrical instrument is disclosed in U.S. Letters Pat. entitled ELECTRICAL MUSICAL INSTRUMENT submitted by inventors Cutler et al. having No. 3,309,454. The instrument disclosed in this copending application pertains to a means for automatically producing selected rhythms so as to be independent of the quality of touch of the musician playing the instrument. Also, the invention provides a musical instrument having therein means for automatically sounding selected rhythms at tonal pitches determined by the musician who plays the instrument and which also serves to stimulate or trigger special sound effects, particularly percussion effects, such as drums, cymbals and the like, produced naturally or artificially.

The apparatus of the present invention pertains to an electrical means for generating a variety of such special sound effects including novel triggering circuits therefor such that the means may be selectively operated from the keyboards of a conventional instrument, as an electrical organ, for example, to achieve automatic rhythm accompaniment utilizing the special effects or which may be played independently thereof at the command of the musician for purposes of separate or nonautomatic rhythm accompaniment. If desired, the electrical means of the present invention may be played by itself as an instrument to sound tonal pitches representing special sound effects without manual or pedal keyboard manipulation.

Through control switches, the various detected trigger signals are selectively introduced to special sound effect generator circuits or noise makers each of which embodies a novel voice generating circuit which includes a unique keying circuit for initiating circuit operation by control of the bias thereto in order to produce the desired special effect. By the discrete selection of electronic components, tonal pitches representing certain percussion sounds such as cymbals, castanets, and drums, can be produced.

In some instances, a rapidly repeating beat is required to sound a special effect, such as, for example, the effect of a drum roll or castanets, so that the present invention incorporates a driving circuit coupled to a keying circuit to provide a series of discrete initiating pulses to automatically drive the selected voice generator at a selected repetition rate. When a drum roll effect is desired, a unique circuit is provided so that the snare drum voice generator may be employed to produce that effect. The snare drum and drum roll effect are the same voice in structure and share the same components. The snare drum requires only a single pulse to initiate the voice generator while for drum roll purposes, a drive multivibrator is employed which drives the snare drum voice repeatedly to produce the rolling effect.

With particular reference to the production of tonal pitches representative of cymbals and snare drums, novel noise

generator and noise voicing networks are provided for electronically generating "white" noise which is formed with regard to frequency response and waveform envelope shape to provide a plurality of different voice signal outputs. Although separate voicing circuits are employed, the same noise generator is shared through the employment of a novel diode network. A feature resides in the fact that the noise output signals can be varied and controlled by operating on the supply voltage to the noise generator.

Therefore, it is a primary object of the present invention to provide an electrical musical instrument for producing a variety of tonal pitches and envelopes representative of special sounding effects such as percussion effects, including drums and cymbals and the like.

Another object of the present invention is to provide an electrical musical accessory for generating a variety of special sound effects which may be operatively coupled to an electrical musical instrument such as an organ for example, wherein the special sound effects may be employed as the rhythm accompaniment to the musical selection being rendered on the musical instrument either manually independent of the instrument or automatically in connection therewith.

Still another object of the present invention is to provide a musical instrument having a plurality of tone generating means for sounding tonal pitches in which the attack and decay characteristics of the sounded tones are inherently incorporated into the instrument so as to be independent of the quality of the touch of the musician playing the instrument.

A further object of the present invention is to provide a musical instrument as above including a novel noise generator having a noise diode network which is a reversed biased semiconductor junction operating in the diode breakdown region so that the current flow through the diode tends to fluctuate in a random fashion around a median value.

Still a further object of the present invention is to provide a musical instrument as described above incorporating a novel noise generator wherein the noise output can be varied and controlled by varying the supply voltage to the generator.

Another object of the present invention is to provide an instrument as described incorporating a novel noise source capable of effecting different signal decay envelope shapes for different voices wherein the input signal voices share a common noise source simultaneously with minimal interaction.

Still another object of the present invention is to provide a musical instrument as above incorporating a novel special sound effects generator for sounding a tonal pitch which is repeated rapidly such as is characteristic of castanets and a drum roll.

Still further object of the present invention is to provide a musical instrument as discussed above having a voice generator operatively coupled to a driver circuit which may be employed to produce a percussive sound effect such as a single snare drum beat and wherein the same generator may be employed to produce a different effect such as a drum roll.

