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Adler et al.

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[45] **Mar. 12, 1974**

[54] **JOGGING COMPUTER**

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[73] Assignees: **said Adler and Bax; Gary Coates,** Ashton, Md.; **Wayne Johnson,** Alexandria, Va. ; part interest to each

[22] Filed: **July 31, 1972**

[21] Appl. No.: **276,470**

[52] **U.S. Cl.** ..... **340/323,** 128/2.1 A, 235/92 CA, 235/92 FQ, 340/363, 324/161

[51] **Int. Cl.** **G08b 23/00**

[58] **Field of Search** ..... 340/323, 263; 128/2.1 R, 128/2.1 A, 205 R, 206 F; 272/DIG. 6; 324/161; 73/507, 518; 235/92 CA, 92 FQ

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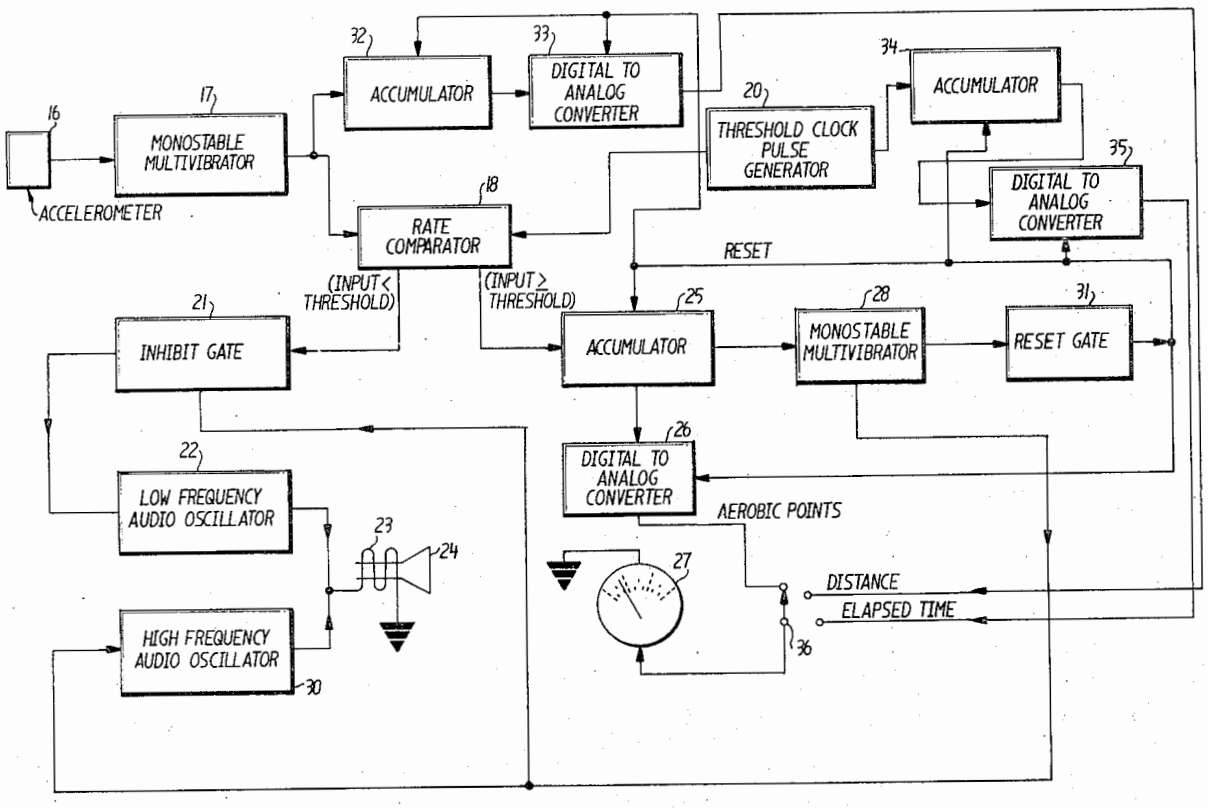
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Primary Examiner—John W. Caldwell
Assistant Examiner—Robert J. Mooney
Attorney, Agent, or Firm—Wigman & Cohen

[57] **ABSTRACT**

This disclosure relates to a portable solid-state device for measuring and indicating physical exercise achievement attained through exercises, for example, walking, running and/or jogging in place or over a distance course in accordance with a predetermined exercise regimen. The device includes a digital computer to which is fed the output from an electromechanical sensor adapted to generate an electrical impulse in response to each step taken by an individual while walking, running or jogging at or above a predetermined rate. The computer counts the number of steps taken by the exerciser and measures the rate thereof, and integrates the product of the number and rate over the period of the exercise. The level of the integral is continuously compared to a pre-programmed schedule of a predetermined exercise regimen, and either audible or visual signal means or both are provided for indicating desired levels of achievement of the exercise regimen.

