United States Patent

[11] 3,553,334

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[21] Appl. No. **699,149**
[22] Filed **Jan. 19, 1968**
[45] Patented **Jan. 5, 1971**
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[54] **AUTOMATIC MUSICAL RHYTHM SYSTEM WITH OPTIONAL PLAYER CONTROL**
20 Claims, 17 Drawing Figs.

[52] **U.S. Cl.** 84/1.03, 84/1.26, 307/223
[51] **Int. Cl.** G10f 1/100, G10h 1/02
[50] **Field of Search** 84/1.01, 1.03, 1.24, 1.25, 1.26

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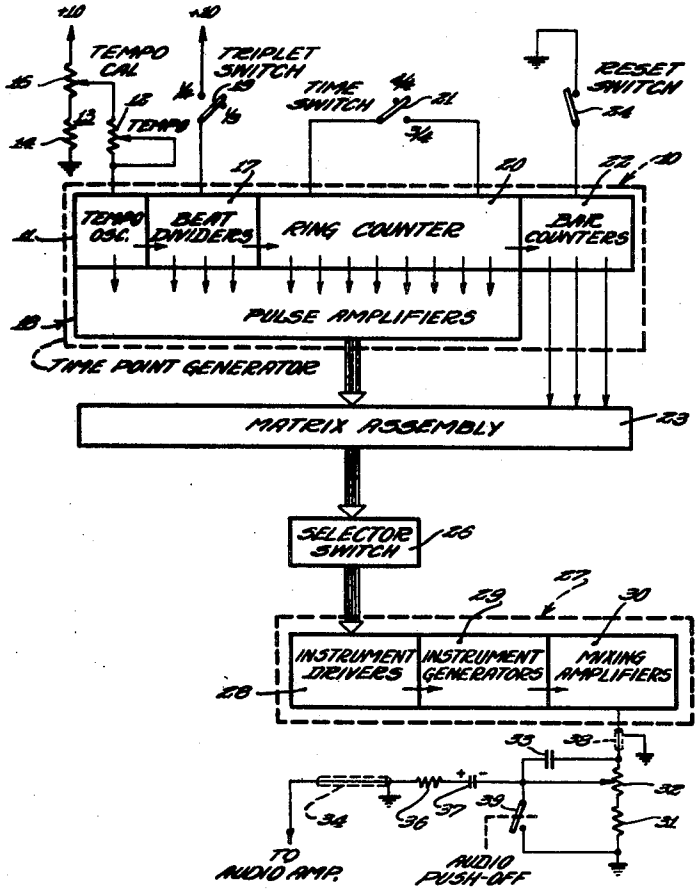
Primary Examiner—W. E. Ray
Attorney—Hill, Sherman, Meroni, Gross & Simpson

ABSTRACT: An electronic rhythm device including a clock generator of adjustable frequency, controls for the clock generator to produce evenly or unevenly spaced output signals, a ring counter driven by the clock generator and having controls to bypass some of the stages of the ring counter, a plurality of sound generator circuits, connecting means comprising a plurality of resistor matrices connected between the outputs of the ring counter and the outputs of the clock generator and the inputs of the sound generators, and an automatic follow circuit to control the clock generator rate and an alternative automatic follow circuit.



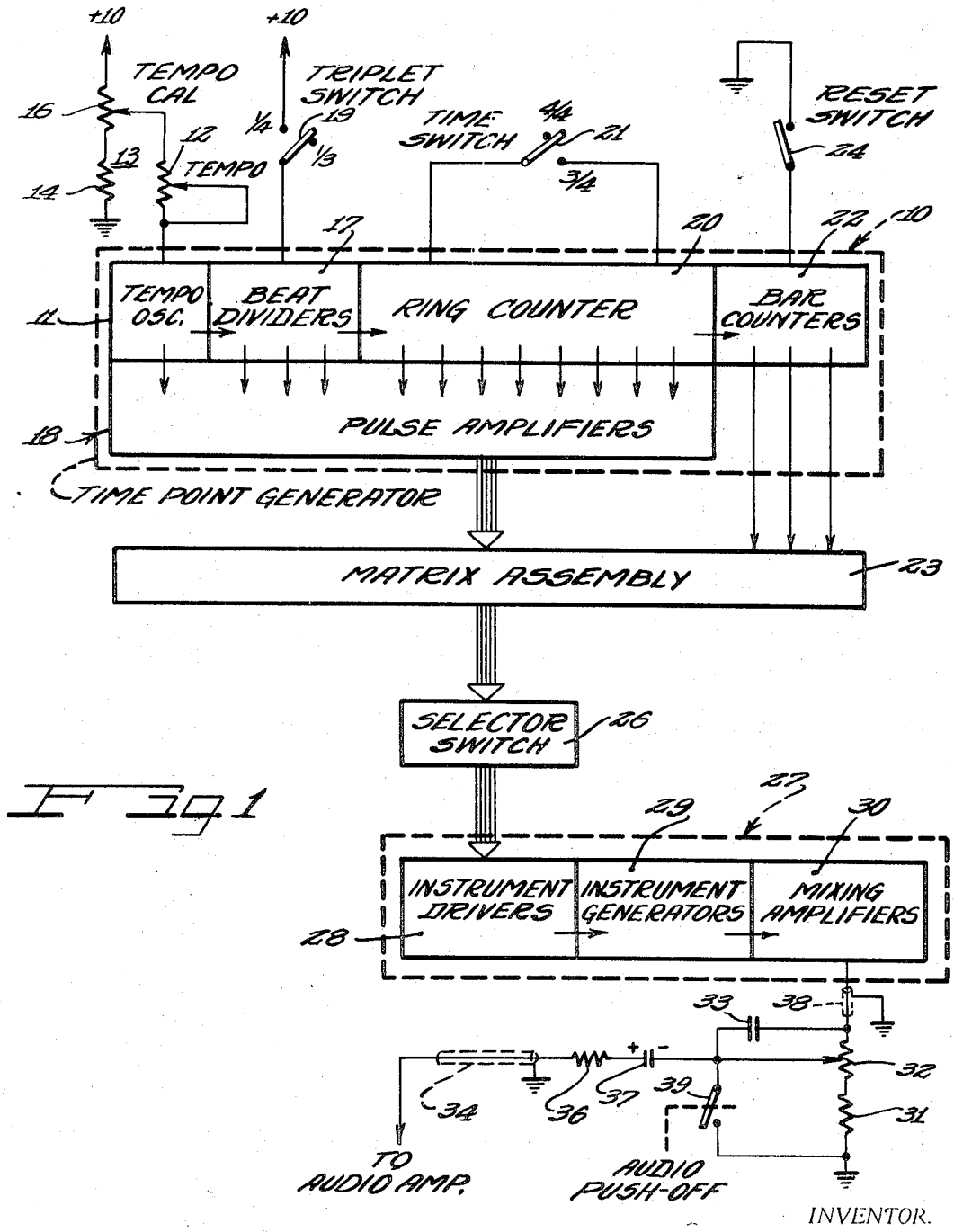


Fig. 1

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Fig. 2a

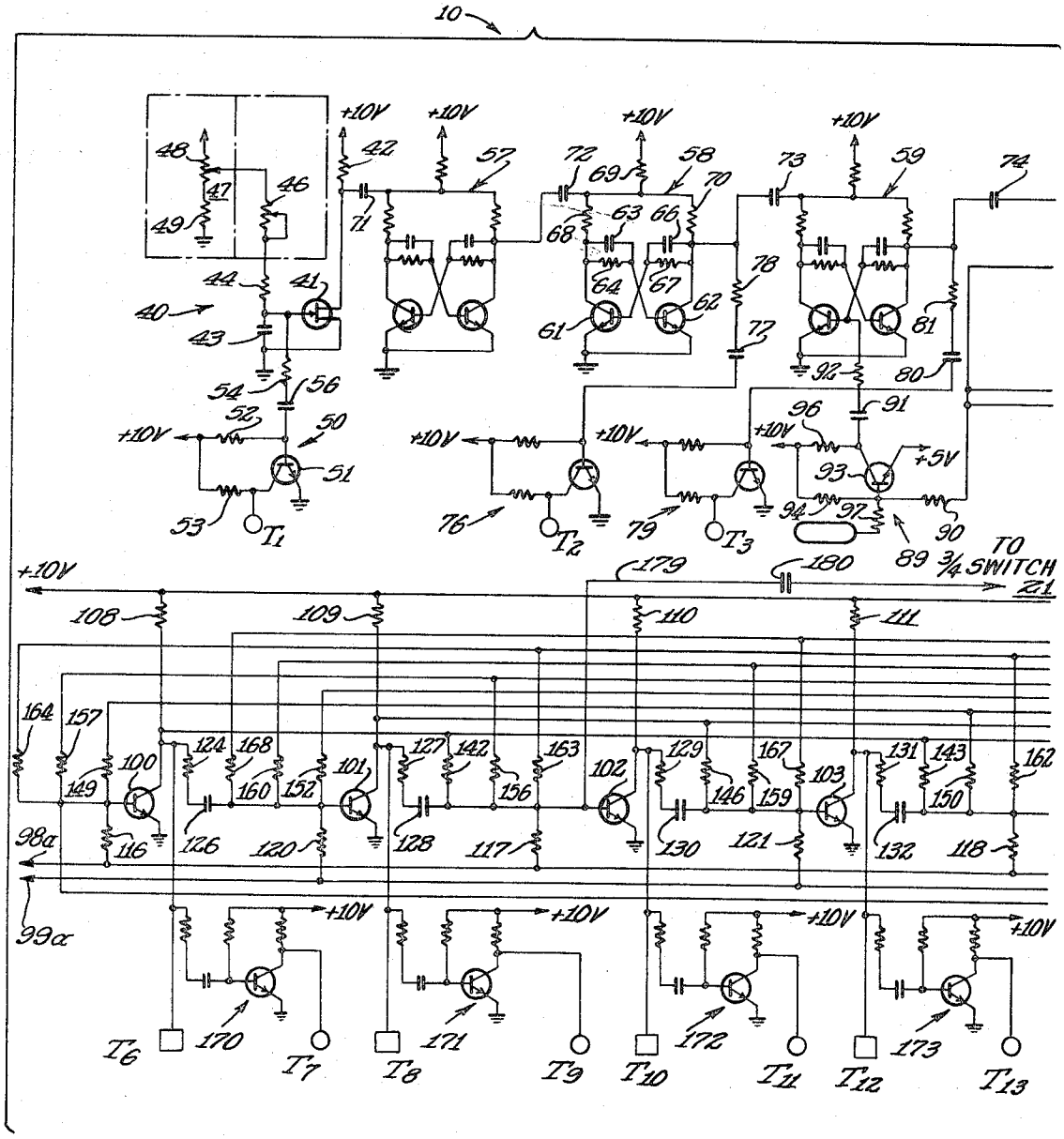

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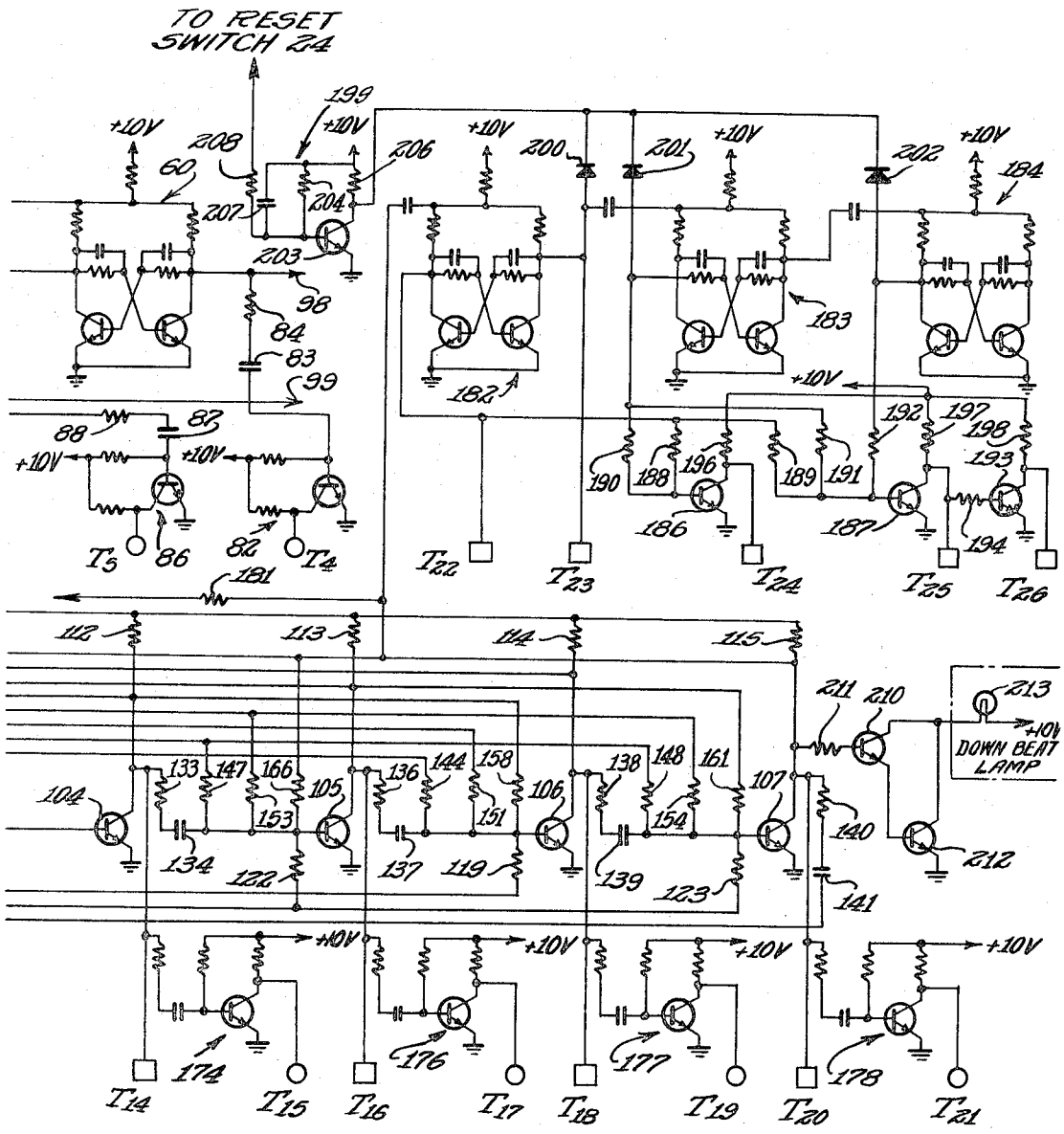
Fig. 2b