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. The present invention, both as to its organization and manner of operation, together with further objects and advantages thereof, may best be understood by reference to the following description, taken in connection with the accompanying drawings, in which:

FIG. 1 is a functional block diagram of the musical instrument system of the present invention showing in a general way the associations among the major system circuits; and

FIGS. 2 through 4 comprise a complete detailed circuit diagram of the wiring of the electrical musical system with the electrical elements in the power supply, detector circuits and channel control circuits being shown in FIG. 2, the electrical elements in the individual voice oscillator circuits being located in FIG. 3 and electrical elements in the cymbal, snare drum and noise generator circuits being located in FIG. 4.

Referring to FIG. 1, there is illustrated an electrical musical system in accordance with the present invention of a keyboard

instrument type having a plurality of keyboards. There is shown by way of example in FIG. 1, an accompaniment keyboard and tone generators 10 and a pedal keyboard and tone generator 11. Associated with the keyboards, are suitable electrical tone signal generating means, which whenever keys on the keyboard 10 are depressed, supplies tone signals to an output 14 for example, and whenever a pedal on the pedal keyboard 11 is depressed, introduces a signal to output 15. Such signals may be applied to an audio output system which includes an electroacoustic transducer such as a loud speaker 17 via an amplifier 18. Voicing networks are provided for each keyboard, numeral 20 representing the manual keyboard voicing and numeral 21 representing the pedal keyboard voicing.

However, the tone signals may be supplied, if desired, to a separate musical instrument system so that special sound effects may be incorporated into the musical composition being rendered by the musician. In general, the musical instrument system of the present invention further includes, as represented in broken lines, a detecting circuit 19 for receiving signal outputs from the great keyboard and tone generator 10 and the pedal keyboard and tone generator 11, a channel control means 23 for effecting instrument operation via selector switch positions for accompaniment keyboard and pedal keyboard or independent push button control, and a plurality of voice generators included in a cymbal circuit board 24 and a drum circuit board 25 which generates a variety of special sound effects responsive to control signal initiation from the channel control means 23. It should be clear that names cymbal board and drum board are general names chosen for convenience in referral. The names do not rigidly imply the exact content of the boards.

Depending on the particular organ model to which the present invention is coupled, either a pedal sustain input or a pedal nonsustain input will be employed for pedal detection in a pedal keydown detector 37. Some organ models constructed without provision for pedal sustain produce an AC voltage output signal on the output line 15 at the output of a pedal divider included in the pedal keyboard and tone generator 11 which directly follows the pedal keying from the keyboard. When a pedal is depressed, an AC output signal is produced, and when the pedal is released, the AC output signal ceases instantaneously.

However, organ models having provision for pedal sustain produce a DC voltage output signal on the output line 15 from the pedal sustain section of the pedal key generator which may be taken, for example, from a point at the end of a conventional sequentially connected pedal key switch series. Typically, this signal is +7.5 volts DC when the pedals are all up and open circuited when any pedal is depressed. The addition of a resistance coupling the output line 15 to ground completes the ground path when a keyboard pedal is depressed. In this manner, the keying of pedals can be followed even though the audible pedal signal may be sustained.

A great keydown detector 22 and the pedal keydown detector 37 operate in response to the great keyboard and tone generator 10 and pedal keyboard and tone generator 11 inputs, respectively, by providing an output signal of suitable waveform along lines 39 or 40, as the case may be, to the channel control means 23 represented by broken lines. The control means includes a plurality of suitable channel switches 41 which may be actuated to select various voicing generators, to be described in detail later, and to determine whether such voice generators are stimulated by signal outputs produced by either the great keydown detector or the pedal keydown detector. The switches may be so actuated that the various voice and noise generators will operate solely from the accompaniment keyboard or operate solely from the pedal keyboard depending upon the setting of the switches. In addition, switching is provided at numeral 31 so that a given voice may be operated from both the accompaniment keyboard and pedal keyboard. The control means 23 also includes a plurality of push button switches 42 which may be manually actuated

irrespective of the organ keyboards. The operation and description of the switches are more precisely defined or described in Pat. No. 3,342,967 entitled PUSHBUTTON SWITCH filed by inventors Tichenor et al. The assignee of the PUSHBUTTON SWITCH is the same assignee as of the present application. The waveform of the signal output from the channel control means is indicated by a numeral 43 and takes the form of a positive voltage level which for the purposes of this description may be said to be a positive 15 volt signal. The output signal is impressed on a line 44 which represents a cable comprising a single wire leading to each voice generator.