16 Claims, 5 Drawing Figures



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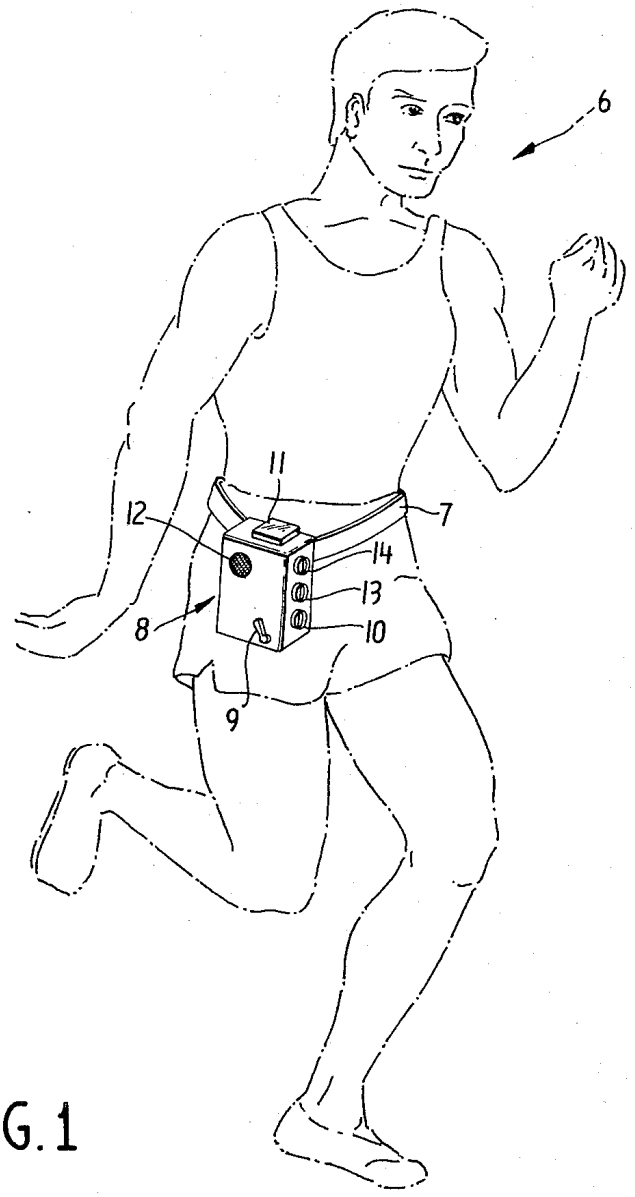


