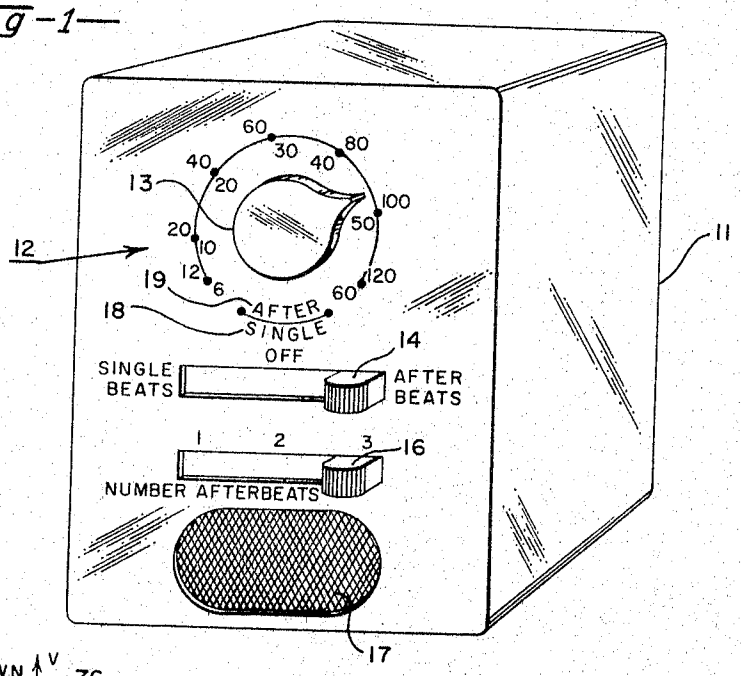
May 16, 1967 A. S. PANDE ETAL 3,320,608

AFTER BEAT METRONOME

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Fig-1



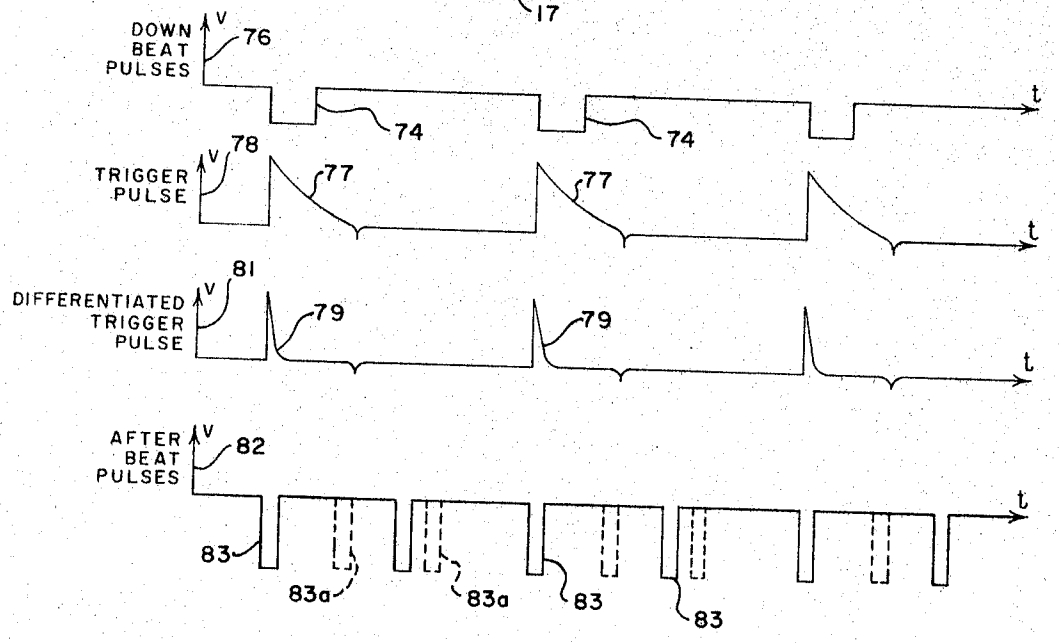


Fig-3

INVENTOR.(S)
GORDON D. BROWNING
ALBERT S. PANDE
BY Manfred M. Warren
Their Attorney