A plurality of voice generators is shown contained within the drum board block 25 and the cymbal board block 24 defined by broken lines. A variety of percussion sound effects are included within these cymbal and drum blocks such as, for example, the brush cymbal, snare drum and crash cymbal as contained within the cymbal board arrangement and such as a bass drum block, bongo, clave and castanet tonal pitches as contained within the drum board arrangement. The voltage signals from the channel control means are introduced via cable 44 to one or more of the plurality of voice generators as determined by the switch position of the channel control switches 41 or the push button switches 42. The signal voltage is initially applied to a timing circuit, such as the timing circuit associated with the block sound effect indicated by numeral 45 for the purpose of differentiating and shaping the voltage signal into a pulse. The output from each of the timing circuits takes the form of the differentiated waveshape such as illustrated by numeral 46 on circuit output line 47 and the shaped timing pulse is then impressed to an oscillator circuit 48 which places a forward bias on the base electrode of the transistorized circuit to cause circuit oscillation. The oscillator output represents a waveform such as illustrated by numeral 50 which takes the form of a damped sinusoidal waveshape which is transmitted via an output line 51 to a common bus line 52.

The block oscillator or voice generator, for example, as illustrative of all the voice generators, has the characteristic of delivering via its output line 51, an electric signal which, when applied to the loudspeaker 13, stimulates the sound of a block instrument. One beat is delivered to the loudspeaker whenever a trigger voltage from the channel control means 23 is applied to the voice generator timing circuit 45 via input 44. In similar fashion, the cymbal generator applies to its output an electric signal having the characteristics of a cymbal stroke. All of the special voice generators are connected to the common output bus 52 which is connected through a preamplifier circuit 53 to the input of the power amplifier 18 via a volume control circuit 54 and a tone compensating network 55.

In order to faithfully reproduce some sounds, such as the sounds of a snare drum roll or castanet effect, it is necessary to not only generate a tone pitch envelope simulating a beat, but to cause rapid repetition of the beat to occur. Therefore, in accordance with the present invention, with respect to special sounds such as drum roll and castanet effects, the signal voltage 43 from the control means 23 is impressed or applied directly to driver multivibrator circuits, such as circuits 56 and 57, prior to the introduction thereof to the timing circuit associated with the particular voice generator intended to be operated. The driver multivibrator circuit provides a series of rectangular pulses as illustrated by the waveform 58 which when impressed upon the timing circuits, causes a series of output pulses to occur such as represented by a numeral 60 appearing on a line 61 operably coupled between a castanet timing circuit 62 and a castanet oscillator 63. The resultant waveform from the castanet voice generator is a series of damped sinusoidal waveforms as indicated by numeral 64.

A feature resides in the present invention in the fact that a snare drum timing circuit 65 and a snare drum voice circuit 66 provides proper sound effects not only for a snare drum tonal pitch as indicated by waveform 67, but operates in conjunction with the drum roll multivibrator circuit 56 to produce a

drum roll effect from the snare drum voice generator. An output line 68 from the snare drum voice generator circuit is connected directly to the common audio bus line 52. The snare drum and drum roll are the same voice in structure and share the same components. The difference in production of the effects lies in the manner in which the input signals thereto are processed. The snare drum input signal is transmitted directly to a pulse forming network whereas the drum roll signal input supplies a voltage signal to the voice drive multivibrator 56, which in turn drives the snare drum timing circuit 65 repeatedly to produce the effect for which the voice is named. The snare drum and drum roll are made up of two audible components; first, a sound produced by a pulsed oscillator very similar to that used for the block circuit. This sound imitates that of a drum head being struck and the resultant resonant ringing. The second component is from a novel noise generator circuit 70. This sound imitates that of the snares rattling. The two circuits are activated simultaneously and their output coupling network including a snare drum filter 71 having an output lead 72 coupled to the bus line 52 is chosen to produce the proper volume and tonal balance in relation to the snare drum pulsed oscillator required to imitate the genuine instrument.

The noise generator circuit 70 is also employed in conjunction with a crash cymbal driver and timing circuit 73 to effect the sound of crashing cymbals. The crash cymbal circuit 73, when activated by the signal pulse 43 from the channel control means 23 supplies a current signal in the form of a waveform 74 via line 75 to the noise generator circuit 70 which modifies the signal and introduces it to a crash cymbal filter 76 containing a suitable voicing network. The filter is connected to the common audio bus 52 by means of lead 77.