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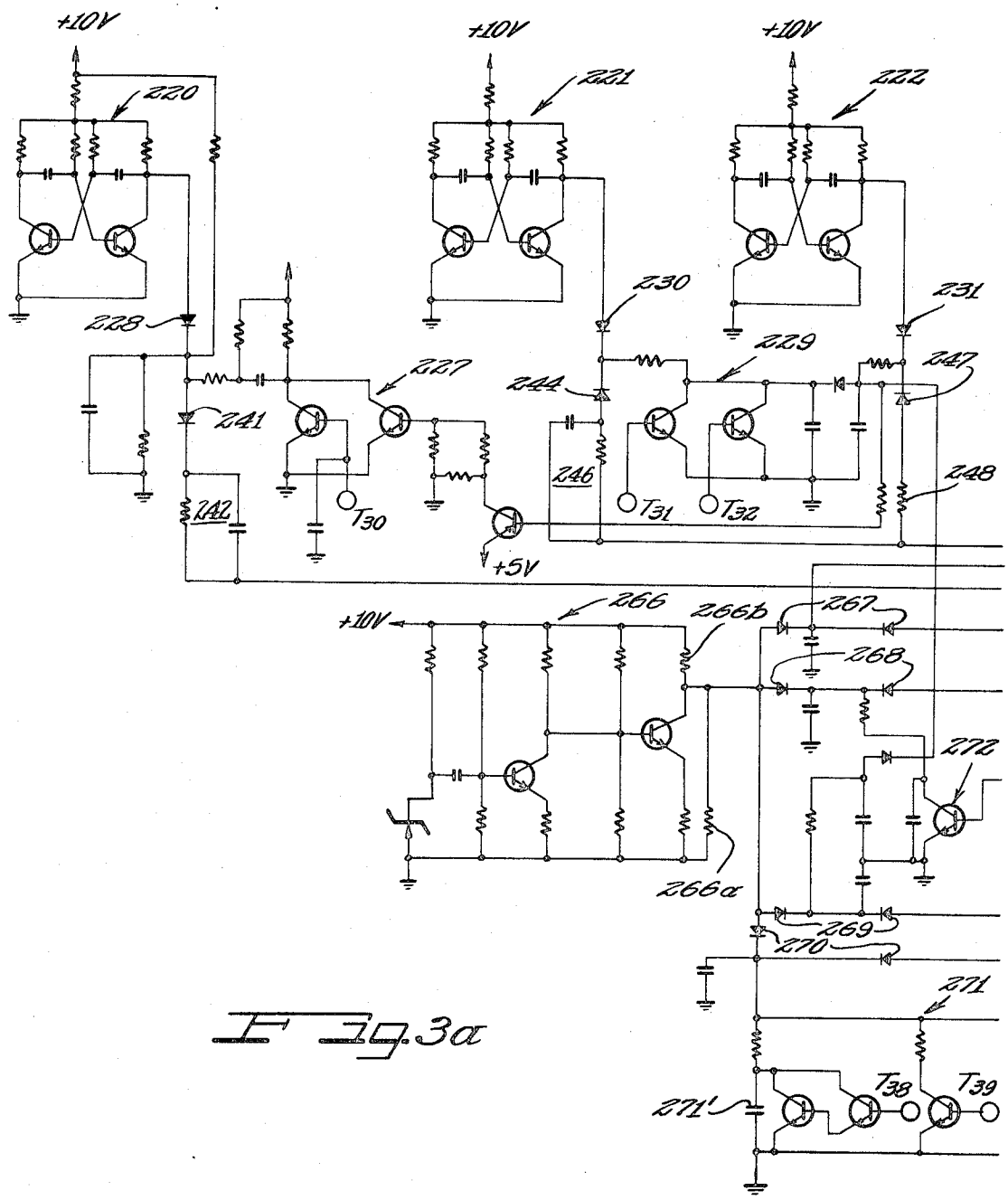

Fig. 3a

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Fig. 3b

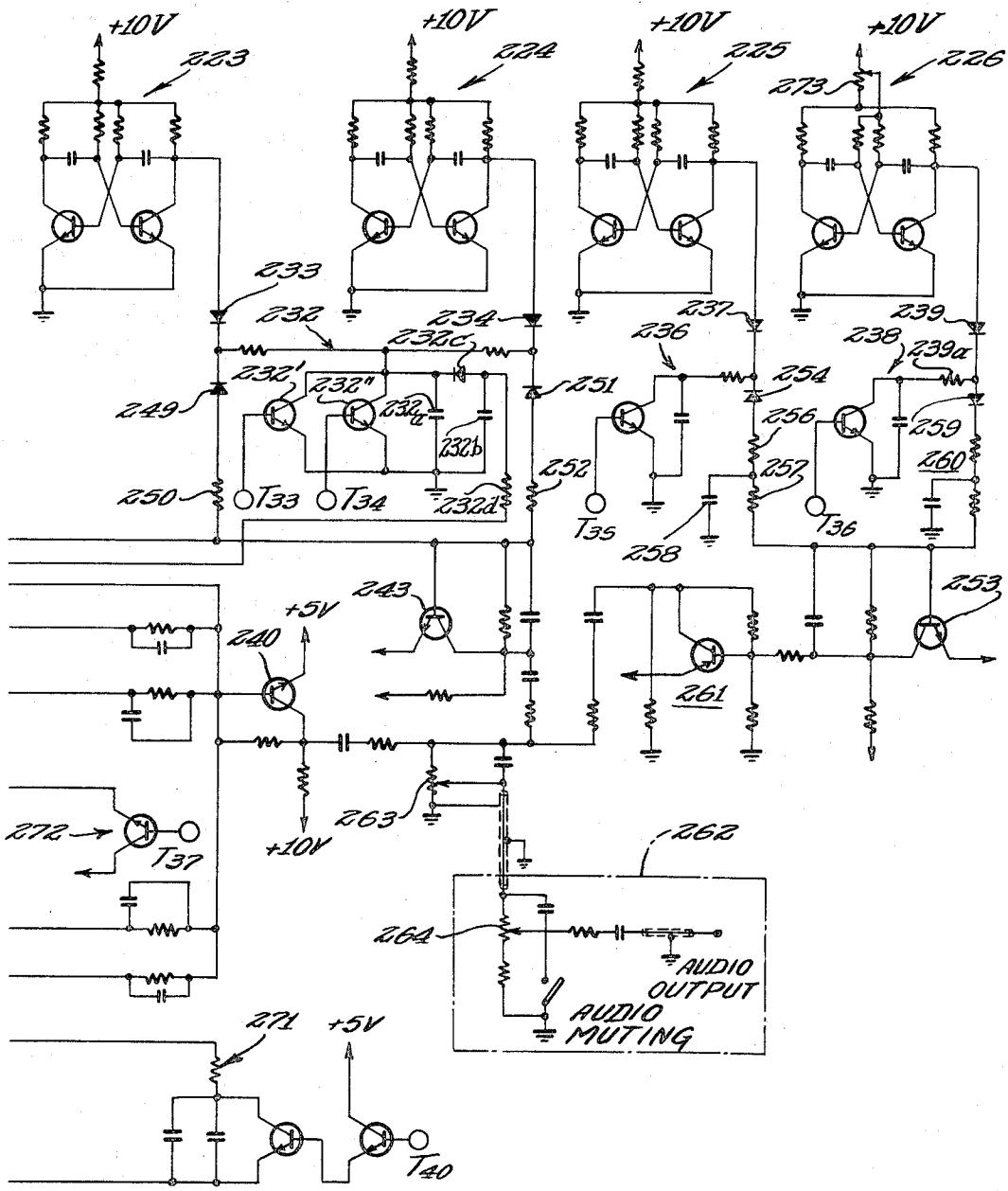

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Fig. 9

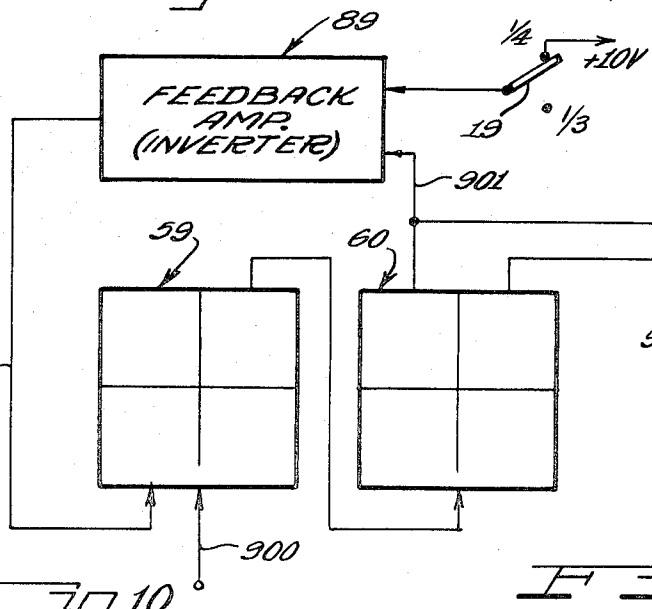


Fig. 4

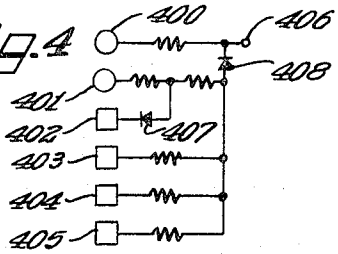


Fig. 5

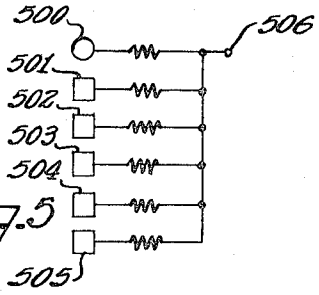


Fig. 10

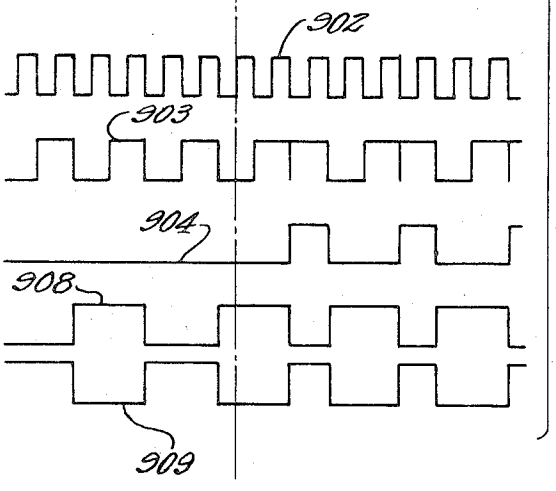
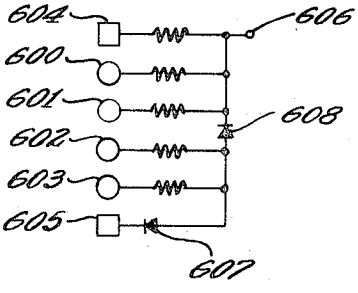


Fig. 6



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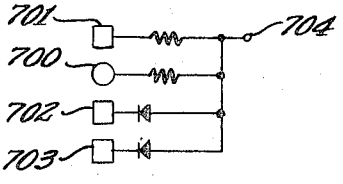
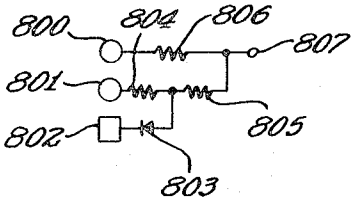