FIG. 1

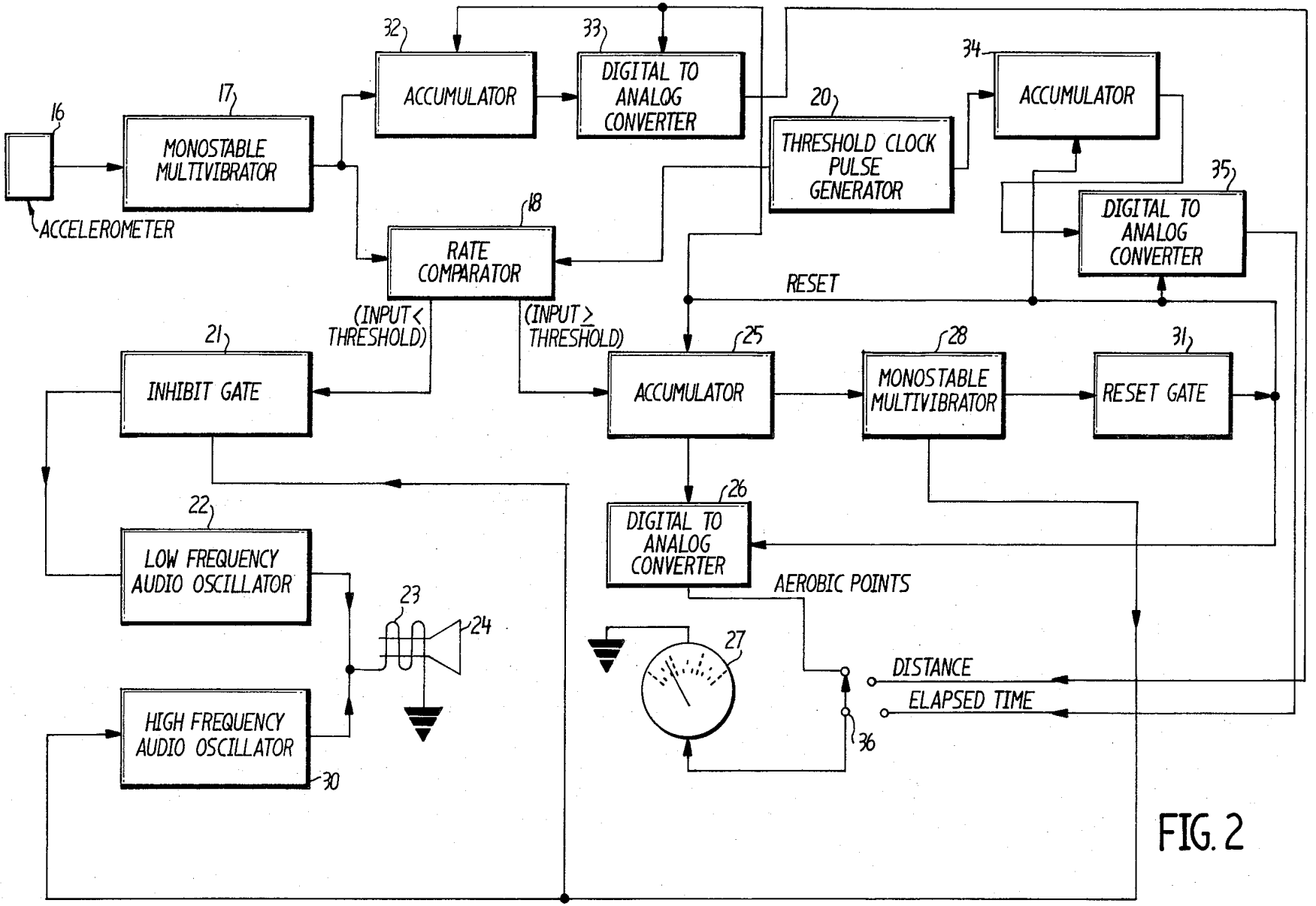

16
ACCELEROMETER
17
MONOSTABLE MULTIVIBRATOR
32
ACCUMULATOR
33
DIGITAL TO ANALOG CONVERTER
34
ACCUMULATOR
20
THRESHOLD CLOCK PULSE GENERATOR
35
DIGITAL TO ANALOG CONVERTER
18
RATE COMPARATOR
RESET
(INPUT < THRESHOLD)
(INPUT ≥ THRESHOLD)
21
INHIBIT GATE
25
ACCUMULATOR
28
MONOSTABLE MULTIVIBRATOR
31
RESET GATE
22
LOW FREQUENCY AUDIO OSCILLATOR
26
DIGITAL TO ANALOG CONVERTER
AEROBIC POINTS
23
24
27
DISTANCE
ELAPSED TIME
36
HIGH FREQUENCY AUDIO OSCILLATOR
30