Also, employed with the noise generator circuit 70 is a brush cymbal sound generating means which includes a timing circuit 78 that initiates a pulse 80, similar to the pulse 46 which is supplied to a one-shot multivibrator circuit 81 via line 82 in response to the signal voltage level 43. The multivibrator 81 produces a pulse 83 on an output line 84 which modified by the noise generator circuit 70 and transmitted to the common bus 52 via a brush cymbal filter 85 including a suitable voicing network.

The noise generator 70 is shared between three voices, namely, the brush cymbal, crash cymbal and combination snare drum and drum roll. It should be noted that there is also the advantage of having different decay waveform envelope shapes for different voices due to the lack of crosstalk between the various inputs to the noise generator. This feature is due to the use of a novel diode decoupling network and the ability of the noise source to accept multiple collector loads with little change in output. The snare drum and drum roll voice has a short waveform envelope with a sharp attack. The brush cymbal has a medium length wave form envelope with a slow attack and the crash cymbal has a long decay after a moderately fast attack. These voices can share the noise generator simultaneously with minimal interaction.

Referring now to FIGS. 2-4, a detailed description will follow of the basic circuit included in the major blocks indicated by broken lines in FIG. 1 of the keydown detector circuits 19 and channel control means 23 as illustrated in FIG. 2; of the drum board 25 and preamplifier 53 illustrated in FIG. 3; and of the cymbal board 24 illustrated in FIG. 4.

FIG. 2 illustrates a suitable power supply for the electrical musical instrument of the present invention which basically includes a step down transformer 86 having the secondary windings thereof coupled to a full wave bridge capacitor-input rectifier as indicated by arrow 87 coupled in turn to a DC voltage regulator as indicated in the general direction of arrow 88. The output of the power supply is a regulated +15 volt potential, for example, at terminal 90 and an additionally decoupled 14.6 volts, for example, at the terminal 91. In general, the voltage at terminal 90 supplies high current drain for trigger and driver circuits and terminal 91 supplies the low current drain for the audio circuits.

With respect to the pedal keydown detector 37 included in the keydown detector circuits 19, the pedal keydown detector consists primarily of a single stage amplifier indicated in the general direction of arrow 92 followed by a two-stage trigger circuit indicated in the direction of arrow 93.

The first single stage amplifier is indicated in the drawings as a PNP transistor biased in such a manner that it is normally nonconducting. In the presence of a suitable AC signal on line 38 at the input, a condition appears on negative half-cycles with the result that capacitor 94 is charge to approximately +6 volts. The presence of a DC voltage signal less positive than approximately 6 volts (emitter potential in steady state) at the DC input on line 36 will also cause conduction of the transistor and the resultant charging of capacitor 94. As explained previously, either a DC signal or an AC signal input is used depending on the particular organ type to which the musical instrument of the present invention is attached. In general, the DC input is used for those organ models with pedal sustain and the AC signal input for those without pedal sustain. The organ models without pedal sustain produce a signal at the output of a pedal divider in the pedal keyboard and tone generator 11 which directly follows the pedal keying from the pedal keyboard. When a pedal is depressed, the signal is produced, when the pedal is released, the signal ceases instantaneously. The result is that the musical instrument will follow precisely.

A problem arises if the pedal keydown detection is attempted through use of the AC pedal signal in an organ with pedal sustain. The AC signal from the pedal divider included in the pedal keyboard and tone generator circuit 11 does not cease when a pedal is released in the case of pedal sustain but continues for some time to allow the sustain effect. The divider signal, therefore, is not satisfactory for use as a keydown signal, because it does not strictly follow the playing of pedals. A pedal down signal used for sustain pedals is a DC voltage taken from a point at the end of a pedal key-switch string, for example, which may be included in the pedal keyboard and tone generator circuit 11. This signal is typically positive 7.5 volts DC when the pedals are all up and open circuited when any pedal is down. The addition of a 15K resistor completes the ground path when a pedal is depressed. In this fashion, the musical instrument can follow the keying of pedals even though the audible pedal signal is sustained.