Fig. 8



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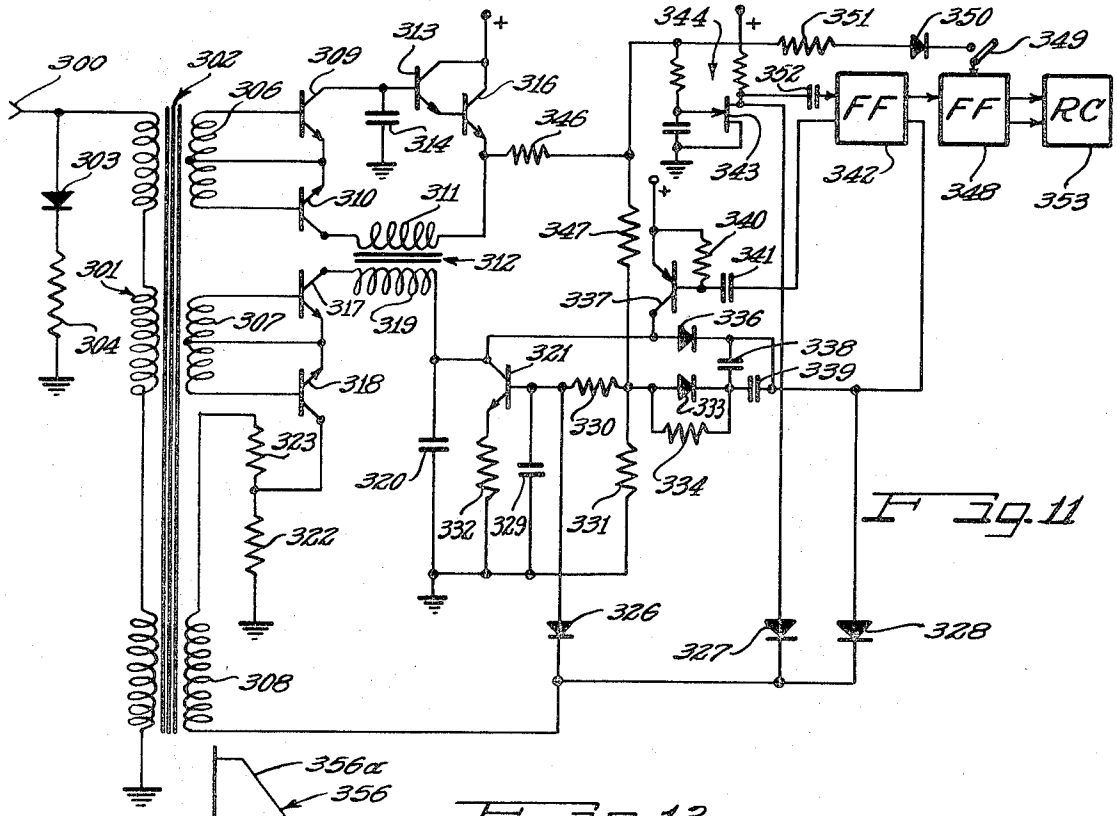

Fig. 11

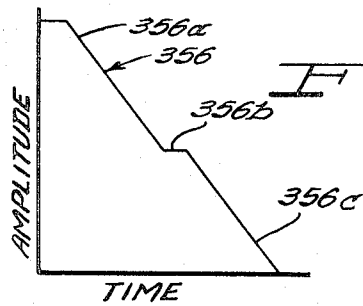

Fig. 13

Fig. 12

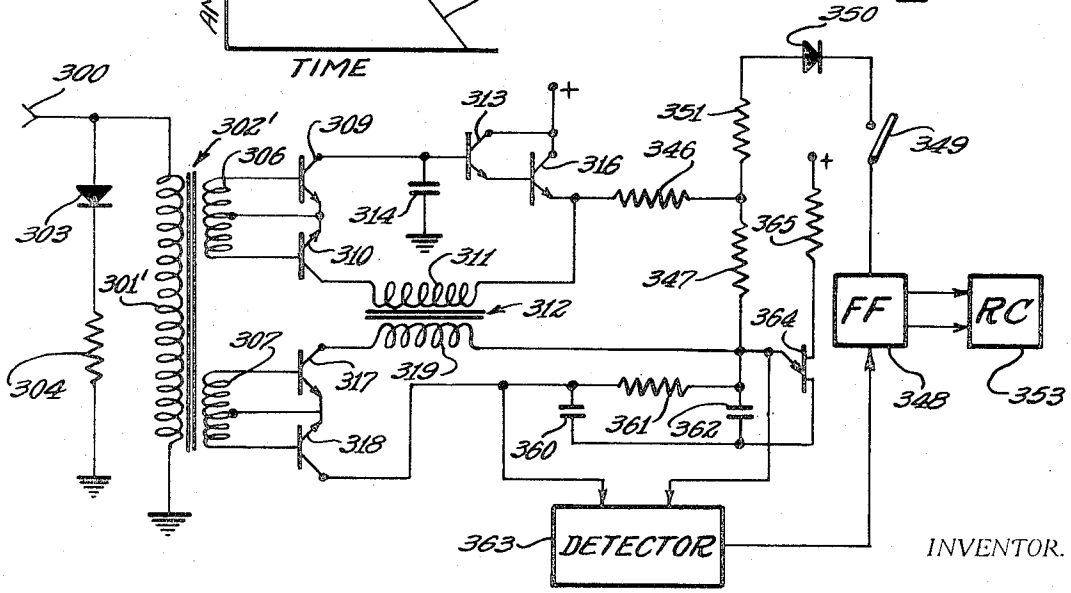

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Fig. 14

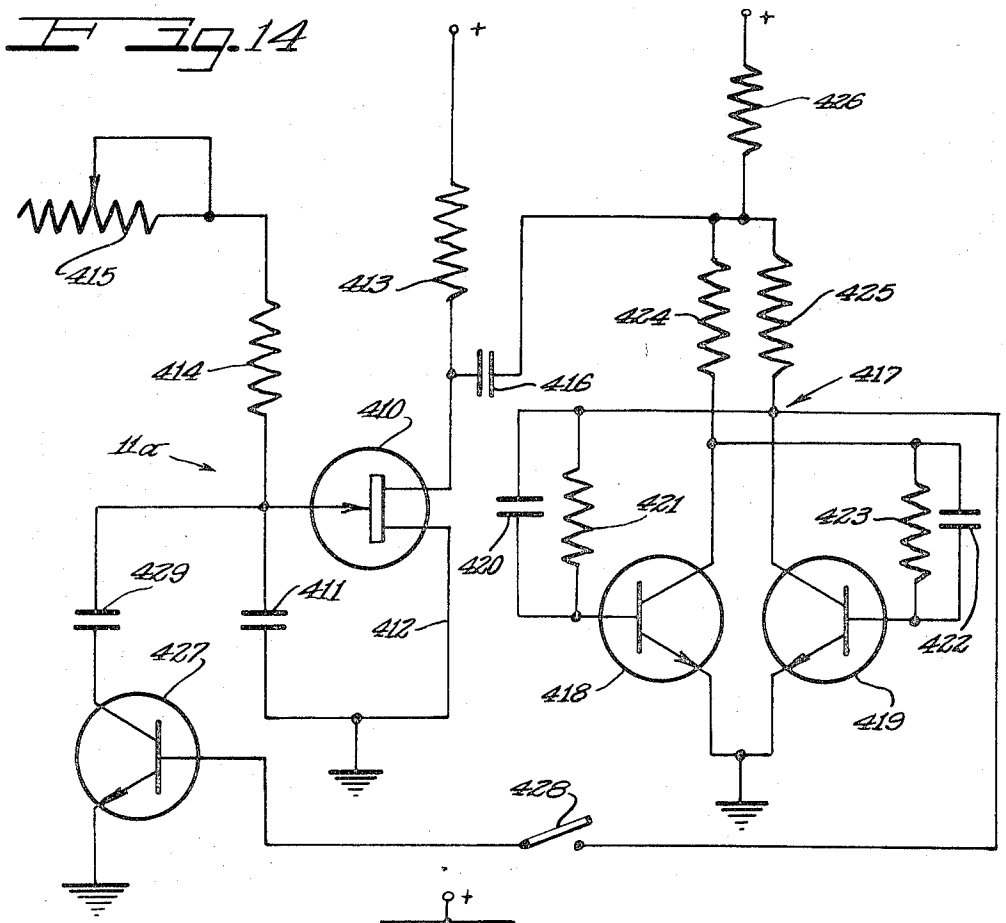
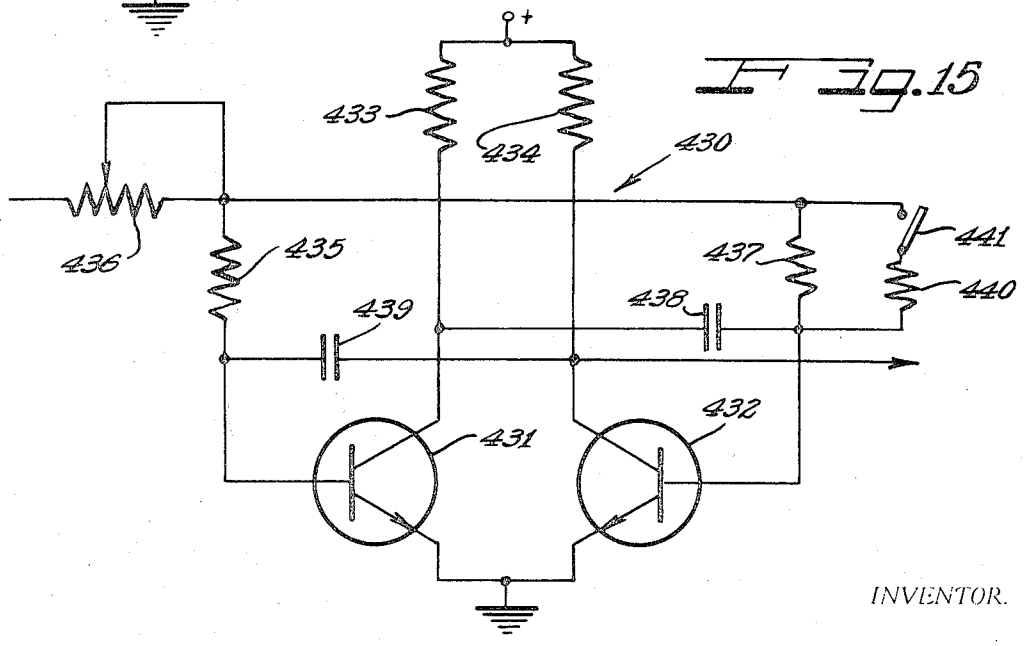


Fig. 15



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AUTOMATIC MUSICAL RHYTHM SYSTEM WITH OPTIONAL PLAYER CONTROL

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention is directed generally to an electronic rhythm-producing sound device for automatically generating sounds in rhythmic patterns for use alone or in accompaniment with other musical instruments. Specifically, the invention is directed to a new and improved circuit arrangement for a rhythm-producing sound device.

2. Description of the Prior Art

Heretofore, automatic rhythm devices use electronic clock means which would produce evenly spaced pulses to drive ring or binary counters of a fixed number of stages. The proper pattern of pulses for producing rhythmic patterns were then obtained by gating the proper pulses from the chain each time the counter cycled. A large number of evenly spaced pulses had to be included in the cycle in order to permit all the desired patterns to be obtained. Accordingly, the present invention decreases the number of pulses necessary by providing unevenly spaced pulses when required. In so doing, the gating and logic circuitry required to obtain the desired pulse pattern is greatly simplified. In addition to the simplification resulting from working with a fewer number of pulses and of more closely fitting the pattern to be produced, the present invention also uses the more economical resistor matrices instead of the diode matrices of prior-art devices.

SUMMARY OF THE INVENTION

The device includes a time-point generator, a plurality of direct current coupled matrix patterns, and an instrument generator. The time-point generator comprises a tempo oscillator which generates a series of pulses to control the rate of the rhythm device. The frequency of the tempo oscillator is adjustable. The pulse signal information from the tempo oscillator is delivered to a series of beat dividers which include a feedback path from the fourth stage to the third stage to make the overall scale of the series of dividers either 16 or 12. The tempo oscillator and beat divider together form a clock generator. In the scale of 16 mode of operation, the intermediate beats are evenly spaced throughout the bar of music as sixteenth notes, while in the scale of 12 position they are of odd spacing and occur as triplet notes. The last stage of the binary dividers is connected to an eight-stage ring counter. The ring counter generates eight pulses. The last stage of the ring counter is connected to a second chain of binary dividers which has a total count capacity of eight. The second chain of dividers constitutes a bar counter whose output is decoded and used to selectively control changes in the pattern of music on only the second, fourth and eighth bar of the pattern. The outputs from the tempo oscillator, beat dividers, and ring counter are delivered to pulse amplifiers which reshape the outputs into fast-rise short-duration pulses which occur at different points in time depending on the origin of the pulse.

The pulses derived from the foregoing are delivered to the matrix assembly where they are combined to form subpatterns as required by the different arrangements of music. There is a plurality of patterns or arrangements which can be selected by a selector switch, and each of the patterns is derived from its own subpattern or matrix output. In musical arrangements where more than one instrument sound requires the same drive pattern, the matrix producing that particular subpattern is duplicated so that there are separate but identical drives for each musical instrument sound generator.

The final major component of the rhythm device of the present invention is the musical instrument sound generator which includes keying circuits to operate corresponding multivibrators. The keying circuit includes means to reshape the square wave pulses of the multivibrator into wave forms which approximate those produced by actual musical instruments. These reshaped wave forms are delivered to audio amplifiers for reproduction in a loudspeaker system.