FIG. 2

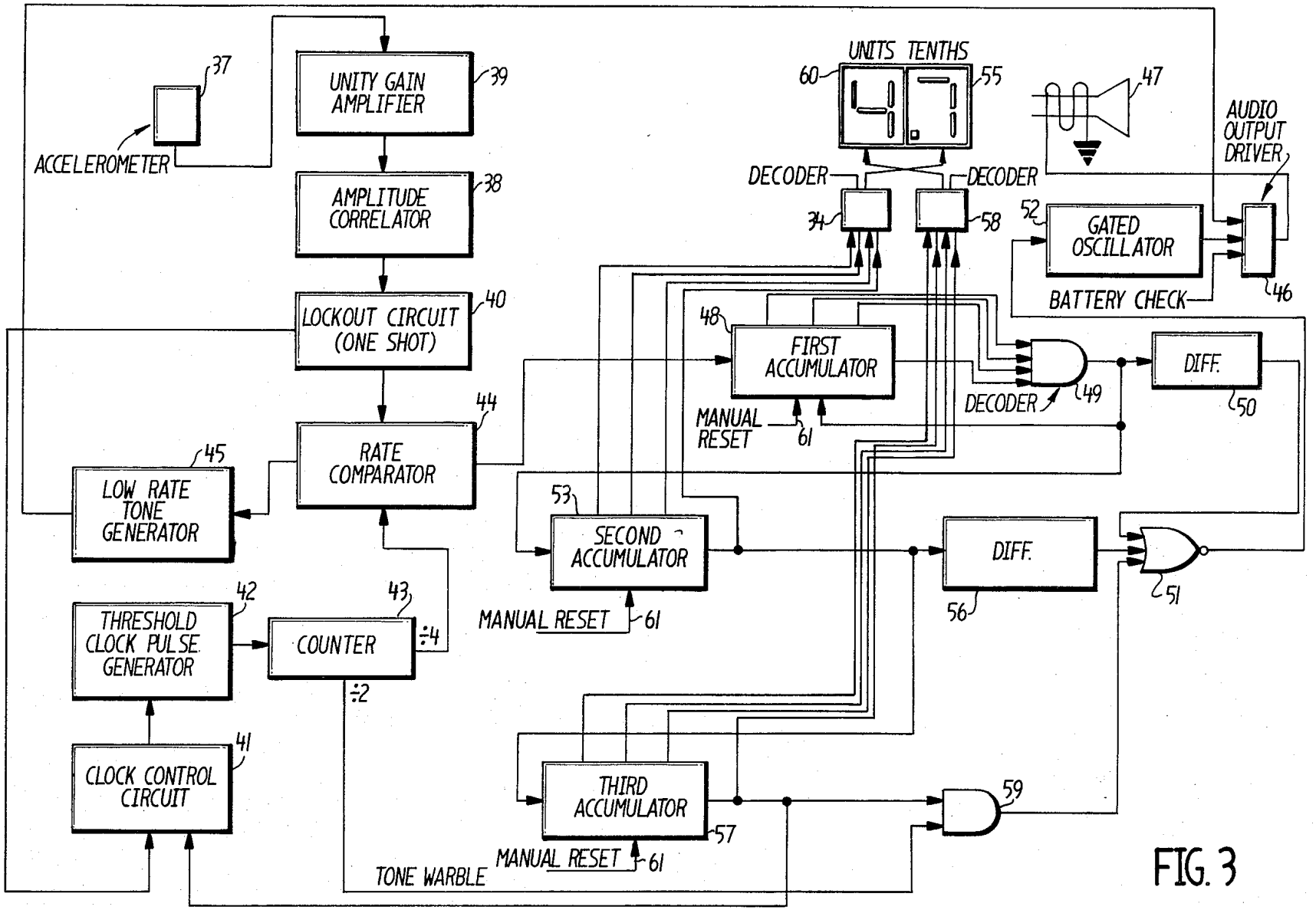

ACCELEROMETER
37
UNITY GAIN AMPLIFIER
39
AMPLITUDE CORRELATOR
38
LOCKOUT CIRCUIT (ONE SHOT)
40
RATE COMPARATOR
44
LOW RATE TONE GENERATOR
45
THRESHOLD CLOCK PULSE GENERATOR
42
COUNTER
43
÷4
÷2
CLOCK CONTROL CIRCUIT
41
TONE WARBLE
UNITS TENTHS
60
55
DECODER
DECODER
34
58
47
AUDIO OUTPUT DRIVER
52
GATED OSCILLATOR
BATTERY CHECK
46
48
FIRST ACCUMULATOR
MANUAL RESET
61
DECODER
49
DIFF.
50
53
SECOND ACCUMULATOR
MANUAL RESET
61
DIFF.
56
51
THIRD ACCUMULATOR
57
MANUAL RESET
61
59