The second part of the detector 93 is a two-stage amplifier with regeneration through a resistor 95. This regeneration causes an input hysteresis which produces a well-defined switching action as the voltage on capacitor 94 varies. The circuit triggers when the voltage on capacitor 94 reaches approximately positive 2.5 volts and will not unlatch until the voltage drops below approximately positive 1.5 volts. This hysteresis makes the trigger circuit relatively insensitive to ripple voltage on capacitor 94 when an AC input is used. The steady state conditions for the trigger circuit are transistor 96 in a cutoff condition and transistor 97 also in cutoff. A positive input at the base electrode of transistor 96 causes conduction of both transistors 96 and 97 and an output of about positive 14.3 volts. This positive 14.3 volts appears on the pedal bus line 40 which connects to the channel control means 23 so that any voices which are switched to the pedal bus may be operated when any pedal key on the keyboard and tone generator 11 is depressed.

The great keydown detector circuit 32 consists of a two-stage AC amplifier consisting of transistors 100 and 101 driving a normally cutoff PNP transistor 102. Transistor 102 supplies charging current for capacitor 103 which in turn, drives a trigger circuit consisting of transistors 104 and 105.

As connected to a typical electrical organ, the great keydown detector receives a signal of about 50 mv. from the great keyboard and tone generator 10. The signal is amplified by transistors 100 and 101 to a level sufficient to drive transistor 102 from saturation to cutoff with signal alternation. The collector current of transistor 102 charges capacitor 103 through a collector resistor to about positive 6 volts. This volt-

age supplies input for the trigger circuit in a manner as described for the pedal keydown detector.

A channel control means 23 is shown to comprise a plurality of rocker tab switches 41 which are arranged to operate between a great keyboard position indicated by numeral 106 and a pedal keyboard position indicated by contact numeral 107. Initially, the musical instrument of the present invention is turned to on, off or duo by means of a suitable ganged switch 108 and the rocker tab switches are selectively operated so that the musician can choose to operate the special sounding generators from either the pedal keyboard or the great keyboard or both. In addition to the rocker tab switches, there is provided a plurality of pushbutton switches, such as switch 42 which upon depression, causes a positive 15 volt signal to be applied on the appropriate line in cable 44. In this manner, the electrical instrument of the present invention may be played independently of any other organ or other musical circuitry to which it may be attached.

The following circuit description will relate to FIG. 3 and will describe the sound generator 48 for effecting the sound of a block as an example of the other special sound effects included in the drum board, 25.

The circuit consists of a phase shift oscillator circuit indicated in the general direction of arrow 48 with means assuring that forward bias for the base of transistor 110 is not continuously supplied. A resistor 111 is chosen as approximately the value which would connect to B+ if the circuit were to function as a continuous output oscillator. The circuit constants are chosen so that the oscillation amplitude is a function of the instantaneous DC voltage at an input point A. In addition, the circuit is optimized for minimum frequency shift with variation of the voltage at point A. The circuit parameters may be adjusted to provide a wide range of frequency stable set decay times thus producing a wide variety of time frequency effects whereby the components are chosen to effect the voice type desired from any given circuit.

Referring in more detail to the schematic of the block oscillator circuit 48, assume that initially the charge on a capacitor 112 is equal to 0 and that a positive 15 volt signal 43 is supplied on input line 113. The voltage across a resistor 114 rises instantaneously to +15 volts and then decays according to the RC time constant. The output from the oscillator will be seen to rise and then decay in a similar fashion to the voltage across resistor 114. This rise and decay closely approximates the natural rise and decay of many percussion instruments. The exact envelope developed by the pulse forming network of resistor 114, capacitor 112 and resistor 111 is varied from voice to voice. Other similar networks may be ganged to create additional voice expressions using the same basic RC oscillator. Typical are the cymbal voices, which share the noise generator but with different decay envelopes.

Assume that some later time, the voltage signal 43 is removed. The voltage across capacitor 112 will now be in a polarity to cause conduction through a diode 115 and the reset resistor 116. Resistor 116 is chosen so that the RC time constant is sufficiently short to allow rapid repeating of the voice.

Examination of the pulse forming circuit has shown that two separate RC time constants have been made through inclusion of diode 115. One is the charging time constant of capacitor 112 and the other a considerably shorter time constant for discharging capacitor 112.

In the instance of the block voice oscillator just described, a single tone or pitch represented by waveform 50 in FIG. 1 is generated responsive to the input voltage signal 43. However, to represent the sounds of a castanet or a drum roll, it is necessary to provide repeated notes or pitches. To obtain this effect, discussion will proceed by detailed description of the castanet circuit which includes an astable multivibrator 57 with provision for switching into operation in a predictable state. Also included is the timing circuit 62 similar to the timing circuit just described with respect to the block voice and a castanet phase shift oscillator circuit 63 which is similar to the oscillator circuit described with respect to the block voice.