The rhythm device of the present invention is energized by a direct current voltage power supply which produces, for example, 5 and 10 volts for the transistor circuitry and a negative 3.5 volts for the matrix assemblies. The power supply is preferably voltage regulated with zener diodes to maintain the voltage within the prescribed limits while variations from 90 to 130 volts AC may occur at the input line.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram showing generally the circuit arrangement of a rhythm sound-producing device constructed in accordance with principles of this invention;

FIG. 2 is divided into two segments designated FIGS. 2*a* and 2*b* and shows a detailed schematic diagram of the circuit arrangement of the time-point generator of FIG. 1;

FIG. 3 is divided into two segments designed FIGS. 3*a* and 3*b* and shows a detailed schematic diagram of the circuit arrangement of an instrument sound generator of FIG. 1;

FIGS. 4, 5, 6, 7 and 8 show the arrangement of several different matrices which can be connected between the time-point generator and the instrument sound generator of FIGS. 2 and 3;

FIG. 9 is a simplified block diagram showing the general circuit arrangement of the beat divider circuit incorporated in the time-point generator of FIG. 1;

FIG. 10 is a series of wave forms illustrating the operation of the beat divider circuit of FIG. 9;

FIG. 11 is a schematic diagram of an automatic follow circuit arrangement which may be used in conjunction with the rhythm sound device of the present invention;

FIG. 12 is a schematic diagram of an alternate arrangement of an automatic follow circuit which may be used in conjunction with the rhythm sound-producing device of the present invention;

FIG. 13 illustrates a wave form generated by the automatic follow circuits of FIGS. 11 and 12;

FIG. 14 is an alternate arrangement of a clock generator circuit which can be used in accordance with the principles of this invention; and

FIG. 15 is still another alternate arrangement of a clock generator which can be used in accordance with the principles of this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Seen in FIG. 1 is a rhythm sound-producing device constructed according to this invention and includes a time-point generator 10 which produces a plurality of sequential spaced-apart pulses which may correspond to the sequential spacing of a line or bar of written music. The time-point generator 10 includes a tempo oscillator 11 the frequency of which is selectively variable by a potentiometer 12. The potentiometer 12 is connected to a voltage divider network 13 comprising a resistor 14 and a potentiometer 16. The potentiometer 16 is used to calibrate the voltage applied to the tempo oscillator thereby calibrating the range of frequency of oscillation.

The output of the tempo oscillator 11 is delivered to a beat divider circuit 17 and to one of a plurality of pulse amplifiers designated generally by reference numeral 18. The beat divider network 17 is formed by a plurality of flip-flop circuits. A switch 19 is connected to the beat divider network 17 to selectively change the voltage applied to a portion of the beat divider network thereby enabling the network 17 to divide by four or divide by three as desired. The output of the beat divider network 17 is delivered to certain ones of the plurality of pulse amplifiers 18 and to the input of a ring counter 20.

The tempo oscillator 11 together with the beat divider circuit 17 form a clock generator which controls the function of the rhythm device. A clock generator so formed in accordance with this invention can selectively produce evenly or unevenly spaced pulse signals to provide a plurality of different kinds of pulse patterns corresponding to the different kinds of musical arrangements.

Also, according to the present invention, the ring counter **20** is a direct-coupled self-biasing circuit which, in the preferred embodiment, has eight stages. It will be understood that the ring counter of the present invention may have more or less than eight stages.

The ring counter **20** is biased such that seven of the eight stages are conducting in the saturated mode of operation and one stage is nonconducting at all times. Pulses from the beat divider network **17** will cause the nonconducting stage to become conductive and the next preceding stage to become conductive.

The eight stages of the ring counter are divided into two groups, one group containing the odd-number stages and the other group containing the even-number stages.

Connected to the ring counter **20** is a time switch **21** which enables the ring counter to generate a 4/4 time or a ¾ time depending upon the type of music being reproduced by the rhythm sound generator. By way of example, the ring counter **20** is an eight-stage counter wherein the output of the last stage is fed back to the input of the first stage thereby allowing the ninth pulse from the beat divider to restart the count by eight cycle. With the time switch **21** in the open position, as shown on the drawing, the ring counter will produce eight pulses in sequence. However, when the time switch **21** is in the closed position, the first two stages of the ring counter are bypassed, thereby converting the ring counter into a count by six circuit. This feature enables the ring counter **20** to generate both 4/4 and ¾ time counts for the various types of music being reproduced.

The plurality of outputs of the ring counter **20** are connected to still another group of pulse amplifiers **18** and to a bar counter **22**. The bar counter **22** is formed by a chain of three binary stages or flip-flops having a total binary-counting capacity of eight which is a musically correct bar structure. Each time the ring counter **20** produces the eight pulse of the count by eight sequence of operation it generates an output pulse at the input of the bar counter **20**. The output of the bar counter is decoded by a series of logic circuits, which will be described hereinbelow, and applied to a matrix assembly **23**. Also connected to the bar counter **20** is a reset switch **24** which resets all of the flip-flop circuits of the bar counter to the zero count.

Also connected to the matrix assembly **23** are the outputs of the pulse amplifiers **18**. The matrix assembly **23** is constructed primarily of resistors which are direct current coupled to the pulse amplifiers and bar counter.

The output of the matrix assembly **23** is connected to a selector switch assembly **26** and therefrom to an instrument sound generator **27**. The selector switch **26** connects the proper matrices within the matrix assembly **23** to the respective ones of a plurality of instrument driver circuits **28**. The instrument drivers **28** are connected to one or more of a plurality of instrument generator circuits **29**. The output of the instrument generators are then applied to mixing amplifiers designated generally by reference numeral **30**.

The output of the mixing amplifiers is connected to an audio amplifier (not shown) through a coupling circuit comprising a voltage divider network which is formed by resistor **31** and a potentiometer **32**. A capacitor **33** has one end thereof connected to the movable contactor of the potentiometer **32** and the other end thereof connected to one end of the resistance element of the potentiometer **32**. The audio signal passing through the capacitor **33** and the movable contactor of the potentiometer **32** is delivered to a shielded cable **34** through a resistor **36** and a coupling capacitor **37**. The output of the mixing amplifiers **30** is connected to the coupling circuit through a shielded cable **38**. Connected to the junction of the movable contact of the potentiometer **32** and the capacitor **33** is a switch **39** which is connected to ground potential. When the switch **39** is closed, the audio signal from the mixing amplifiers **30** is grounded to mute the output of the rhythm sound device.

FIG. **2** is a detailed schematic diagram of the time-point generator **10** of FIG. **1** and is divided into two segments FIG. **2***a* and FIG. **2***b*. The tempo oscillator is designated generally by reference numeral **40** and includes a unijunction transistor **41**. The transistor **41** has the first base electrode thereof connected to ground potential and the second base electrode connected to a positive 10 volt direct current power source, (not shown), through a resistor **42**. A charging capacitor **43** is connected between the emitter electrode of the unijunction transistor **41** and ground potential and receives charging current through a resistor **44** and a potentiometer **46**. The potentiometer **46** is connected to a voltage divider network **47** comprising a potentiometer **48** and a resistor **49**.

The tempo oscillator is operated as a free-running unijunction relaxation oscillator. The charging capacitor **43** receives charging current through the resistor **44** and the potentiometer **46**. When the charging capacitor **43** is charged sufficiently to cause an appreciable current flow to pass between the emitter and base 1 of the unijunction transistor, the capacitor **43** is quickly discharged through the emitter base junction of the transistor. The emitter current flowing through the transistor **41** greatly reduces the interbase resistance of the transistor to cause an increase in current flow between base 1 and base 2. The increase in current flow between the base electrodes of the transistor cause a voltage drop to be developed across the load resistor **42** thereby producing a pulse at the output of the tempo oscillator. When the voltage across the charging capacitor **43** decreases sufficiently to increase the emitter base 1 resistance thereof, the emitter stops conducting and the process repeats itself. This action produces a sawtooth wave form at the emitter junction of the transistor **41** and a series of sharp negative-going pulses at the second base electrode of the transistor and across the load resistor **42**. The pulses produced by the tempo oscillator are the basic timing signals for the rhythm sound-producing device of the present invention. By varying the resistance of the potentiometer **46**, the charging time of the charging capacitor **43** is changed to change the operating frequency of the oscillator. The potentiometer **48** of the voltage divider network **47** is used to calibrate the tempo oscillator when the tempo control potentiometer **46** is set at its minimum resistance value. Therefore, the maximum frequency of the tempo oscillator **40** is preadjusted by the calibration resistor **48**.

Pulse signal information is taken from the emitter junction of the transistor **41** and delivered to a pulse amplifier stage **50**. The pulse amplifier stage **50** comprises one of the pulse amplifiers **18**, shown in FIG. **1**. A transistor **51** has the emitter electrode thereof connected to ground potential and the base electrode thereof connected to a positive voltage source through a biasing resistor **52**. The collector electrode of transistor **51** is connected to the voltage source through a load resistor **53**. The pulse signal information from the emitter of transistor **41** is delivered to the base of transistor **51** through a coupling network comprising resistor **54** and capacitor **56**. The sawtooth wave form generated at the emitter of unijunction transistor **41** is then transformed into a pulse signal and applied to the output terminal T_1 of the pulse amplifier stage **50**.

All of the pulse amplifiers used in the time-point generator of the present invention are constructed in substantially the same manner as that of the pulse amplifier **50** and it will be understood that each pulse amplifier operates in precisely the same manner.

In operation, when no pulse signal information is applied to the base electrode of the transistor **51** the transistor is biased through resistor **52** in the saturated mode of operation. That is, sufficient base current is supplied through resistor **52** to allow current flow to pass between the emitter collector junction of the transistor limited only by the collector load resistor **53**.

When a negative-going pulse is applied to the base electrode of transistor **51** through the coupling capacitor **56**, the transistor **51** is rendered nonconductive thereby decreasing the collector current and increasing the collector voltage to produce an output pulse at terminal T_1. The coupling capaci-

tor 56 quickly charges through resistor 54 and renders the transistor 51 conductive in the saturated mode of operation. It will be noted that only negative-going pulses applied to the base electrode of transistor 51 will cause pulse outputs to be developed thereby. Positive-going pulses would only tend to cause the transistor 51 to conduct harder thereby having no effect at the output terminal T_1. The coupling resistor 54 and coupling capacitor 56 are selected to form a differentiating network which is responsive only to rapid changes in the pulse signal information applied therethrough.

The pulse signal information developed across the load resistor 42 of the tempo oscillator circuit 40 is delivered to the first of a series of divider networks or flip-flop circuits 57, 58, 59, and 60. Each of the flip-flop circuits 57—60 is constructed in substantially the same manner, and, for purposes of simplicity, only the flip-flop circuit 58 will be discussed in detail.

The flip-flop circuit 58 includes a pair of transistors 61 and 62 having their emitter electrodes connected to ground potential. The collector electrode of transistor 61 is connected to the base electrode of transistor 62 through a coupling network comprising capacitor 63 and resistor 64. Similarly, the collector electrode of transistor 62 is connected to the base electrode of transistor 61 through a coupling network comprising capacitor 66 and resistor 67. The collector of transistor 61 is connected to a positive voltage source through a load resistor 68 and a voltage-dropping resistor 69. The collector electrode of transistor 62 is connected to the positive voltage source through a load resistor 70 and the resistor 69.

The flip-flop stage 58, as well as flip-flops 57, 59, and 60, is basically a two-stage, direct-coupled amplifier with positive feedback. Initially, either transistor 61 or transistor 62 must be in the saturated mode of operation. For example, if transistor 62 is in the saturated mode of operation, the collector voltage is very near ground potential. This low voltage is coupled to the base electrode of transistor 61 and is sufficient to hold the transistor 61 in the cutoff condition. Therefore, the voltage at the collector of transistor 61 is, for example, approximately 5 volts and this voltage is coupled to the base electrode of transistor 62 through resistor 64. The high positive potential applied to the base of transistor 62 is sufficient to maintain the transistor in the saturated mode of operation. Input signals applied to the flip-flop stage are differentiated by the input coupling capacitor 72 and the resistor 69 to produce a negative-going pulse at the junction of resistors 68 and 70 and 69. The negative-going pulse is coupled through the collector resistors 68 and 70 and the base resistors 64 and 67. The base of transistor 61 and the collector of transistor 62 are not affected by the negative-going pulse. However, the collector of transistor 61 and the base of transistor 62 are driven slightly negative. This action starts to turn off transistor 62 and turn on transistor 61. Once this action is initiated, the positive feedback in the circuit insures that the transistor 62 will be rendered nonconductive and transistor 61 rendered conductive in the saturated mode of operation. Each time a negative-going pulse is applied to the flip-flop 58 the flip-flop changes its state of conduction. Therefore, two pulses applied to the input of the flip-flop stage will produce a single pulse at the output thereof. Each stage 57—60 operates in exactly the same manner as described above such that the total division accomplished by the stages between the tempo oscillator and the output of stage 60 is 16.

Pulse signal information from the tempo oscillator 40 is delivered to flip-flop stage 57 through a coupling capacitor 71, and the output of flip-flop stage 57 is delivered to the input of flip-flop stage 58 through a coupling capacitor 72. Similarly, the output of flip-flop stage 58 is coupled to the input of stage 59 through a coupling capacitor 73 and the output of stage 59 is coupled to the input of stage 60 through a coupling capacitor 74. It will be understood that the coupling capacitors 71—74 together with their associated voltage-dropping resistor, resistor 69 of stage 58, form a differentiating circuit to produce pulse inputs to each of the flip-flop stages.