FIG. 3

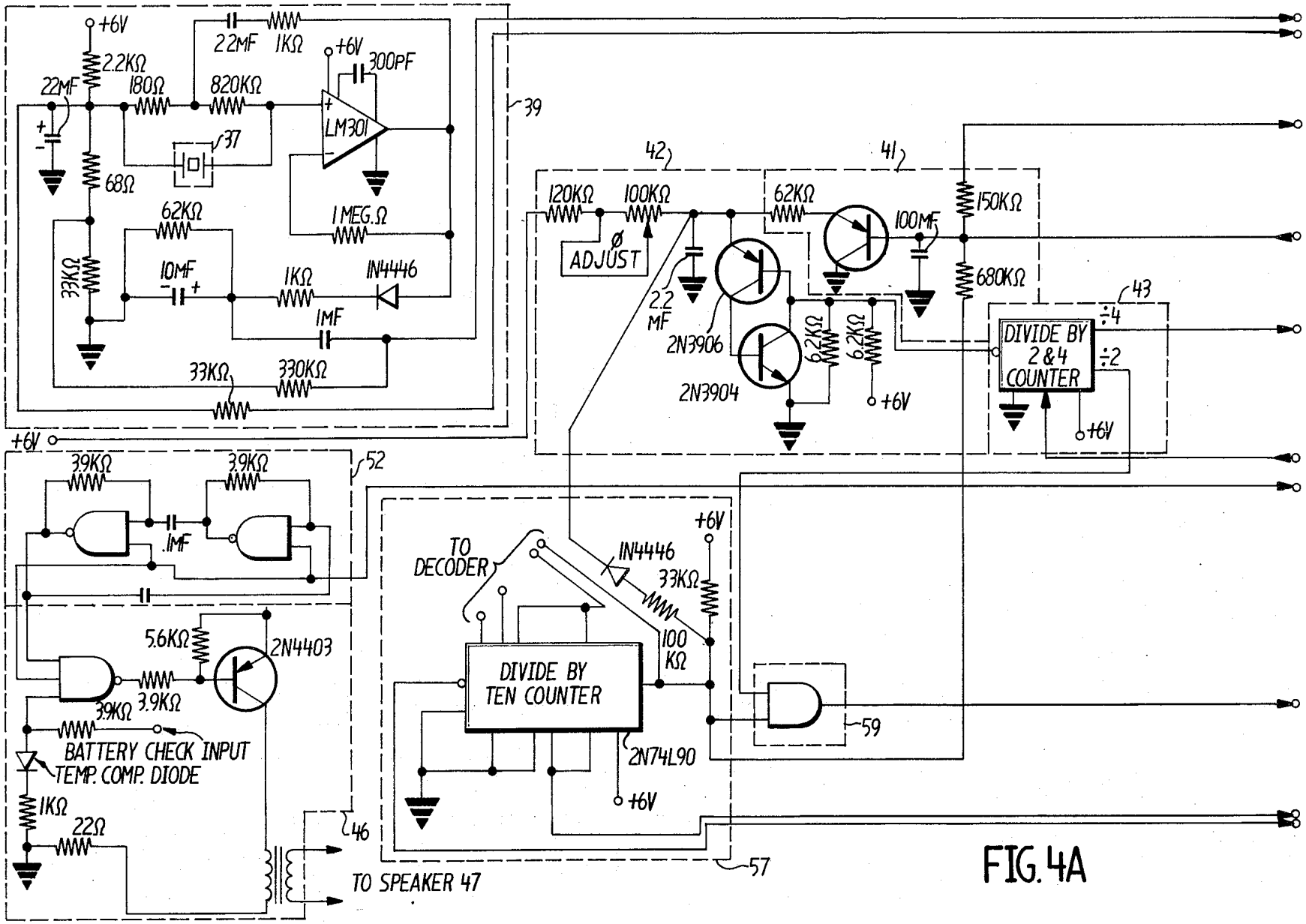

+6V
2.2KΩ
22MF
1KΩ
180Ω
820KΩ
300PF
LM301
37
39
68Ω
62KΩ
1 MEG.Ω
33KΩ
10MF
1KΩ
IN4446
1MF
33KΩ
330KΩ
42
41
120KΩ
100KΩ
62KΩ
100MF
150KΩ
680KΩ
ADJUST
2.2 MF
2N3906
2N3904
9.2KΩ
9.2KΩ
43
DIVIDE BY 2 & 4 COUNTER
÷4
÷2
52
3.9KΩ
3.9KΩ
.1MF
5.6KΩ
2N4403
3.9KΩ
BATTERY CHECK INPUT
TEMP. COMP. DIODE
1KΩ
22Ω
46
TO SPEAKER 47
TO DECODER
IN4446
33KΩ
100 KΩ
DIVIDE BY TEN COUNTER
2N74L90
59
57