Operation of the voice drive multivibrator 57 can be easily understood by assuming a resistor 117 value equal to 0 and the presence of a +15 volt signal 43 on line 118 leading from cable 44. The circuit is then an ordinary free running (astable) multivibrator. The resistors 120 and 117 have been included to allow adjustment of the base supply voltage and, therefore, adjustment of the oscillation frequency, such as approximately 15 cycles per second in this case.

When a voltage signal 43 is not applied via lead 118, oscillation ceases and the circuit voltages drift to steady state values. An important feature of the circuit is the relationship of these steady state values to the output signal when a voltage signal on line 118 is initially applied. Assuming that the signal voltage has not been applied for some time and therefore, the circuit is not oscillating, the steady state conditions will be as follows: transistor 121 will be in saturation due to current flow through a resistor 122. The collector electrode of transistor 121 will be at nearly positive 15 volts. A transistor 123 cross coupled to transistor 121 will not be conducting due to the lack of emitter supply voltage, therefore, the collector electrode of transistor 123 will be at 0 volts. A capacitor 124 is charged to positive 15 volts where it connects to the collector or transistor 121 and a voltage equal to that at the junction of the voltage divider resistor 117 and resistor 120 where it connects to the base electrode of transistor 123. A capacitor 125 is at 0 volts where it connects to the collector electrode of transistor 123 and approximately positive 15 volts where it connects to the base electrode transistor 121. At the instant of voltage signal 43 on line 118, capacitor 124 begins to charge towards positive 15 volts through the base-emitter junction of transistor 123 which causes saturation thereof. Saturation of transistor 123 causes cutoff of transistor 121 due to the initial charge on capacitor 125 and the circuit is started into oscillation. It can be seen from the foregoing discussion that transistor 123 will always be driven to saturation initially when a voltage signal 43 appears on line 118 and that the leading edge of the first output pulse from transistor 123 will be coincident with the supply of the signal voltage 43. The advantage of this switching method is the lack of delay from signal application to output generation.

The multivibrator is connected as a drive source for a percussion voice. It can be seen that the multivibrator simply acts as an automatic switch with the rate and dwell of switching representing a function of the time constants within the multivibrator circuit. A resistor 126 acts as the reset path for capacitor 127 as well as the collector load for transistor 123. Its value is selected for optimum reset time constant in conjunction with capacitor 127. An alternate input path to the voice to be triggered can be connected directly to the collector electrode of transistor 123 and this feature is more fully explained in detail in connection with the following description of the snare drum and drum roll aspects.

As shown in FIG. 4, the snare drum and drum roll are the same voice in structure and share the same components. The difference lies in the way the input signal 43 is processed. The snare drum input 129 goes directly to pulse forming networks indicated in the general directions of arrows 65 and is a "single-shot" voice. A drum roll input lead 130 supplies a voltage 43 for the voice drive multivibrator indicated in the direction of 56, which in turn drives the snare drum voice repeatedly, producing the effect for which the voice is named. The snare drum and drum roll are made up of two audible components; first, a sound produced by a voice oscillator indicated in the direction of arrow 66 similar to that used for the block effect described above. This sound imitates that of the drum head being struck and the resultant resonant ringing. The second component is from the noise source generator 70 and this sound imitates that of the snares rattling. The two circuits are activated simultaneously and their output coupling networks are chosen to produce the proper volume and tonal balance required to imitate the genuine instrument.

For purposes of describing operation, assume that a voltage of positive 15 volts is supplied to the drum roll input 130. The drum roll multivibrator 56 will oscillate and supply a pulsing

DC voltage to the snare drum pulse forming circuitry 65. This pulsing voltage is formed into short pulses by capacitor 132 and associated components and periodically charges a capacitor 133 to approximately 22 volts. Capacitor 133 supplies current to the noise source 70 and the result is an output from the noise source which decays in a manner similar to the settling of the snares on a snare drum.

Simultaneous to the above, a pulse is formed by the input circuitry of the strike tone oscillator 66 which produces a tone which imitates the sound of the drummer striking the head. The two sounds combine at the output audio bus 52 to make the total effect of the instrument.