The output of flip-flop stage 58 is coupled to the input of stage 59 and to a pulse amplifier circuit 76 through a coupling capacitor 77 and a resistor 78. The pulse amplifier circuit 76 operates in substantially the same manner as that of the pulse amplifier circuit 50. A negative-going pulse at the output of flip-flop stage 58 will render the transistor of the pulse amplifier 76 nonconductive to produce a positive-going pulse at the output terminal T_2 thereof. Similarly, the output of flip-flop stage 59 is coupled to the input of stage 60 and to a pulse amplifier stage 79 to produce a pulse at the output terminal T_3 of the pulse amplifier. Also, the output of flip-flop stage 60 is coupled to a pulse amplifier stage 82 through a coupling capacitor 83 and a resistor 84 to produce a pulse at the output terminal T_4 of the pulse amplifier 82. The flip-flop stage 60 has a second output terminal thereof connected to a pulse amplifier stage 86 through a coupling capacitor 87 and a resistor 88, and to a feedback amplifier circuit 89. The feedback amplifier 89 is connected to the second output of flip-flop stage 60 through a resistor 90, and therefore is direct current coupled to the flip-flop stage 60. The output of the feedback amplifier 89 is connected to the input of one of the transistors of the flip-flop stage 59 through a coupling capacitor 91 and a resistor 92.

The feedback amplifier 89 includes a transistor 93 which has the base electrode thereof connected to a positive voltage source through a biasing resistor 94. Also connected to the positive voltage source is the collector electrode of transistor 93 through a load resistor 96. The base of transistor 93 is connected to the triplet switch 19, shown in FIG. 1, through a resistor 97.

In operation, when the triplet switch 19 is in the closed position, a positive bias voltage is applied through the resistor 97 to the base of transistor 93. The transistor 93 is held in the saturated mode of operation due to the bias supplied through the resistor 97 and through the resistor 94. Therefore, a pulse signal supplied to the base of transistor 93 from the second output of the flip-flop stage 60 has no effect on the amplifier stage and no output signal will be produced at the collector junction thereof. Therefore, the last two flip-flop stages 59 and 60 operate in their normal mode to divide by four. On the other hand, when the switch 19, of FIG. 1 is in the open position, the bias supplied to the base of transistor 93 through resistor 97 is removed. The bias for transistor 93 is now derived from the coupling resistor 90 and the biasing resistor 94. It will be noted that the emitter of transistor 93 is connected to a positive voltage source which is less than the positive voltage source connected to the collector thereof. For example, the emitter is preferably connected to a positive 5 volt source. Therefore, the transistor 93 will conduct whenever the input through coupling resistor 90 is equal to or greater than the positive 5 volts supplied to the emitter of transistor 93. It can be seen that the output of the feedback amplifier 89 will follow the second output of the flip-flop stage 60. Therefore, every third input pulse to the flip-flop stage 59 is fed back from the second output of the flip-flop stage 60 to the input of flip-flop stage 59 thereby resetting the stage 59. This action reduces the total count capacity of the last two flip-flops 59 and 60 from four counts to three counts. The output of the last flip-flop stage 60 is then nonsymmetrical in a ratio of 2:1 or divided at third intervals rather than in halves.

According to the present invention, each of the pulse amplifiers as well as the feedback amplifier 89 are operated in the saturated mode of operation and produce output pulses only when the transistor of each stage is rendered nonconductive. This feature greatly simplifies the circuit arrangement of the rhythm device of the present invention and reduces the possibility of pulses produced by one stage affecting the operation of the other stages in the circuit.

The pulses produced at the output of flip-flop stage 60, are applied to circuit points 98 and 99 which, in turn, are connected to circuit points 98*a* and 99*a* which are signal input terminals of an eight-stage ring counter. Although the present invention shows an eight-stage ring counter it will be understood

that a ring counter having any number of stages may be used in accordance with the principles of this invention.

According to this invention a single transistor is used in each stage of the ring counter. The ring counter comprises transistors **100, 101, 102, 103, 104, 105, 106,** and **107**. The emitter electrode of each transistor is connected to ground potential while the collector electrode thereof is connected to a positive voltage source through a corresponding load resistor **108, 109, 110, 111, 112, 113, 114,** and **115** respectively. It will be noted that each stage of the ring counter is constructed in substantially the same manner.

The circuit point **98***a* from the output of the beat divider network **60**, is connected to the base electrodes of transistors **100, 102, 104,** and **106** through corresponding resistors **116, 117, 118,** and **119** respectively. Similarly, the circuit point **99***a* is connected to the base electrode of transistor **101, 103, 105,** and **107** through corresponding resistors **120, 121, 122,** and **123** respectively.

The collector electrode of transistor **100** is coupled to the base electrode of transistor **101** through a resistor **124** and a capacitor **126**, while the collector electrode of transistor **101** is coupled to the base electrode of transistor **102** through a resistor **127** and a capacitor **128**. It will be noted that the outputs of the remaining transistors **102—107** are coupled to the corresponding down-stage transistors through resistive capacitive networks comprising resistors **129, 131, 133, 136, 138** and **140** and capacitors **130, 132, 134, 137, 139,** and **141** respectively.

The collector of transistor **100** is direct current coupled to the base electrode of transistors **102, 104,** and **106** through resistors **142, 143,** and **144** respectively. The collector of transistor **101** is direct current coupled to the base electrode of transistors **103, 105** and **107** through resistors **146, 147,** and **148** respectively. The collector of transistor **102** is direct current coupled to the base electrode of transistors **100, 104,** and **106** through resistors **149, 150,** and **151** respectively. The collector of transistor **103** is direct current coupled to the base electrode of transistors **101, 105,** and **107** through resistors **152, 153,** and **154** respectively. The collector electrode of transistor **104** is direct current coupled to the base electrode of transistors **100, 102,** and **106** through resistors **157, 156,** and **158** respectively. The collector electrode of transistor **105** is direct current coupled to the base electrode of transistors **101, 103,** and **107** through resistors **160, 159,** and **161** respectively. Similarly, the collector electrode of transistor **106** is direct current coupled to the base electrode of transistors **100, 102,** and **104** through resistors **164, 163,** and **162** respectively, and the collector electrode of transistors **107** is direct current coupled to the base electrode of transistors **101, 103** and **105** through resistors **168, 167,** and **166** respectively. It will be noted that the output of the last transistor **107** is coupled back to the input of the first transistor **100** through the resistor **140** and capacitor **141**.

In operation, the biasing of each of the transistors **100—107** arranged such that seven of the transistors are operated in the saturated mode of operation while only one of the transistors is nonconductive. The transistors **100, 102, 104,** and **106** form one group of count circuits while transistors **101, 103, 105,** and **107** form a second group of count circuits. In each group of transistors the base electrode of each transistor is connected to the collector electrodes of the other three transistors in the group. The interconnecting resistors and the collector load resistor of each stage in the group are sized such that any three stages of the group will be held in the saturated mode of operation if the remaining stage is in the cutoff condition. The transistor which is in the cutoff mode of operation will remain cut off as long as the collector voltage of the remaining three saturated transistors remains below the voltage necessary to bias the transistor on.

Each base electrode of transistors **100—107** is coupled to the circuit points **98***a* and **99***a* to receive drive pulses therefrom. The drive pulses are developed at the output of the flip-flop stage **60** of the beat dividers. When the second stage of the flip-flop **60** is in the saturated mode of operation, substantially no drive pulse is delivered to the nonconductive transistor of the group of transistors **100, 102, 104** and **106**. On the other hand, when the second stage of flip-flop circuit **60** is rendered nonconductive, a positive pulse is applied to the circuit point **98***a* to drive the nonconductive transistor of the group **100, 102, 104,** and **106** into the saturated mode of operation thereby placing all of the transistors in the group in the saturated mode. Therefore, the transistor being rendered conductive produces an output pulse through the resistor capacitor coupling network between each of the transistor stages and the following stage, which is one of the transistors of the second group, is rendered conductive. That is, when the voltage on the circuit points **98***a* and **99***a* causes a previously cutoff transistor to be rendered conductive, the drop in collector voltage applied through the resistor capacitor coupling network to the base of the succeeding saturated transistor will cause this transistor to be cut off. As the voltage on the circuit point **99***a* is removed due to the saturated condition of the first stage of flip-flop circuit **60** the stage which is rendered nonconductive remains nonconductive and holds the other transistors in the group in the saturated mode of operation.

The nonconductive mode of operation is then shifted from one transistor to another and from one group to another as the output of flip-flop circuit **60** changes state. That is, the stage in each group of transistors of the ring counter becomes nonconductive in turn in response to the successive output pulses of the flip-flop circuit **60**. During the time each of the transistors is nonconductive, the voltage on the collector electrode thereof goes positive while the voltage developed at the base electrode thereof goes negative. Therefore, either of the voltages developed at each of the transistor stages of the ring counter can be used as an output pulse.

In each of the resistor capacitor coupling networks between the successive transistors of the ring counter the resistor functions as a voltage divider with the resistance networks connected to the base of the preceding stage such that the voltage swing at the base is a fraction of the voltage swing of the collector. This allows the collector voltage swing to be several times the maximum base emitter reverse voltage rating which is quite small in some transistors. This circuit arrangement allows the voltage at the collector electrode to rise sharply when the transistor is cut off. This action drives the other transistors in the group more quickly into the saturated mode of operation and reduces the possibility of spurious operation.

It will be understood that the number of stages in the ring counter could be increased or decreased by changing the number of stages in each group. Also, it will be understood that the ring counter could be arranged such that all but one of the transistors is operated in the cutoff mode while only one of the transistors is in the saturated mode.

The output of transistor **100** is connected to a terminal T_6 and to a pulse amplifier **170** which, in turn, is connected to a terminal T_7. The transistor **101** is connected to a terminal T_8 and to a pulse amplifier **171** which, in turn, is connected to a terminal T_9. The transistor **102** is connected to a terminal T_{10} and to a pulse amplifier **172** which, in turn, is connected to a terminal T_{11}. The transistor **103** is connected to a terminal T_{12} and to a pulse amplifier **173** which, in turn, is connected to a terminal T_{13}. Similarly, transistors **104, 105, 106,** and **107** are connected to terminals T_{14}, T_{16}, T_{18}, and T_{20} and to pulse amplifiers **174, 176, 177,** and **178** respectively. The pulse amplifiers **174, 176, 177,** and **178** are connected to output terminals T_{15}, T_{17}, T_{19}, and T_{21} respectively. At each of the output terminals represented by a square there is produced a gating pulse, while at each of the output terminals represented by a circle there is produced a pulse signal output. The terminals T_6—T_{21} are arranged for direct current coupling to one or more matrices of the matrix assembly **23**, shown in FIG. **1**. Also, it will be understood that each of the pulse amplifiers **170, 171, 172, 173, 174, 176, 177,** and **178** are constructed and operate in substantially the same manner as the pulse amplifier **50** connected to the tempo oscillator **40**.

According to the present invention, the output of the last transistor **107** of the ring counter is connected to the base electrode of transistor **102** through a line **179**, a capacitor **180**, the switch **21**, shown in FIG. **1**, and a resistor **181**. When the switch **21** is in the closed position, connecting resistor **181** to capacitor **180**, the feedback of transistor **107** is coupled to transistor **102** rather than to transistor **100** thereby decreasing the numerical size of the ring counter from eight stages to six stages. This feature enables the time-point generator of the present invention to produce both 4/4 time pulses and ¾ time pulses necessary for musical arrangements by using the same electronic circuitry.

The output of the last transistor **107** of the ring counter is also coupled to the input of a series of flip-flop circuits **182**, **183**, and **184**. The flip-flop circuits **182—184** are constructed in substantially the same manner as flip-flop circuit **58** and operate similar thereto. The first stage of flip-flop circuit **182** is direct current coupled to a terminal T_{22} and to the base of two transistors **186** and **187** through resistors **188** and **189** respectively. The transistors **186** and **187** form NAND gate circuits. The output of the second stage of the flip-flop circuit **182** is connected to a terminal T_{23}.

The first stage of the flip-flop circuit **183** is direct current coupled to transistor **186** through a resistor **190** and to transistor **187** through a resistor **191**. The second stage of the flip-flop circuit **183** is capacitively coupled to the input of flip-flop circuit **184**. The first stage of flip-flop circuit **184** is direct current coupled to transistor **187** through a resistor **192**.

The output of transistor **187** is direct current coupled to the base electrode of a transistor **193** through a resistor **194**. The transistors **186, 187,** and **193** are connected to a positive voltage source through load resistors **196, 197,** and **198** respectively. The pulse or gate voltage developed at the load resistors is applied to terminals T_{24}, T_{25}, and T_{26}. The output pulse developed at terminal T_{26} will be opposite that developed at terminal T_{25} due to the circuit arrangement of transistors **187** and **193**. When transistor **187** is in the saturated mode of operation, transistor **193** is cut off thereby producing a positive pulse at terminal T_{26}. On the other hand, when transistor **187** is cut off, bias is applied to transistor **193** sufficient to cause the transistor to be saturated and thereby applying ground potential or negative gate pulse to terminal T_{26}.

The output of the second stage of the flip-flop circuit **182** and the output of the first stages of flip-flop circuits **183** and **184** are connected to a switching circuit **199** through diodes **200, 201,** and **202**. The switching circuit **199** includes a transistor **203** which has its emitter electrode connected to ground potential and the base electrode thereof connected to a positive voltage source through a resistor **204**. The collector electrode of transistor **203** is connected to the positive voltage source through a load resistor **206**. A capacitor **207** is connected across the bias resistor **204**. The base electrode of transistor **203** is connected to the reset switch **24**, of FIG. **1**, through a resistor **208**.

When the switch **24** is closed, resistors **204** and **208** form a voltage divider network such that the voltage at the base of transistor **203** is reduced thereby rendering the transistor substantially nonconductive. With the transistor **203** in the nonconductive mode of operation the diodes **200, 201,** and **202** are reversed biased thereby allowing the flip-flop stages **182, 183,** and **184** to operate in their normal mode of operation. However, when switch **24** is opened, the transistor **203** is rendered conductive in the saturated mode of operation thereby placing ground potential at the cathodes of each of the diodes **200—202**. This action will reset the flip-flop stages **182—184** which form the bar counters.