May 16, 1967 A. S. PANDE ETAL 3,320,608

AFTER BEAT METRONOME

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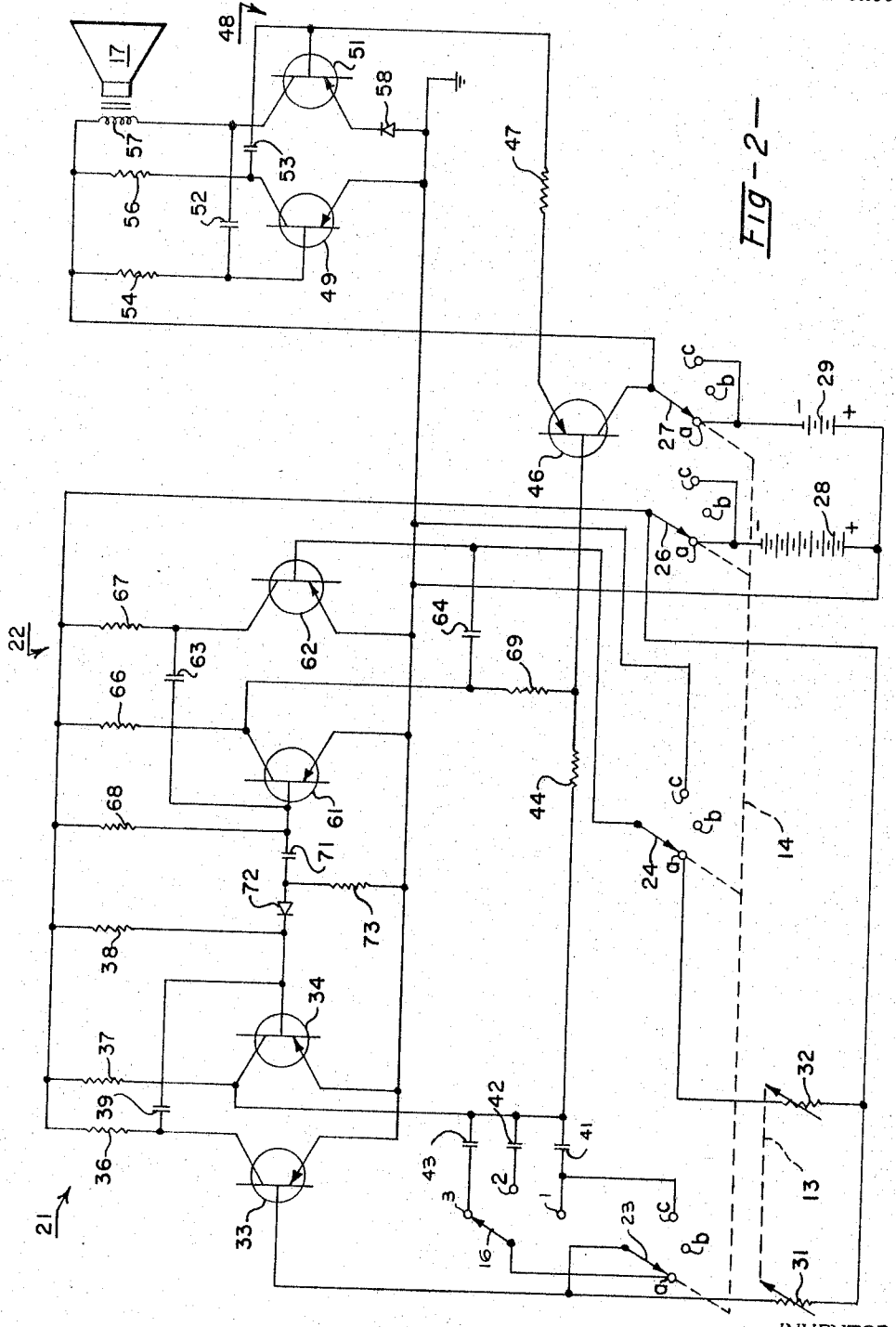


FIG-2

INVENTOR.(S)
GORDON D. BROWNING
ALBERT S. PANDE
BY Manfred M. Warren
Their Attorney

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3,320,608

AFTER BEAT METRONOME

Albert S. Pande, 6776 Thornhill Drive, Oakland, Calif. 94611, and Gordon D. Browning, 19056 Stanton Ave., Castro Valley, Calif. 94546

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3 Claims. (Cl. 340—384)

This invention relates generally to metronome devices, and more particularly to such devices as are equipped for selective variation of the characteristics of the sound pulses produced by the device.