Assuming that the snare drum input is activated while the drum roll is operating, the effect will be that of shorting from the collector electrode to the emitter electrode of a transistor 134 and the drum roll will cease. This effect is very advantageous from the musicians point of view inasmuch as the musician can, for example, set the musical instrument to trigger the drum roll from the great keyboard 10 and the snare drum from the pedal keyboard 11. The interplay due to cancellation can be utilized to produce some complicated sounds with much less motion on the part of the musician than would normally be required to make the same effects without the cancellation feature. This can be of value to a novice musician as well as a seasoned one.

Continuing with the detailed description of FIG. 4, the following will pertain to the crash cymbal. The crash cymbal voice is made up of white noise from the noise generator 70. The first stages of the circuit consist of a pulse forming network indicated in the direction of arrow 135 which drives an emitter follower indicated in the direction of arrow 73. The emitter follower charges a timing capacitor 137 which in turn supplies current to the crash cymbal input of the noise generator 70 via output line 75.

In operation, it can be seen that the input circuitry of the crash cymbal pulse forming network up to the emitter follower is similar to the input circuitry of any of the phase shift oscillator voices. The operation of this part of the circuit is covered in detail in the section of the phase shift oscillator operation as described in connection with the block oscillator 48. The present circuit produces a positive pulse at the base electrode of the emitter follower when a voltage is received via line 138 from cable 44. This pulse causes current to flow charging the capacitor 137 to approximately positive 15 volts. On termination of the charging pulse, the capacitor supplies current to the noise source 70 for a period of time determined by the charge drain from the capacitor. The resulting output from the noise source is coupled to the audio signal bus 52 through the crash cymbal voicing circuit indicated in the direction of arrow 76. Circuit 76 is parallel tuned filter section peaked rather broadly at about 2.5 kc. The frequency components thus emphasized and the nature of the long decay envelope produce a sound which closely approximates that of a crash cymbal.

The brush cymbal circuitry consists primarily of a monostable multivibrator 81, a timing circuit 78 and the noise source 70 and the brush cymbal voicing circuit 85. In operation, an input to the circuit via a line 135 from cable 44 carries a positive going DC voltage signal which is differentiated and formed into a positive pulse that is applied through a diode 136 to the base electrode of a transistor 137. At rest, transistor 137 is normally cut off. This pulse is amplified and inverted by transistor 137 applied to the base electrode of a transistor 138 to cut this latter transistor off. At this time, a capacitor 140 begins to charge toward B+ through a resistor 141 and the potential at the collector electrode of transistor 138 goes positive. This positive excursion starts to charge a capacitor 142 through a resistor 143 and adds to the base current of transistor 137. This action is regenerative and the circuit will stay in this state until capacitor 142 no longer supplies sufficient current to hold transistor 137 in conduction. At his point, the circuit resets to the original state. The purpose of using this type of circuit to charge capacitor 140 is to allow a

charging ramp on capacitor 140 which is self-completing if the input terminates before capacitor 140 is fully charged. If this were not the case, a short input signal would result in an incomplete sounding of the brush cymbal voice.

As capacitor 140 is charged through resistor 141 and a diode 144, the noise generator output rises to a peak value as indicated by waveform 83 in FIG. 1 and the monostable timing cycle terminates and the voltage across capacitor 140 begins to fall toward its steady state value of approximately 7.5 volts. The discharge rate of capacitor 140 is determined by the current flow in the noise source 70. Since this current flow decreases as the voltage across capacitor 140 decreases, the output is heard to decrease in a manner which closely imitates the exponential decay of the sound of a brush cymbal. The actual output sound is coupled through the brush cymbal voicing circuit 85 to the audio signal bus 52. The brush cymbal voicing circuit is a parallel tuned filter section, peaked around 8 kc. This accentuates the high frequency components of the noise to imitate the key characteristic of a brush cymbal.

The noise generator 70 consists of noise generating diode 145 and a combination transistor amplifier and bias regulator indicated in the direction of 146. The noise diode is a reversed biased semiconductor junction which operates in the breakdown region. That is to say, the supply voltage to the noise source is larger than the breakdown voltage of the diode. In this mode of operation, the current flow through the diode tends to fluctuate in a random fashion around a median value. This median value is commonly referred to as the Zener potential of the diode. Exact nature of the mechanism producing these fluctuations is very complicated. However, for the purposes of this description, it is not believed necessary to describe the physics of the phenomena.

Although diodes have been used for noise producing elements, the circuit configuration of the present invention is believed to be new and unique. The actual circuit as applied to the musical instrument illustrates that the circuit is shared between three voices, considering the snare drum and drum roll as the same voice, hence three collector resistors, three disconnect diodes and three outputs are employed.