The bar counter formed by the three flip-flop stages **182—184** has a total count capacity of eight which is a musically correct bar structure. Each time the ring counter produces an output pulse at the last stage thereof it triggers the first flip-flop stage **182** of the bar counter. Flip-flop circuits **183** and **184** follow the first stage **182** and accumulate a total of eight different states of operation. In this way the bar counter keeps track of the number of cycles through which the ring counter passes up to eight cycles and then repeats the operation. The output of the bar counter is decoded by the NAND gates connected thereto to produce positive gate pulses during every second, fourth, and eighth bar. These gates are used to effect electrical changes in the matrix assembly **23**, of FIG. **1**, to introduce pattern changes during every second, fourth and eighth bar.

Since a musical flourish usually occurs during the eighth bar the bar counter is reset to the seventh bar position. This is accomplished by pulling the appropriate collectors of the flip-flop circuits **182, 183,** and **184** down through diodes **200, 201,** and **202** to force the bar counter to assume the seventh bar position. The reset drive for the flip-flop circuits **182, 183,** and **184** is provided by the saturated mode of operation of the switching circuit **199**. The resistor **204** maintains the transistor **203** in the saturated condition thereby applying approximately ground potential to the cathodes of the diodes **200, 201,** and **202**. The diodes **200, 201,** and **202** are forward biased and conduct rather than allow the level at the collectors of the transistors of the flip-flops **182—184** to rise so that the bar counter is held in this state. When the switch **24** is closed, ground potential is applied to the base of transistor **203** through resistor **208** thereby rendering transistor **203** nonconductive and raising the voltage developed at the collector thereof. This action reverse biases the diodes **200, 201** and **202** and allows the bar counter to proceed in the normal fashion.

A transistor **210** is connected to the last transistor **107** of the ring counter through a resistor **211**. The transistor **210** is connected to a transistor **212** and to a lamp **213**. The transistor **210** and **212** and lamp **213** form an indicating circuit which produces a visual light pulse during predetermined time intervals. The light pulse is used as a downbeat indicator for the person who is using the rhythm sound device for accompaniment. Transistors **210** and **212** are arranged in a Darlington configuration to develop a high gain.

FIG. **3** is divided into two portions of **3***a* and **3***b*. FIG. **3** is a detailed schematic diagram of the instrument sound generator **27** of FIG. **1**. The instrument sound generator of FIG. **3** includes a plurality of free-running multivibrator circuits **220, 221, 222, 223, 224, 225,** and **226**. The multivibrator **220** is connected to a drive circuit **227** through a diode **228**. The multivibrator **221** is connected to a drive circuit **229** through a diode **230**, and the multivibrator **222** is also connected to the drive circuit **229** through a diode **231**. The multivibrator **223** is connected to a drive circuit **232** through a diode **233**. Also connected to the drive circuit **232** is the output of the multivibrator circuit **224**. The multivibrator circuit **225** is connected to a drive circuit **236** through a diode **237**. Similarly, the output of the multivibrator **226** is connected to a drive circuit **238** through a diode **239**.

The output of the multivibrator **220** is delivered to an audio amplifier transistor **240** through a diode **241** and a wave-shaping network **242**. The output of the multivibrator **221** is delivered to an audio amplifier transistor **243** through a diode **244** and a wave-shaping network **246**. The output of the multivibrator **222** is also applied to the input of the audio amplifier transistor **243** through a diode **247** and a resistor **248**. Similarly, the output of the multivibrator **223** is applied to the input of the audio amplifier transistor **243** through a diode **249** and a resistor **250**. Also applied to the input of transistor **243** is the output of multivibrator **224** through a diode **251** and a resistor **252**.

The output of multivibrator **225** is applied to an audio amplifier transistor **253** through a diode **254** and a pair of resistors **256** and **257** which are center tapped by a capacitor **258**. The resistors **256** and **257** and capacitor **258** form a wave-shaping network for the multivibrator **225**. The output of the multivibrator **226** is applied to the input of the audio amplifier transistor **253** through a diode **259** and a wave-shaping network **260**.

The output of the audio amplifier transistor **253** is direct current coupled to the input of a transistor amplifier stage **261** which in turn, is capacitive coupled to an audio output circuit **262**. It will be noted that the output of transistor amplifiers **240** and **243** also is capacitive coupled to the audio output stage **262**. The output of the instrument sound generator may include a level control comprising potentiometer **263** and a volume control comprising potentiometer **264**. Also, it will be noted that the audio amplifier transistors receive more than one signal from the multivibrator circuits and therefore the amplifiers are also mixing stages to produce in the audio output circuit **262** a composite audio signal.

The instrument sound generator also includes a noise generator circuit **266** which is direct current coupled to the input of the audio amplifier transistor **240** through a plurality of sets of gating diodes **267**, **268**, **269**, and **270**. The noise generator produces audio signals of erratic frequencies but which signals complement the quality of the sound generator so as to more accurately simulate actual musical instruments. The noise generator includes a zener diode and a pair of direct current coupled amplifiers. The last stage of the two-stage amplifier has a resistor **266***a* connected between the collector of the transistor and ground potential. The resistor **266***a* is equal in value to a resistor **266***b* which is the collector load resistor of the stage. This circuit arrangement limits the maximum output voltage of the amplifier to one-half of the supply voltage. This feature keeps the amplitude of the noise generator equal to the output of the other signal sources and also keeps the output amplitude constant so that the noise keyers, the sets of diodes **267**, **268**, **269** and **270**, do not feed noise signal information therethrough due to the peaks of the noise signal.

The noise generator **266** is rendered operative by a drive circuit **271**, shown on FIGS. **3***a* and **3***b*, or by drive circuit **272** shown on FIGS. **3***a* and **3***b*. The drive circuits **271** and **272** include a plurality of transistor stages which may be connected to the matrix assembly through the selector switch **26**, of FIG. **1**. The drive circuit **229** interacts with the drive circuit **272** such that the noise generator **266** may be rendered operative during any one of a plurality of time points generated by the time-point generator of FIG. **2**.

According to the present invention, the multivibrators **220**—**226** are direct current coupled to the inputs of the audio amplifier transistors through gating diode circuits. That is, by way of example, the output of the multivibrator **226** is direct current coupled to the base of audio amplifier transistor **253** through the gating diodes **239** and **259**. Also, the drive circuits may contain one or more drive transistors to cause the output of each of the multivibrator circuits to be applied to the audio amplifier transistor associated therewith. This is a combination of elements and circuit arrangement which greatly simplifies the circuitry and reduces the number of components necessary to provide a rhythm sound-producing device of the character described herein.

The drive circuit **227** includes an input terminal T_{30} connected to the base electrode of one of the transistors of the drive circuit. The drive circuit **229** includes a pair of input terminals T_{31} and T_{32} while the drive circuit **232** includes a pair of input terminals T_{33} and T_{34}. The drive circuit **236** includes an input terminal T_{35} while the drive circuit **238** includes an input terminal T_{36}. Similarly, the drive circuit **272** includes an input terminal T_{37} while the drive circuit **271** includes a plurality of input terminals T_{38}, T_{39}, and T_{40}. Certain ones of the input terminals T_{30}—T_{40} are direct current coupled to corresponding ones of output terminals of the time-point generator through the selector switch **26** and the matrix assembly **23**, of FIG. **1**. According to this invention, each of the transistors in the output circuits of the time-point generator are operated in the saturated mode of operation while each of the transistors in the input circuit of the instrument sound generator are operated in the cutoff mode of operation. This feature enables direct current coupling between the time-point generator and the instrument sound generator and greatly simplifies the circuitry as well as reducing the number of components necessary for proper operation thereof.

Also according to the present invention the multivibrator stage **226** includes a potentiometer **273** connected to the DC supply line thereby providing means for changing the frequency of oscillation of the circuit. By way of example, the multivibrator stage **226** is operated at approximately 70 Hz which is used to simulate the bass drum sound. However, as the sound of the bass drum may be changed somewhat by adjusting the tension of the skin of the drum so also can the sound of the bass drum generator **226** be adjusted.

The operation of each of the multivibrator circuits **220**—**226** together with their associated drive circuits are substantially the same and therefore a typical operation of one of the circuits will be given. By way of example, and not by way of limitation, the multivibrator circuit **226** produces a square wave output of 5 volts amplitude and a peak DC value of +5 volts. With no drive pulse supplied to input terminal T_{36} the transistor of the drive circuit **238** remains cut off and the capacitor connected in parallel with the transistor charges up to the peak signal value through diode **239** and the resistor **239***a*. This causes the junction between the diodes **239** and **259** to receive, for example, +5 volts thereby reverse biasing the diodes to the off condition so that no signal information from the multivibrator **226** passes therethrough. When a pulse from the time-point generator is applied to the terminal T_{36} through the matrices and selector switch, of FIG. **1**, the transistor of drive circuit **238** is rendered heavily conductive and discharges the capacitor in parallel therewith thereby lowering the potential at the junction between diodes **239** and **259**. While the point between the diodes **239** and **259** is below 5 volts, both diodes will conduct and signal information from the multivibrator **226** will pass therethrough. When the drive pulse from the time-point generator dissipates, the transistor of drive circuit **238** is again rendered nonconductive to cause the capacitor in parallel therewith to recharge to the peak signal voltage. This circuit action generates an envelope of signal information with an exponential decay controlled by resistor **239***a* and the capacitor in parallel with the transistor of the drive circuit **238**.

The signal passing through the diodes **239** and **259** is filtered by the wave-shaping network **260** so as to cause the signal to approach a more perfect sinusoidal signal. The sinusoidal signal is then delivered to the base electrode of an amplifier transistor **253** which, in turn, delivers the audio signal information to the audio output circuit **262**.

Circuit modifications are employed to obtain control of more than one multivibrator sound generator from a single drive circuit. For example, the multivibrators **223** and **224** are controlled simultaneously by the drive circuit **232**. For purpose of simplicity, consider the drive circuit **232** a singular transistor type similar to that of the drive circuit **238**. When an input pulse from the time-point generator is applied to the input terminal of the drive circuit the midpoints between the diodes **233** and **249** and diodes **234** and **251** decreases in voltage thereby causing the diodes to become conductive and simultaneously apply the output of the multivibrator **223** and **224** to the audio amplifier **243**.

A still further circuit modification of the present invention is the use of two or more input circuits including a pair of timing capacitors separated by a diode so as to cause the diode keyers associated with certain ones of the sound generator multivibrators to be operative for different time intervals. For example, the drive circuit **232** includes a pair of transistors **232′** and **232″** which are connected to input terminals T_{33} and T_{34} respectively. Connected in parallel with the transistors is a capacitor **232***a* which, in turn, is connected in parallel with a capacitor **232***b* through a diode **232***c*. When a drive pulse is applied to either input terminal T_{33} or T_{34} the transistor associated therewith will be rendered conductive thereby discharging capacitor **232***a* and capacitor **232***b* through the diode **232***c*. That is, both capacitors **232***a* and **232***b* discharge simultaneously and at the same rate. However, the charging rate of the capacitors are different due to the blocking diode **232***c*. For example, the charging rate of capacitor **232***a* is controlled by the resistors connected to the midpoints between

the gating diodes 233 and 249 and gating diodes 234 and 251. On the other hand, the charging rate of capacitor 232*b* has no effect on the charging rate of capacitor 232*a* due to the blocking diode 232*c*. It will be noted that the charging rate of capacitor 232*a* is made faster than the charging rate of capacitor 232*b* thereby maintaining a constant reverse bias on the diode 232*c* during the recharging operation to maintain the charge rates independent of one another.

The drive circuits 238 and 232, described hereinabove, are typical of the remaining drive circuits associated with the instrument sound generator of FIG. 3. It will be noted that the drive circuit 232 controls the multivibrators 223 and 224 simultaneously in response to the charge rate of capacitor 232*a* while the capacitor 232*b* controls the operation of one of the gating diodes associated with the noise generator 266.

Further circuit modifications are employed in the circuit arrangement of drive circuit 271. For example, the drive circuit 271 includes three input terminals T_{38}, T_{39}, and T_{40}. A drive pulse to the input terminal T_{39} discharges a capacitor 271' which recharges at a rate responsive to the value of resistance connected in series therewith. Similarly, an input pulse to terminal T_{39} causes forward bias of the gating diodes 270 but the forward conduction stops immediately upon removal of the drive pulse applied to terminal T_{39} as there is no capacitance to recharge in parallel with the transistor associated therewith. A drive pulse to terminal T_{40} discharges a pair of capacitors in parallel with the transistor associated therewith to again cause conduction through the gating diodes 270. Therefore, it will be understood that the drive circuit 241 controls a single gating circuit but at different time rates dependent on which terminal receives a drive pulse.