In addition to their well known use by musicians, metronomes find other varied utilization as for example in accompanying calisthenics, dancing, or similar physical activities. In many of the instances requiring rhythm enunciation, it is desirable that the audible sounds or beats have distinguishable sound characteristics, to define what often are referred to as down beats and after beats. Thus, the music teacher or calisthenic leader in vocally setting a rhythm will often emphasize a down beat and then follow this by one or more less pronounced after beats to establish the desired rhythm. The overall repetition rate as well as the number of after beats for each down beat may vary over a relatively wide range in accordance with the various needs of a given situation.

Accordingly, it is an object of the present invention to provide a metronome device for providing down beat sound pulses, followed by one or more audibly distinguishable after beat sound pulses.

Another object of the invention is to provide a metronome device for providing down beat sound pulses, followed by one or more audibly distinguishable after beat sound pulses.

Another object of the invention is to provide a metronome of the type described in which manually operated means are provided for readily selecting different numbers of after beats, for varying the repetition rate of the down beats and after beats, and for changing the mode of operation of the device to function either with or without after beats.

A further object of the present invention is to provide an after beat metronome of the type described constructed with simple electronic circuitry utilizing relatively few and inexpensive components, yet which provides reliable and high quality operation.

The invention possesses other objects and features of advantage, some of which of the foregoing will be set forth in the following description of the preferred form of the invention which is illustrated in the drawings accompanying and forming part of this specification. It is to be understood, however, that variations in the showing made by the said drawings and description may be adopted within the scope of the invention as set forth in the claims.

Referring to said drawings (2 sheets):

FIGURE 1 is a perspective external view of a device embodying the present invention.

FIGURE 2 is a schematic diagram of an electrical circuit included in a preferred embodiment of the invention.

FIGURE 3 is a series of graphs depicting functional operation of certain portions of the circuit shown in FIGURE 2.

The preferred embodiment of the invention shown in the accompanying drawings generally comprises means for producing a plurality of spaced primary sound pulses, sometimes referred to hereinafter as down beats, means for selectively varying the repetition rate of said pulses, means for producing a repetitious time sequence of a plurality of secondary sound pulses at least one of which is interposed in time between successive ones of said primary

pulses, said secondary pulses being audibly distinguishable from said primary pulses and being sometimes hereinafter referred to as after beats.

The general function of the instant after beat metronome is best described with respect to FIGURE 1, wherein is shown a housing **11** having a dial face **12** with a rotatable knob **13** mounted for use in conjunction with the dial face. A switch **14** is provided for selecting the mode of operation of the metronome, being movable into position for either single beats or for down beats and after beats. The switch **14** also is movable to an off position for controlling the electrical power supplies. Another switch **16** is movable to three positions to select the number of after beats when the switch **14** is positioned for the after beat mode of operation. A speaker **17** produces audible sound pulses which comprise the down beats and after beats.

In more detail, the dial face **12** includes an outer dial **18** which as shown in calibrated between 12 to 120 and represents the number of beats per minute when the metronome is in its single beat mode of operation. That is, the knob **13** selects the repetition rate of sound pulses from the outer dial **18** when the switch **14** is positioned for single beats, and the pulses produced are all of the same audible characteristics.

The dial face **12** also includes an inner dial **19** which as shown in calibrated between 6 to 60 and represents the number of major beats per minute when the metronome is in its after beat mode of operation. More specifically, when the switch **14** is positioned for after beats, the knob **13** selects the repetition rate of the down beats and the switch **16** selects the number of after beats to be interposed between each of the down beats. Thus, for example, if the knob **13** is pointed at "30" on the inner dial, and the switch **16** is positioned for "2" after beats, there will be a total of 90 beats per minute, which include a repetitious time sequence of a down beat followed by two evenly spaced audibly distinguishable after beats. If for example, the knob **13** is at "30" on the inner dial, and the switch **16** is at "1" after beat, there will be a total of 60 beats per minute, which include a sequence of one down beat and one after beat.