FIG. 4A

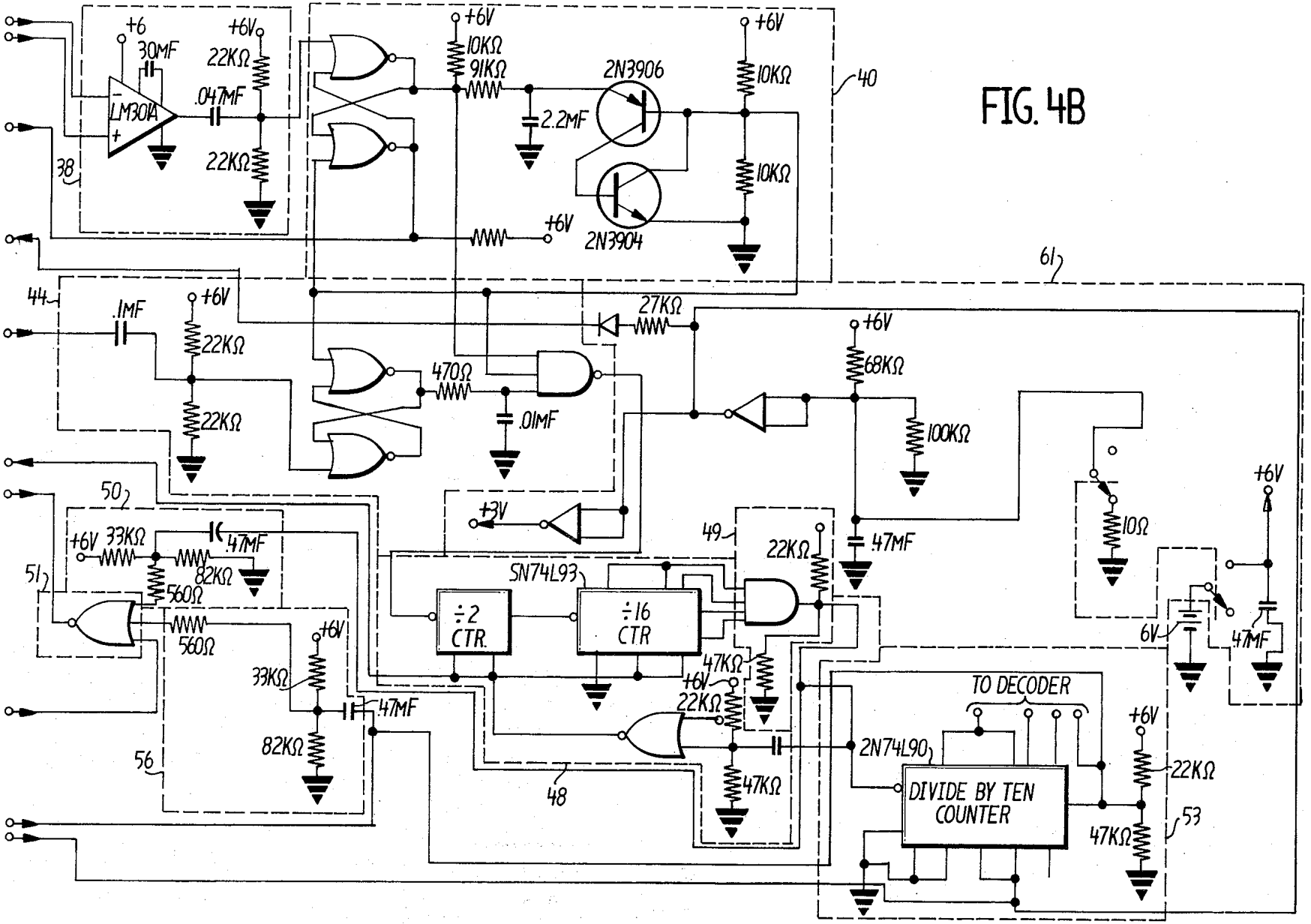

+6
30MF
+6V
22KΩ
.047MF
LM301A
22KΩ
38
+6V
10KΩ
91KΩ
2N3906
2.2MF
10KΩ
40
10KΩ
+6V
2N3904
61
44
.1MF
+6V
22KΩ
22KΩ
27KΩ
+6V
68KΩ
470Ω
.01MF
100KΩ
+3V
50
+6V
33KΩ
.47MF
82KΩ
560Ω
51
49
22KΩ
.47MF
SN74L93
÷2 CTR.
÷16 CTR
10Ω
+6V
6V
.47MF
47KΩ
+6V
22KΩ
TO DECODER
560Ω
33KΩ
+6V
.47MF
82KΩ
56
48
2N74L90
47KΩ
DIVIDE BY TEN COUNTER
+6V
22KΩ
47KΩ
53

FIG. 4B

JOGGING COMPUTER

BACKGROUND OF THE INVENTION

This invention relates generally to the field of physical exercising, and more particularly to the art of measuring and indicating physical exercise achievement attained by an individual in accordance with a predetermined exercise regimen or program.

Routine physical exercise has long been extolled by virtually every medical authority as essential to good health and longevity. Because of modern conveniences and work-saving technology, the average person expends less physical energy today than did his counterparts in generations past. As a result, the current generation, particularly in the Unites States, by and large does not get the physical exercise necessary for good health.

In the past several years, there has been a gradual awakening to the need for a more systematized approach to the problem of exercise. Particularly, individuals in the over-thirty years age bracket are having routine exercise prescribed by their physicians as a preventive measure against heart disease and other associated cardio-vascular disorders. Numerous recent publications have recognized a correlation between physical fitness and exercise and have delineated detailed regimens or programs of exercise intended to yield the desired results.

Chief among these publications are two books, Cooper, *Aerobics*, M. Evans and Company, Inc., New York, N. Y. (1968) and Cooper, *The New Aerobics*, M. Evans and Company, Inc., New York, N. Y. (1970). These books stress the benefits of exercises, particularly running and jogging, which increases blood circulation, breathing, and the use of lungs. The author, Kenneth H. Cooper, M.D., has devised a detailed exercise regimen which produces output or achievement in a point system, the "aerobics" point system. These books, and others like them, have contributed in large part to a virtual jogging boom in the United States and elsewhere. On any given day, in parks, playgrounds, gymnasiums and streets, people can be found walking, running and jogging to earn their "points."

The "aerobics" system, as well as other similar systems, requires an individual to walk, to run or to jog in place or on a measured track with a stop watch to determine his rate of speed. Thereafter, the individual must refer to tables and charts and make mental computations to arrive at his earned number of "points." The problems inherent in such a program are, of course, numerous. Not only does the individual have to find a measured track, but he must make frequent reference to the books and tables, stop watches, distances, pacers, and finally make his computations. Moreover, after running a given distance, the exerciser may find that he was running too slowly and thus not qualify for any "points." The exerciser may in some instances run at too high a rate, not realizing that he may be over-exerting himself, until he finishes running the selected measured track and then notes the elapsed time. Such over-exertion may be physically harmful to some individuals.

SUMMARY OF THE INVENTION

It is a primary object of this invention to simplify adherence to an exercise regimen involving a "points" system.

Another object of this invention is to promote running and jogging as a form of systematized exercise by eliminating the need for a measured track, stop watch and mental computations from "points" system regimens.

More particularly, it is an object of this invention to provide a device for measuring and indicating directly in "points" physical exercise achievement attained through walking, running or jogging in accordance with a predetermined exercise regimen.

Another object of this invention is to provide a device which will provide a continuous or periodic indication that an exerciser is moving above a threshold rate commensurate with a predetermined exercise regimen.

A further object of this invention is to provide a device for measuring and indicating in "points" physical exercise achievement attained in accordance with a predetermined exercise regimen which avoids the possibility of an exerciser inadvertently over-exerting himself.