For purposes of simplicity in operational explanation, collector resistor 147, disconnect diode 148 and single output 150 will be described. Assuming a noise diode breakdown of 10 volts, the operation of the circuit is pictured as having a potential at the input which is raised from 0 to 15 volts on line 84. In the increment from 0 to 10 volts, no current will flow in the diode 145 so that no base current will be supplied to the transistor 146 and consequently no collector current will flow. When the input exceeds 10 volts, the noise diode 145 will begin to conduct, collector current will be caused to flow and diode 148 will be biased into conduction. The transistor will then be active as an amplifier and the minute fluctuations in base current, produced by the noise diode, will be amplified and appear as a signal at the output of the noise generator 70 along line 150. An increase in supply voltage will cause a corresponding increase in current flow through the circuit and an increase in noise output. The noise output can be varied and controlled, therefore, by varying the supply voltage to the generator. This feature is important to the operation of the musical instrument of the present invention. It should be noted that the current through the noise source is degenerative in that an increase in noise source current is countered by a decrease in collector voltage. A capacitor 151 acts to eliminate degeneration of noise current. The circuit degeneration tends to hold the operating point constant for variations in temperature and device parameters. It is interesting to note that variations of two to one in values of the resistors and the Beta of the transistor produce a negligible variation in output.

A brief discussion will follow wherein the noise source will be described as having multiple inputs rather than the single input as just discussed. With respect to operation of the noise generator wherein the circuits to share said generator assume potentials of less than 10 volts, which is a typical noise source breakdown, at lines 152 and 75 and a potential of positive 15

volts at line 84, diode 148 will be forward biased and diodes 153 and 154 will be reversed biased. Noise produced will flow to output line 150 and be blocked from output line 155 and 156. It is this feature which permits the use of separate voicing circuits, but still share the noise source generator 70. If two or more noise voices are operated simultaneously, the paths of signal flow will be through the respective filters for the voices operated. Those familiar with amplifier gain determination will at first glance expect the noise output to decrease when more than one noise voice is operated. This would be expected because of the paralleling of collector loads. The circuit of the present invention compensates for this, however, by increased current flow in the noise source. The result is an output of practically constant amplitude at the collector electrode of the noise source, regardless of the collector load. It should be noted that there is also the possibility of having different decay envelope shapes for different voices due to the lack of crosstalk between the inputs. The snare drum, drum roll, voice has a short envelope with a sharp attack. The brush cymbal has a medium length envelope with slow attack and the crash cymbal has a long decay after a moderately fast attack. These voices can thus share the noise source simultaneously with minimal interaction.

While particular embodiments of the present invention have been shown and described, it will be obvious to those skilled in the art that changes and modifications may be made without departing from this invention in its broader aspects, and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

We claim:

1. In a noise generator and actuating circuit combination comprising:

- a transistor amplifier having base, emitter and collector electrodes;
- a noise diode coupled to said base electrode operating in the voltage breakdown region;

a signal supply voltage selectively applied to said noise diode in said breakdown region characterized as having the supply voltage to the noise source larger than the breakdown voltage of said noise diode to cause operation of said noise diode;

said amplifier being responsive to minute fluctuations in base current due to operation of said noise diode to amplify the fluctuating base current to produce an output signal;

the current through said amplifier is degenerative in that an increase in noise source current is countered by a decrease in collector voltage;

a capacitor coupled between said diode and said emitter electrode to eliminate degeneration of noise current;

said noise diode is used as a bias element to produce DC degeneration and tends to make said amplifier relatively insensitive to DC loading;

a plurality of oscillator voicing circuits for electrically producing tonal pitches; and

a diode decoupling network operably connected between said voicing circuits and said noise diode for selectively isolating tonal pitches produced by selected ones of said voicing circuits.

2. The invention as defined in claim 1 wherein:

said voicing circuits include multivibrator oscillator circuits.

3. The invention as defined in claim 1 wherein:

said voicing circuits include phase shift oscillator circuits.

4. The invention as defined in claim 1 wherein:

said voicing circuits include phase shift oscillator circuits and multivibrator oscillator circuits.

5. The invention as defined in claim 4 wherein:

said diode decoupling network includes one disconnect diode for each one of said voicing circuits; and wherein each of said voicing circuits includes a collector resistor connected to its respective one of said disconnect diodes.