As regards now the illustrated embodiment of the invention for electronically performing the above described functions, reference is made to FIGURE 2 wherein is shown a first oscillator circuit **21**, which selectively produces the sound pulses for the single beat mode or the pulses for the after beats in the after beat mode, and a second oscillator circuit **22** which produces the pulses for the down beats in the after beat mode. The above noted switch **14** is seen to include four ganged arms **23**, **24**, **26** and **27**, which are each movable to terminals *a*, *b*, and *c*. The switch arms **26** and **27** respectively control power supplies **28** and **29**, with the supplies being off when the arms are connected to the terminals *b*, and being on when connected to either the terminals *a* or *c*.

The knob **13** is seen to be represented by a pair of variable resistances **31** and **32**, which are ganged together so that regardless of the position of the knob **13** the value of the resistance **31** is a percentage of its maximum value equal to the percentage resistance **32** is of its maximum value. In the preferred embodiment described herein the resistances **31** and **32** are of identical specification so that their values are also always equal. When the switch arm **23** is connected to its terminal *c*, the device is in its single beat mode and the resistance **31** is coupled to the oscillator **21** to form a part of its RC circuit for controlling the repetition rate of pulses produced. The switch arm **24** when connected to its terminal *c* shorts out the oscillator **22** to ground, and the resistance **32** is disconnected.

Describing the circuit now with regard to the single beat mode of operation, the oscillator **21** is seen to comprise a generally conventional multivibrator circuit including a pair of transistors **33** and **34** which as shown are of the PNP type and have their emitters connected to ground. The collectors of the two transistors are respectively coupled through resistors **36** and **37** to the supply **28**, which as shown is a negative 18 volts. The base of the transistor **33** couples to the supply **28** through the variable resistance **31**, while the base of the transistor **34** is coupled to the supply **28** through a fixed resistor **38**. A capacitor **39** couples the base of the transistor **34** to the collector of the transistor **33**, while the collector of the transistor **34** is similarly capacitatively coupled through a capacitor **41** and the switch **23** to the base of the transistor **33**.

The oscillator **21** as just described functions in a generally conventional manner and produces an output of a repetitious sequence of pulses, which can be taken off at the collector of the transistor **34** as shown and coupled through a resistor **44** to the base of a gate transistor **46**. The transistor **46** is powered through its collector by the supply **29**, and feeds an output pulse from its emitter through a resistor **47** into an audio oscillator circuit **48**. Whenever a pulse from the oscillator **21** triggers the gate **46**, the gate causes an audio frequency pulse to be formed in the circuit **48**, which is then coupled to the loudspeaker **17** for producing an audible sound pulse of the predetermined frequency.

The audio circuit **48** is seen to include a pair of transistors **49** and **51**, of the PNP type as shown, having the respective bases of one coupled to the collector of the other by capacitors **52** and **53**. A resistor **54** is coupled between the base of transistor **49** and the supply **29**, and a resistor **56** is coupled between the collector of transistor **49**. The collector of the transistor **51** couples through the coil **57** of the speaker **17** to the supply **29**, with the input from the gate **46** being at the base of the transistor **51**. The emitter of the transistor **49** is connected to ground and a diode **58** is interposed between ground and the emitter of the transistor **51** for D.C. biasing.

With the switch **14** in the single beat mode, the circuit as just described will produce a series of identical evenly spaced audible pulses from the speaker **17**, with the repetition rate controlled by the position of the variable resistance **31**.

When the switch **14** is moved into the after beat mode, the switch arms **23** and **24** connect to their respective terminals *a*, and accordingly, the resistance **32** now becomes coupled into the oscillator circuit **22**, which as will be described is substantially identical in basic design to the oscillator **21**. The arm of the switch **16** is now operative to select one of the capacitors **41**, **42**, or **43** to couple between the collector of the transistor **34** and the base of the transistor **33**.

As shown, the oscillator **22** includes a pair of transistors **61** and **62**, each of which respectively has its base coupled to the collector of the other through the capacitors **63** and **64**. Resistors **66** and **67** respectively couple the collectors of the transistors **61** and **62** to the supply **28**, and a resistor **68** couples the base of the transistor **61** to the supply **28**. The base of the transistor **62** is coupled to the supply **28** through the variable resistance **32**, and the oscillator **22** as just described has its output fed from the collector of the transistor **61** through a resistor **69** to the gate **46**.