Still another object of this invention is to provide a portable solid-state device adapted to be carried by a person and which is operatively arranged to sense and to count the number of steps taken by the person while walking, running or jogging, as well as to determine the rate thereof, and which will make mathematical computations to determine the energy output of the exerciser and compare that output to a predetermined exercise regimen schedule, and which will signal the exerciser to indicate desired levels of achievement of the exercise regimen.

Briefly, these and other objects are accomplished in accordance with this invention by providing a portable, solid-state, miniature digital computer adapted to be strapped to the belt or otherwise conveniently carried on the person of an individual while walking, running or jogging, and which is adapted to sense automatically, to compute and to report exercise achievement directly in "aerobic" points. By "aerobic" points, of course, is meant the measure of exercise achievement in accordance with Dr. Kenneth H. Cooper's system of earned points, as explained in his books, *Aerobics*, supra, and *The New Aerobics*, supra. It should be understood, of course, that while the invention is specifically described herein as keyed to the "aerobics" point system, the computer of this invention could be preprogrammed in accordance with any other similar point system or exercise regimen which lends itself to measuring achievement in specific units.

The device includes an electromechanical transducer, in the form of an accelerometer, which is capable of sensing each step taken by an exerciser while walking, running or jogging either in place or over a distance course. The accelerometer in conjunction with associated circuitry produces a train of electrical impulses which are used as an input to the computer. Preferably, the transducer may be a piezo-electric crystal having a cantilevered weight for converting mechanical impulses to electric signals. It should be understood, however, that other type sensors may be used within the scope of the invention.

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The number of electrical impulses coming from the sensor (which corresponds to the number of steps taken by the exerciser), provided they accrue at least at a minimum rate, are counted by the computer which also measures the rate thereof with respect to time. The product of the number of steps and the rate at which they are taken is integrated continuously over the full period of the exercise. The computer accumulates the integrated input data and constantly compares the level of the integral to a pre-programmed exercise regimen schedule. When the level of the integral corresponds to predetermined points on the exercise regimen schedule, the computer indicates to the exerciser the achievement directly in the units of the regimen; for example, "points" in the "aerobic" point system. The signal may be either an audible signal or a visual signal, or a combination of both audible and visual signals. Moreover, the reporting system is preferably continual; i.e., periodic indications are given to the exerciser as he attains cumulative levels of achievement of the exercise regimen, even in circumstances which exist during exercise periods involving changes in the exercising rate. Thus, an exerciser can avoid the possibility of inadvertently over-exercising and need not during a single exercise period exercise at a fixed rate.

In the preferred embodiment of the invention, as described herein, "aerobics" tables from Dr. Kenneth H. Cooper's books, *Aerobics*, supra, and *The New Aerobics*, supra, are plotted as curves on a chart and programmed into the computer. The curves plot walking, jogging and running speed against earned "aerobic" points and yield a certain amount of "points" for running at a given rate for a given distance. Moreover, the curves are exponential rather than linear such that the yield in "points" is greater at the higher rates of running speed.

It has been found that the computer of this invention will report "aerobic" points within a fifteen percent error of the "aerobic" tables. This error may be attributed primarily to the variations under actual running conditions from the assumed constant length of stride and average grade conditions programmed into the computer. In the case of stationary running or jogging, the stride rate error is non-existent and the primary errors are due to variations in fitting the computer curve to the aerobics curve and to variations due to battery aging and temperature variations. These errors, at maximum, are about ±7.0 percent.

In keeping with the "aerobics" system, the computer includes an internal clock which advances at a predetermined rate against which the rate of the incoming data is measured. If the rate of the incoming data is below the rate of the clock, the data is rejected and thus does not contribute to the integrated output level. Consequently, if the exerciser is walking, running or jogging below the predetermined threshold level, his efforts will not count towards the attainment of his exercise objective. In one embodiment of the invention, the computer will signal the exerciser when he is running below the threshold level. In any event, even if the exerciser is running above the threshold rate, the computer mathematically performs a subtraction of the threshold rate from the incoming signal such that the only data which is integrated is that which exceeds the threshold level. Preferably, the threshold level may be set by the exerciser in accordance with his desire to run, to jog or to walk, so as to exclude signals developed in the last or the two lesser speed modes from contributing to the "points" which are to be accumulated.

BRIEF DESCRIPTION OF THE DRAWINGS

With the above and other objects in view as may hereinafter appear, the nature of the invention can be more clearly understood by reference to the several views illustrated in the accompanying drawings, the following detailed description thereof, and the appended claimed subject matter.

FIG. **1** is a pictorial view of an exerciser who has a portable exercise measuring and indicating device constructed in accordance with this invention on his person.

FIG. **2** is a block diagram of an illustrative embodiment of an exercise measuring and indicating device constructed according to the present invention, audible and visual indicating means being provided.

FIG. **3** is a block diagram of a second preferred embodiment of an exercise measurement and indicating device constructed according to the present invention, visual and audible indicating means being provided.