Seen in FIGS. 4 through 8 are typical matrices which are associated with the matrix assembly 23 of FIG. 1. It will be understood that the matrices shown in FIGS. 4—8 are shown to explain the circuit connection between the time-point generator and the instrument sound generator and are not to be construed in a limiting sense. The matrix may comprise a single resistor connected between one of the output terminals of the time-point generator and an input terminal of the instrument sound generator. However, a more sophisticated matrix is shown in FIG. 4 which includes a pair of terminals 400 and 401 for receiving drive pulses from the time-point generator. Also associated with the matrix of FIG. 4 is a plurality of terminals 402, 403, 404, and 405 for receiving gating pulses from the time-point generator. It will be understood that terminals represented by a circular designation indicate that the signal information applied thereto is a drive pulse while terminals designated by a square receive gating pulses. The matrix has a single output terminal 406 which is connected to one of the input terminals T_{30}—T_{40} of FIG. 3 as desired. For example, a drive pulse applied to terminal 400 is delivered directly to the output terminal 406 through a resistor to render the drive circuit connected thereto operative. On the other hand, a drive pulse applied to terminal 401 passes through the first of a series of resistors and then through a diode 407 to ground potential as the circuit point 402 is connected to the collector of a saturated gating transistor, for example, terminal T_{20} of FIG. 2. Therefore, drive pulse applied to terminal 401 will not pass through the matrix until a positive gate pulse is applied to terminal 402. Gate pulses applied to terminals 403, 404, and 405 are used to drive the drive circuits through a diode 408. The diode 408 insures that gating signals applied to terminals 403—405 will not affect the drive pulse applied to terminal 400.

The matrix shown in FIG. 5 is a simple resistor matrix including a plurality of input terminals 500, 501, 502, 503, 504, and 505 connected to a single output terminal 506 through a plurality of corresponding resistors. A pulse or gate signal applied to any of the terminals of the matrix shown in FIG. 5 will cause the drive circuit connected to terminal 506 to be rendered operative.

Shown in FIG. 6 is a matrix including a plurality of terminals 600, 601, 602, and 603 arranged for connection to drive pulse output terminals of the time-point generator of FIG. 2. Also associated with the matrix of FIG. 6 is a pair of gating terminals 604 and 605 for connection to any one of the plurality of output gate terminals of the time-point generator. Terminals 600, 601, and 604 are resistive coupled to an output terminal 606 while terminals 602, 603, and 605 are resistive diodes coupled to the output terminal 606. Pulse signal information applied to terminals 600, 601, and 604 cause the drive circuit connected to output terminal 606 to be rendered operative. However, the pulse signal information applied to terminals 602 and 603 is shorted to ground potential through diode 607 until such time that a positive pulse is applied to terminal 605. The diode 608 is used to isolate the two portions of the matrix to eliminate interaction between terminals 600, 601, and 604 and terminals 602, 603, and 605.

FIG. 7 shows a further modified form of a matrix which may be used in accordance with the principles of this invention. The matrix of FIG. 7 includes a single pulse drive terminal 700 and a plurality of gate pulse terminals 701, 702, and 703. Pulse signal information will be applied to the output terminal 704 only when a positive pulse is applied to both terminals 702 and 703.

FIG. 8 shows a matrix including a pair of pulse input terminals 800 and 801 and a single gate terminal 802. The diode 803 is connected between a pair of resistors 804 and 805 which, in turn, are connected in parallel with a single resistor 806. The resistors 804 and 805 are selected to be approximately one-half the value of resistor 806 so that the total series resistance of the resistors is approximately equal to the value of resistor 806. A drive pulse applied to terminal 800 is delivered to the output terminal 807 to cause the drive circuit connected thereto to be rendered operative. Only a portion of the pulse signal applied to terminal 807 is passed to ground potential through the resistor 805 and diode 803. A drive pulse applied to terminal 801 is short circuited to ground potential when the transistor of the time-point generator connected to the terminal 802 is in the saturated mode. On the other hand, when a positive pulse is applied to the gate terminal 802 pulse signal information applied to terminal 801 will be delivered to output terminal 807.

According to the present invention a unique feature is the ability of the time-point generator to produce triplet pulses so as to obtain selectively different pulse width signal information so as to produce more realistic rhythm sounds. For a better understanding of this novel circuit arrangement reference is now made to FIG. 9 which shows the flip-flop circuits 59 and 60 in block form. Also shown in block form is the feedback amplifier 89, of FIG. 2. Input pulses to the flip-flop circuit 59 are applied thereto from the output of the flip-flop circuit 58, of FIG. 2, through a line 900. The feedback amplifier 89 is normally held in the saturated mode of operation by the bias applied thereto through the switch 19 which, in turn, is connected to a positive voltage source. Therefore, signals applied to the feedback amplifier 89 from the flip-flop circuit 60 through the line 901 have no effect on the output thereof, and the last two divider stages count in a normal divide by four fashion. When odd or divide-by-three function is required, the bias applied through switch 19 is removed by opening the switch. The removal of the bias now causes the feedback amplifier to be operated in an unsaturated mode to produce an inverted pulse in response to the output of the flip-flop circuit 60. That is, the output of the feedback amplifier follows the output of the last flip-flop circuit 60. Every third input cycle to the line 900 causes a pulse to be fed back from the flip-flop circuit 60 to the flip-flop 59 thereby resetting the flip-flop 59 and reducing the total count capacity of the two flip-flop circuits from four to three.

For a better understanding of the operation of the circuit arrangement of FIG. 9 reference is now made to FIG. 10 which shows the wave forms developed at various points throughout the circuit of FIG. 9. The wave form indicated by reference numeral 902 is representative of the pulse signal information applied to the input of the circuit through line 900. The wave form represented by reference numeral 903 indicates the

wave form delivered from the output of flip-flop **59** to the input of flip-flop **60**. The wave form represented by reference numeral **904** indicates the pulse signal information delivered from the feedback amplifier **89** to the input of flip-flop circuit **59** through the line **906**. Additionally, the wave form represented by reference numerals **908** and **909** indicate the pulse signal information applied to output terminals **98** and **99** respectively. The broken line passing through the wave forms indicates the two modes of operation. That is, the wave forms to the left of the broken line, as seen on the drawing, indicate a divide-by-four condition while the wave forms on the right of the broken line indicate a divide-by-three condition. It will be noted that the output wave forms **908** and **909** are nonsymmetrical in a ratio of 2:1 during the divide-by-three mode of operation.

FIG. **11** is a detailed schematic diagram of an automatic follow circuit which may be used in conjunction with the rhythm sound-producing device of the present invention. The automatic follow circuit operates independently of the time-point generator and may be switched in and out of the circuit as desired and therefore may be considered optional equipment.

The automatic follow circuit shown in FIG. **11** includes an input terminal **300** which is connected to a primary winding **301** of a transformer **302**. Connected in parallel with the primary winding **301** is a diode **303** in series with a resistor **304**.

The secondary of transformer **302** includes a plurality of windings **306**, **307**, and **308**. The winding **306** has the ends thereof connected to the base electrode of a pair of transistors **309** and **310**, and a center tap connected to the emitter electrodes of transistors **309** and **310**. Transistor **310** has the collector electrode thereof connected to one end of a secondary winding **311** of a sampled transformer **312**. The transistor **309** has the collector electrode thereof connected to the base electrode of a transistor **313** and to one end of a capacitor **314**. Transistor **313** is connected in cascade with a transistor **316**.

The secondary winding **307** has the ends thereof connected to the base electrodes of a pair of transistors **317** and **318** and a center tap thereof connected to the emitter electrodes of the transistors. The collector electrode of transistor **317** is connected to one end of a primary winding **319** of the sampled transformer **312**. The other end of the primary winding **319** is connected to a timing capacitor **320** and to the collector electrode of a transistor **321**. The collector electrode of transistor **318** is connected to ground potential through a resistor **322** and to the secondary winding **308** through a resistor **323**. The secondary winding **308** produces reset pulses which are used to control the timing of the automatic follow circuit.

The secondary winding **308** is connected to a plurality of diodes **326**, **327**, and **328**. The diode **326** has the anode thereof connected to the base electrode of transistor **321**. Also connected to the base electrode of transistor **321** is a capacitor **329** and one end of a resistor **330**. The other end of resistor **330** is connected to a resistor **331**. The emitter electrode of transistor **321** is connected to ground potential through a resistor **332**. Resistors **330** and **331** are connected to a diode **333** and a resistor **334** connected in parallel therewith.

The collector electrode of transistor **321** is connected to the anode of a diode **336** and the collector electrode of a transistor **337**. The cathode of diode **336** is connected to the cathode of diode **333** through a pair of capacitors **338** and **339**. A resistor **340** is connected between the base and emitter electrodes of transistor **337**, and a coupling capacitor **341** is connected between the base electrode of transistor **337** and a flip-flop circuit **342**. It will be understood that the flip-flop circuit can be any one of the flip-flop circuit of the beat divider network of the time-point generator of FIG. **2**. Preferably, the flip-flop circuit **342** corresponds to the flip-flop circuit **59** of FIG. **2***a*. The diode **328** has the anode thereof connected to one of the inputs of flip-flop **342** to reset the flip-flop in response to pulse signal information developed at secondary winding **308**.

The diode **327** has the anode thereof connected to one of the base electrodes of a unijunction transistor **343** which forms part of a relaxation oscillator **344**. Also connected to the oscillator **344** is the emitter electrode of transistor **316** through a resistor **346** and the base electrode of transistor **321** through resistors **330** and **347**.

The output of flip-flop **342** is delivered to a flip-flop circuit **348**, which corresponds to the flip-flop circuit **60** of the time-point generator of FIG. **2**. The flip-flop circuit **348** is connected to the oscillator **344** through a switch **349**, a diode **350** and a resistor **351**. Pulse signal information developed by the oscillator **344** is applied to the first flip-flop **342** through the capacitor **352** and therefrom to the second flip-flop **348**. The output of the flip-flop **348** is then delivered to a ring counter **353**, corresponding to the ring counter shown in FIG. **2**.

In operation, player-produced pulses are applied to the input terminal **300** to produce a current drive in the primary winding **301** of transformer **302**. The transformer **302** will be referred to hereinafter as a sampling transformer. The current in the primary winding **301** produces a current pulse in the secondary windings **306**, **307**, and **308**. The pulse in the secondary winding **308** applies a negative potential to the cathodes of diodes **326**,**327**, and **328** while the pulse in secondary windings **306** and **307** cause the transistors associated therewith to become substantially short circuited. This action charges or discharges the timing capacitor **320** to a fixed potential point through the primary winding **319** of the sampled transformer **312** as well as completes the circuit of the secondary of the sampled transformer **312** between the input and output of transistors **313** and **316** which form an emitter follower stage. This action increases or decreases the charge on capacitor **314**, depending on the state of charge existing on the capacitor, by an amount proportional to the difference in voltage on the timing capacitor **320** from the fixed potential. The negative pulse applied to the cathodes of diodes **326**,**327** and **328** momentarily cuts off the discharging transistor **321** and resets the unijunction oscillator **344** and the flip-flop **342**.

One of the outputs of flip-flop circuit **348** is connected through the switch **349**, diode **350** and the resistor **351** to the charging resistor of the unijunction oscillator **344** and to the output of the emitter follower transistor **316** through the resistor **346**. The signal information applied to the oscillator **344** by the emitter follower **316** and by the feedback circuit of flip-flop **348** coact with one another to control the frequency of operation of the oscillator. With the switch **349** closed, conduction through the diode **350** and resistor **351**, when flip-flop **348** is in one state lowers the voltage applied to the discharge transistor **321** and the unijunction oscillator **344**. In the other state of operation of flip-flop **348** diode **350** is reversed biased and there is no conduction through the diode **350** and resistor **351**. Therefore, the frequency of the unijunction oscillator **344** will be different for the two different conditions of flip-flop circuit **348**. Therefore, this action causes a difference in length of the two halves of the square wave signal generated by flip-flop circuit **348** thereby providing the type of drive signal necessary for triplet timing in accordance with the present invention.

When the flip-flop circuit **342** is driven to the condition which does not trigger the input of flip-flop circuit **348**, the charging transistor **337** is driven to saturation to fully charge the timing capacitor **320** to a positive potential. The capacitor **320** discharges at a rate depending upon the output of the emitter follower transistor **316** which controls the conduction of the discharge transistor **321**. The capacitor **320** discharges until the voltage thereacross reaches a clamp point set by the other side of flip-flop circuit **342** through the clamping diode **336**. The voltage on the timing capacitor **320** remains at the clamped potential until flip-flop circuit **342** changes to the other state of conduction which, in turn, lowers the voltage to the clamping diode **336**. This change momentarily cuts off the discharge transistor **321** for a short period of time before it continues to discharge the timing capacitor **320**.

For a better understanding of the discharge operation of timing capacitor **320** reference is now made to FIG. **13** which shows a wave form corresponding to the discharge range of

the capacitor. The wave form **356** includes a first discharge portion **356***a* corresponding to the rate of discharge of capacitor **320** during the period of time when the clamping diode **336** is in the high state. The discharge rate terminates for a short period of time indicated by reference numeral **356***b* and then continues to discharge through transistor **321** as indicated by reference numeral **356***c*.

Seen in FIG. **12** is an alternate arrangement of an automatic follow circuit constructed in accordance with the principles of this invention. In FIG. **12**, the transistor **318** has the collector electrode thereof connected to a capacitor **360** and to a resistor **361**. Also connected to the resistor **361** is a second capacitor **362**.

The collector electrode of transistor **318** and capacitor **360** are connected to one input of a midpoint detector circuit **363**, while the capacitor **362** is connected to a second input of the midpoint detector **363**. Also, the capacitor **362** is connected to the emitter electrode of a unijunction transistor **364** which includes a resistor **365** connected between one of the base electrodes and a positive voltage source. The midpoint detector **363** may take the form of a differential amplifier which is well known in the art.