In accordance with the preferred embodiment of the invention, the oscillator **21** is designed to have twice the repetition rate as the oscillator **22** when the switch **16** is in its "1" after beat position, i.e., coupled to the capacitor **41**. Also, the oscillator **22**, which provides the down beat pulses, is designed to produce a pulse of longer duration than the oscillator **21**, thereby producing the effect

of audibly distinguishable pulses. It is noted that the oscillator **22** triggers the gate **46** to operate the audio oscillator **48** in the same manner as the oscillator **21**, except that the longer duration pulse from the oscillator **22** causes a longer duration audible sound pulse since the gate **46** is held open for a longer time.

The capacitors **42** and **43** are selected so that when the capacitor **42** is connected, i.e., the switch **16** is in its "2" after beat position, the repetition rate of the oscillator **21** is three times that of the oscillator **22**. Likewise, when the capacitor **43** is connected for the "3" after beat position of the switch **16**, the oscillator **21** has a repetition rate four times that of the oscillator **22**.

Further in regard to the foregoing relationships, it is noted that the repetition rate of the oscillator **22** is represented by the approximation,

$$f_d \cong \frac{K_d}{RC_d}$$

where R represents the variable resistance **32**, C_d represents the capacitor **64**, and K_d represents a constant for the given circuit **22**. Similarly, the following approximation provides the repetition rate for the oscillator **21**,

$$f_a \cong \frac{K_a}{RC_a}$$

where R represents the resistance of the variable resistance **31**, C_a represents the particular capacitor **41**, **42**, or **43**, and K_a represents a constant for the circuit **21**. With the resistances **31** and **32** equal, and with the constants for the two oscillators being substantially the same, the following relationship is derived for the condition that $f_a = nf_d$ ($n=2, 3, 4$)

$$C_d = nC_a \ (n=2, 3, 4)$$

Thus, capacitor **64** must be twice the value of capacitor **41**, three times the value of capacitor **42**, and four times the value of the capacitor **43**.

From the foregoing relationships, it will be appreciated that by synchronizing the lower frequency or down beat oscillator **22** to produce its output in coincidence with one of the pulses of the high frequency or after beat oscillator **21**, then the proper number of after beats will be produced in accordance with the above described functioning of the instant metronome. That is, for example, if the high frequency pulses are four times as fast as the low frequency pulses, then three after beats will be produced after each coincidence of a low frequency and high frequency pulse. Such coincidence it is noted will be evidenced by the longer duration pulse of the down beat oscillator completely overshadowing the high frequency pulse, thereby producing the requisite audibly distinguishable down beat.

In regard now to the means for synchronizing the two oscillators to perform as just described, it is seen that the base of the transistor **61** is coupled through a capacitor **71** and a diode **72** to the base of the transistor **34**, with a resistor **73** connecting between the latter capacitor and diode and coupling to ground. The effect of coupling the oscillators **22** and **21** together in this manner is to tie down the high frequency oscillator **21** to produce pulses only in synchronization with the low frequency oscillator **22**, in the required manner. More particularly, and referring now to FIGURE 3, down beat pulses **74** are represented on a graph **76**, the pulses **74** being negative because of the negative voltage supply and correspond to the output taken from the collector of the transistor **61**. A generally sawtooth shaped pulse **77** is created at the base of the transistor **61**, and is depicted on the graph **78** in FIGURE 3 as a trigger pulse. It is noted that the trigger pulse **77** produces a sharp peak coincident with the forward edge of the pulse **74**.

The capacitor **71** serves to differentiate the pulse **77**, so that a differentiated pulse **79** is created at the point of connection between the capacitor **71** and diode **72**, the

pulse **79** being represented on the graph **81** in FIGURE 3. The differentiated pulse **79** then is coupled through the diode **72** to the base of the transistor **34** so that the oscillator **21** is thereby forced to produce a pulse coincident with the pulse **79**. Consequently, as represented in the graph **82**, when the capacitor **41** is connected a series of after beat pulses **83** are produced at a repetition rate twice that of the down beat pulses **74**, and with the down beat pulse **74** being initiated substantially coincident with alternate ones of the pulses **83**. Since the longer duration pulse **74** overrides the coincident pulse **83**, only one pulse **83** is heard and creates the single after beat which is interposed exactly midway between down beat pulses **74**.

A phantom line representation in FIGURE 3 shows after beat pulses **83***a* having a repetition rate three times that of the down beat pulses **74**, thereby causing two after beats to be interposed in equally spaced relation between each down beat.

The following table represents a typical set of components used in the above described circuitry.

T–33, 34, 46, 49, 61, 62		2N1307
T–51		2N291
D–58		1N91
D–72		SD–91
R–31, 32	megohm	0 to 1
R–36, 37, 66, 67		10K
R–38, 68		100K
C–39	μfd	0.5
C–63	μfd	2.0
C–64	μfd	10.0
C–41	μfd	5.0
C–42	μfd	3.33
C–43	μfd	2.5
C–71	μfd	0.02
R–73		4.7K
R–69		68K
R–44		47K
C–52	μfd	1.0
C–53	μfd	2.0
R–54		4.7K
R–56	ohms	470
R–47		1K
S–28	volts	—18
S–29	do	—3

It is noted from the above table that the capacitors **41**, **42**, and **43** are respectively ½, ⅓, and ¼ the value of the capacitor **64**, thus providing the above described relationship with regard to the repetition rates of the down beat and after beat oscillators. In addition, it is noted that the capacitor **63** is four times the value of the capacitor **39**, thus making the duration of the down beat pulses approximately four times that of the after beat pulses.

It will be appreciated that different pulse durations is only one way to produce audibly distinguishable sounds, and that numerous other ways will occur to those skilled in the art. For example, instead of coupling both of the oscillators **21** and **22** to the same audio oscillator **48**, two separate audio oscillators of different frequencies could be provided, each being coupled to one of the oscillators **21** and **22**. In the latter situation, the different sound frequency rather than the pulse duration would distinguish the down beats from the after beats. Similarly, separate audio stages could be provided for each of the oscillators

21 and **22** so that the down beat had a greater volume than the after beats. Furthermore, the down beat oscillator could be coupled to trigger a bell or other audible pulse generator, thus making apparent the widespread possibilities of producing audibly distinguishable pulses as may be desired. It may also be noted that means other than the three capacitors **41**, **42** and **43** may be used to adjust the frequency of the after beat oscillator to integer values of the down beat frequency. For example, instead of varying the capacitors as described, the resistances **31** and **32** may be adjusted appropriate to vary the frequencies of their respective oscillators to provide the requisite integer multiple relationship.

We claim:

1. An after beat metronome comprising, first and second RC timed electronic multivibrator circuits each producing a regular periodic output pulse discernible from the other and with the frequency of one pulse being an integer multiplier of the other, with said first multivibrator circuit providing the slower and said second multivibrator circuit providing the faster pulse respectively, means coupling said circuits for synchronizing said pulses for simultaneous starting time sequence, said first multivibrator circuit being formed to provide a pulse of longer duration than said faster pulse but in synchronism therewith whereby said slower pulse provides the down beat and said faster pulses the after beats, a manually controlled switch and a plurality of capacitors connected for selection thereby in said second circuit providing after beat frequencies of selectable integer multiples of said down beat frequency, and a pair of variable resistors one in each of said mulitvibrator circuits and gang connected for simultaneous manual operation and formed to provide on simultaneous operation equal ratio changes to their respective maximum resistance values for proportionally changing the frequencies of said down and after beats.

2. An after beat metronome as defined in claim **1**, a third multivibrator circuit producing an audio signal, a gating transistor connected to the summed outputs of said first and second multivibrator circuits and to said third multivibrator circuit and utilizing said pulses for turning on and off said third multivibrator circuit, and an audio transducer connected to said third multivibrator circuit.

3. An after beat metronome as defined in claim **2**, and manually controlled means for suppressing the operation of said first multivibrator circuit to provide a single beat mode operation.

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NEIL C. READ, *Primary Examiner.*

I. J. LEVIN, *Assistant Examiner.*