In operation, the midpoint detector **363** produces pulses to drive the flip-flop **348**. The midpoint detector **363** produces the pulses when the voltage across the unijunction transistor capacitor **362** becomes larger than the voltage across the capacitor **360**. The capacitor **360** has a larger capacitance value than the capacitor **362** and connects thereto through the resistor **361** so that the voltage across capacitor **362** remains substantially at the midpoint voltage developed across capacitor **360**. The primary winding **319** of the sampled transformer **312** is connected to the capacitors **360** and **362** through the transistors **317** and **318** when both transistors are in the conductive state. The circuit comprising switch **349**, diode **350** and resistor **351** perform the same function as described in regard to FIG. **11**.

The flip-flop circuit **348** triggers near the midpoint of the voltage swing on the unijunction capacitor **362** to mark the occurrence of the beat and AND beats. When a player-produced pulse is generated early for the beat or AND heat the voltage across capacitor **362** will be below the midpoint voltage and the sampled transformer secondary winding **311** will increase the charge on capacitor **314** thereby changing the output of the emitter follower transistor **316**. On the other hand if the player-produced pulse is late, the voltage across the capacitor **362** is higher than the midpoint voltage and the charge across capacitor **314** is reduced. Therefore, the circuit arrangement provides means for sensing the difference between two voltages to produce a pulse in response thereto to control the operation of the time-point generator.

In accordance with the principles of this invention other modifications may be incorporated in the design of a clock generator which operates in accordance with the principles of this invention. Examples of such circuitry are shown in FIGS. **14** and **15**.

The clock generator shown in FIG. **14** includes a unijunction transistor oscillator **11***a*. The oscillator **11***a* is formed by a unijunction transistor **410** which has the emitter electrode thereof connected to ground potential through a capacitor **411** and one of the base electrodes thereof connected to ground potential through a line **412**. The other base electrode of transistor **410** is connected to a positive voltage source through a resistor **413**. Also connected to the emitter electrode is a resistor **414** and a potentiometer **415**. The potentiometer **415** is the tempo adjustment control for changing the frequency of oscillation.

The output of oscillator **11***a* is delivered through a capacitor **416** to a flip-flop circuit indicated generally by reference numeral **417**. The flip-flop circuit **417** is of conventional circuitry including a pair of transistors **418** and **419**. The emitters of transistors **418** and **419** are connected together and to ground potential. The base electrode of transistor **418** is connected to the collector electrode of transistor **419** through a capacitor **420** and resistor **421** which are connected in parallel. Similarly, the base electrode of transistor **419** is connected to the collector electrode of transistor **418** through a capacitor **422** and a resistor **423** which are connected in parallel. The collector electrode of transistor **418** is also connected to a resistor **424**, and the collector electrode of transistor **419** is connected to a resistor **425**. The resistors **424** and **425** are connected together and to a resistor **426** which, in turn, is connected to a positive voltage source.

According to the present invention, output pulses from the flip-flop circuit **417** are delivered to the base electrode of a transistor **427** via a selector switch **428**. The selector switch **428** corresponds to the triplet switch **19**, seen in FIG. **1**. When switch **428** is closed, and a positive signal is applied to the base electrode of transistor **427**, a capacitor **429** is connected in parallel with capacitor **411** thereby increasing the total charge capacitance of the oscillator circuit. By changing the charge capacitance of the oscillator circuit, the frequency of oscillation will remain the same but the period for one-half cycle of oscillation will change. This features provides the nonsymmetrical pulses necessary to generate the desired time-point signals for producing various rhythmic sounds.

Still another alternate form of a clock generator is shown in FIG. **15**. The clock generator of FIG. **15** is formed by a free-running multivibrator designated generally by reference numeral **430**. The multivibrator includes a pair of transistors **431** and **432** which have their emitter electrodes connected together and to ground potential, and their collector electrodes connected to a positive voltage source through a pair of resistors **433** and **434** respectively.

The base electrode of transistor **431** is connected to a resistor **435** and to a potentiometer **436** which forms the tempo adjustment control. The potentiometer **436** is also connected to the base electrode of transistor **432** through a resistor **437**. The base electrode of transistor **432** is connected to the collector electrode of transistor **431** through a capacitor **438**, and the base electrode of transistor **431** is connected to the collector electrode of transistor **432** through a capacitor **439**.

According to the present invention, a resistor **440** and a selector switch **441** are connected in parallel with resistor **437**. The selector switch **441** corresponds to the triplet switch **19**, of FIG. **1**. When switch **441** is open, the multivibrator circuit **430** produces symmetrical pulses at the output thereof for driving the ring counter and other pulse amplifiers. However, when switch **441** is closed, the resistance path formed by resistors **437** and **440** is decreased thereby changing the period of one-half cycle of the square wave generated by the multivibrator. Therefore, when switch **441** is open the multivibrator will produce symmetrical pulses, and when switch **141** is closed, the multivibrator will produce nonsymmetrical pulses.

Accordingly, the circuit arrangements shown in FIGS. **14** and **15** may be used in place of the tempo oscillator **11** and beat divider **12** which form the clock generator of FIG. **1**.

Although the preferred embodiments of the present invention have been disclosed herein in detail, it will be understood that variations and modifications may be effected without departing from the spirit and scope of the novel concepts of this invention.

I claim:

1. A musical-rhythm-producing sound device comprising:

a. a tempo oscillator for producing pulse signals at a predetermined frequency;

b. an electronic ring counter having an input connected to said tempo oscillator for receiving said pulse signals, and having a plurality of outputs;

c. circuit means connected between said tempo oscillator and said ring counter to change the characteristics of the pulse signals applied to said ring counter for selectively changing the alternate stages of said ring counter between symmetrical and nonsymmetrical count pulse signals;

d. a plurality of sound generator means; and

e. connecting means connected between certain ones of said plurality of outputs of said ring counter and certain

ones of said plurality of sound generator means for rendering said sound generator means sequentially operative in response to said ring counter.

2. A rhythm-producing sound device according to claim 1 further including a chain of flip-flop circuits interposed between said tempo oscillator and said ring counter, and wherein said means connected between said tempo oscillator and said ring counter for changing said ring counter includes means for switching said chain of flip-flops from a divide-by-four condition to a divide-by-three condition.

3. A musical-rhythm-producing rhythm-producing sound device comprising:

a. a tempo oscillator for producing pulse signals at a predetermined frequency;

b. an electronic ring counter having an input connected to said tempo oscillator for receiving said pulse signals, and having a plurality of outputs;

c. a chain of flip-flop circuits interposed between said tempo oscillator and the input of said ring counter;

d. a plurality of sound generator means;

e. connecting means connected between certain ones of said plurality of outputs of said ring counter and certain ones of said plurality of sound generator means for rendering said sound generator means sequentially operative in response to said ring counter; and

f. gate means for gating the output of said tempo oscillator to said sound generator means under the control of at least one of the outputs of said ring counter.

4. A rhythm-producing sound device according to claim 3 wherein said gate means also receives output signals from said chain of flip-flops interposed between said tempo oscillator and said ring counter.

5. In a rhythm-producing sound device comprising in combination:

a source of player-produced impulses;

generator means for generating a series of rhythm instrument drive pulses;

circuit means for shifting the time position of said generator means to make the pulse which is nearest in time to one of the player-produced impulses to be substantially coincident therewith; and

means for changing the rate of operation of said generator means in response to shifting the time position of said generator means.

6. A rhythm-producing sound device according to claim 5 wherein said means for changing the rate of operation of said generator means causes said generator means to be changed by an amount substantially proportional to the fraction of the pulse time cycle over which said circuit means shifts the time position of said generator means.

7. A rhythm sound-producing device comprising: a time-point generator for developing a plurality of sequentially generated drive pulses and a plurality of sequentially generated gate pulses, said time-point generator including:

a tempo oscillator for producing pulse signal information at a predetermined frequency;

a beat divider network having four serially connected flip-flop circuits;

output terminals connected to the last of said flip-flop circuits for receiving pulse signal information having a frequency which is a whole fraction multiple of said predetermined frequency;

a pulse drive circuit connected to the output of at least two of said flip-flop circuits of said beat divider to develop certain ones of said sequentially generated drive pulses;

an eight-stage ring counter having input terminals connected to said output terminals of the last of said flip-flop circuits of said beat divider network for receiving the pulse signal information therefrom and sequentially changing the state of operation of each successive stage of said ring counter;

first circuit means connected to the output of each stage of said ring counter to develop certain other ones of said sequentially generated drive pulses;

second circuit means connected to the output of each stage of said ring counter to develop certain ones of said sequentially generated gate pulses;

a bar counter having three serially connected flip-flop circuits, the first of said flip-flop circuits having input terminals connected to the last stage of said ring counter for receiving a count pulse each time the ring counter goes through one complete cycle, third circuit means connected to the output of each of said flip-flops of said bar counter to develop certain other ones of said gate pulses;

an instrument sound generator for producing a plurality of electrical wave forms representative of different sounds, comprising:

a plurality of free running multivibrators, each multivibrator operated to generate square waves at a frequency indicative of discrete but different sounds;

audiocircuit means having input means connected to the output of each of said multivibrators and further having output means to develop a composite signal of selected ones of said plurality of electrical wave forms;

keying means connected to the output of each of said multivibrators; and

matrix assembly means for applying selected ones of said drive pulses and selected ones of said gate pulses to selected ones of said keying means to cause the output of corresponding ones of said multivibrators to be delivered to the input of said audiocircuit means.

8. An instrument sound generator according to claim 7 wherein said matrix assembly means provides a direct current coupling for said drive pulses and said gate pulses to said keying means.

9. An instrument sound generator according to claim 8 further including means connected between the last stage of said ring counter and the third stage of said ring counter for selectively changing the numerical size of said ring counter from eight to six.

10. An instrument sound generator according to claim 9 further including means connected between the output of the fourth of said flip-flops of said beat divider to the input of the third of said flip-flops of said beat divider to selectively change the count capacity of said third and fourth flip-flops from a divide-by-four count to a divide-by-three count.

11. A rhythm sound-producing device comprising:

clock generator means for producing symmetrical pulse signal information of a predetermined frequency;

counting means having input terminals connected to said clock generator means for receiving said pulse signal information, and including a plurality of output stages;

a plurality of sound generator means;

connecting means connected between said output stages of said counting means for rendering certain ones of said sound generator means sequential operative in response to outputs of said counting means; and

the improvement therein comprising, means connected in circuit with said clock generator for changing said symmetrical pulse signal information to nonsymmetrical pulse signal information.

12. A rhythm sound-producing device according to claim 11 wherein said clock generator is formed by a tempo oscillator and a flip-flop circuit connected to the output of said tempo oscillator, and means connected from the output of said flip-flop circuit to the input of said tempo oscillator for changing the period of one-half cycle of oscillation from said oscillator.

13. A rhythm sound-producing device according to claim 11 wherein said clock generator is formed by a free-running multivibrator having two symmetrical transistor circuits for producing symmetrical square wave signals, and further including resistor and switch means connected in circuit with one of said transistors for unbalancing the circuit to produce nonsymmetrical square wave pulses.

14. A rhythm sound-producing device according to claim 11 further including means for selectively changing the numerical size of said counting means.

15. A rhythm sound-producing device comprising:

clock generator means for producing symmetrical pulse signal information of a predetermined frequency;

counting means having input terminals connected to said clock generator means for receiving said pulse signal information, and including a plurality of output stages;

a plurality of sound generator means;

connecting means connected between said output stages of said counting means for rendering certain ones of said sound generator means sequentially operative in response to outputs of said counting means; and

the improvement therein comprising means connected in circuit with said counting means for selectively changing the numerical size of said counting means.

16. A musical-rhythm-producing sound device comprising:

a. a tempo oscillator for producing pulse signals at a predetermined frequency;

b. an electronic ring counter having an input connected to said tempo oscillator for receiving said pulse signals, and having a plurality of outputs;

c. a plurality of sound generator means;

d. a plurality of groups of resistors, the resistors of each group having one end thereof connected to certain ones of said outputs of said ring counter, and the other end thereof connected together to a common circuit point; and

e. switch means for selectively connecting the common circuit point of certain groups of resistors to certain ones of said sound generator means for rendering said sound generator means sequentially operative in response to said ring counter.

17. A musical-thythm-producing sound device comprising:

a. a tempo oscillator for producing pulse signals at a predetermined frequency;

b. an electronic ring counter having an input connected to said tempo oscillator for receiving said pulse signals, and having a plurality of outputs;

c. means for changing the electronic numerical size of said ring counter;

d. a plurality of sound generator means; and

e. connecting means connected between certain ones of said plurality of outputs of said ring counter and certain ones of said plurality of sound generator means for rendering said sound generator means sequentially operative in response to said ring counter.

18. An instrument sound-generating device comprising:

a. a tempo oscillator for producing pulse signals;

b. a ring counter connected to said tempo oscillator, said ring counter comprising a plurality of single-transistor stages so interconnected in a ring that all but one of the transistors of the ring counter are conductive, and the pulse signal from the tempo oscillator renders the nonconductive transistor conductive which, in turn, renders the following transistor nonconductive, each stage of said ring counter including an output terminal; and

c. a plurality of sound generators respectively connected to the output terminals of said stages to produce sequential sounds of different frequencies in response to the sequence of said ring counter.

19. An instrument sound generator according to claim **18** further including circuit means connected between one stage of said ring counter and some other stage thereof for decreasing the number of effective stages in said ring counter.

20. An instrument sound generator according to claim **18** further including means for changing the frequency of the pulse signals produced by said tempo oscillator, and further including means connected between one stage of said ring counter and some other stage thereof for decreasing the number of effective stages in said ring counter.