FIGS. **4A** and **4B** are a detailed schematic and block diagram of a major portion of the device illustrated in FIG. **3**, and illustrates detailed circuitry for some of the elements shown as blocks in FIG. **3**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. **1**, an exerciser, generally designated by the numeral **6**, is provided with a belt **7** which carries a portable, battery powered, solid-state exercise measuring and indicating device **8** constructed in accordance with the present invention. It is to be understood, of course, that the device **8** could be carried equally well on the person of the exerciser **6** by other conventional means.

As shown in FIG. **1**, the exercise measuring and indicating device **8** includes an on-off switch **9** for energizing the device **8**. A threshold lever selector switch **10** is provided to allow the exerciser **6** to select either a walking, a jogging or a running threshold level. A shaded visual indicator **11**, preferably in the form of a liquid crystal two-digit decimal number display, is positioned on the uppermost surface of the device **8** so as to be readily readable by the exerciser **6**. An audible signal-producing means, such as a loud speaker **12**, is provided in addition to the visual indicator **11**. It is to be understood that, in some applications, the device **8** could be provided only with the visual indicator **11** or the loud speaker **12**. A three-position selector switch **13** is provided which allows the exerciser **6** to select for display on the visual indicator **11** data representing either distance, elapsed time or accumulated "aerobic" points. A control knob **14** is provided to adjust the device **8** so as to accommodate for different strides, e.g., short, medium and long.

Referring to FIG. **2**, the exercise measuring and indicating device includes an accelerometer **16**, in the form of a loaded, cantilevered, piezo-electric crystal or an electromagnetic pickup, which generates a distinct electrical impulse once for each step taken by an exerciser, such as the exerciser **6**, shown in FIG. **1**. The electrical impulses which are processed by a monostable multivibrator are electrical signal representation of the rate of change of acceleration (the second derivative a vertical velocity with respect to time) commonly known as "jerk." The distinct electrical impulses from

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the accelerometer 16 are fed to a monostable multivibrator 17 which responds to the distinct impulses and produces a train of regularly shaped pulses, the pulse repetition rate corresponding to the repetition rate of the distinct processed electrical impulses received from the accelerometer 16. The monostable multivibrator 17 acts essentially as a pulse shaper.

A pulse rate comparator 18 has a first input operatively coupled to the output from the monostable multivibrator 17 and a second input coupled to the output from a threshold clock pulse generator 20. The threshold clock pulse generator 20 generates a train of pulses having a predetermined repetition rate which corresponds to an exercise rate which is to be excluded from the computation of "aerobic" points. It is preferred that the threshold clock pulse generator be settable to one or another of three rates, the lowest rate being a threshold level for the earning of "aerobic" points by walking, the highest rate being a threshold level for the earning of points by running and the middle rate being a threshold level for earning points by jogging.

The pulse rate comparator 18 has two output signals. A first output signal, which appears only when the pulse repetition rate of the pulse from the multivibrator 17 is less than the pulse repetition rate of the pulse from the clock pulse generator 20, is fed via an inhibit gate 21 to a low frequency audio oscillator 22 as its enabling signal. The output of the low frequency audio oscillator 22 is coupled to a drive coil 23 which drives a speaker 24. It is to be understood that the speaker 24 and its associated drive coil 23 may be advantageously replaced by a small, lightweight ceramic transducer of known construction. Such transducers have high acoustic output with low power input. Whenever an exerciser is performing at too low a rate to accumulate "aerobic" points in a selected regimen, as determined by the output from the clock pulse generator 20, the low frequency audio-oscillator 22 produces a distinct, low frequency output signal which is reproduced by the speaker 24 thereby signaling the exerciser to increase the rate of his exercise activity for example, his jogging speed.

A second difference output signal from the rate comparator 18, in the form of a train of pulses corresponding to the positive difference between the train of pulses produced by the mutivibrator 17 and the train produced by the clock pulse generator 20, appears only when the pulse repetition rate of the pulses from the multivibrator 17 is equal to or greater than the pulse repetition rate of the pulses from the clock pulse generator 20. This second output signal is fed to an accumulator 25 which is operatively arranged to count the number of pulses and provide a digital output signal indicative of the number of "aerobic" points or the like being earned by the exerciser.

The digital output signal from the accumulator 25 is fed to the input of a digital-to-analog converter 26 which produces an analog output signal, the analog output signal being fed, via the first input terminal of a multiposition selector switch 36, to a meter 27 which is calibrated and preferably includes a scale which can be directly read in "aerobic" points.

The train of pulses from the monostable multivibrator 17 are also fed to the input of a second accumulator 32 which is operatively arranged to count the number of pulses and provides a digital output signal indicative of the distance or effective distance, in the case the exerciser is exercising in place. The accumulator 32, as well as the accumulator 25, is preferably adjustable so as to accommodate different strides, the adjustment being made by the particular exerciser. The digital output signal from the accumulator 32 is fed to a digital-to-analog converter 33 which produces an analog output signal. The analog output signal from the converter 33 is fed to the second input terminal of the multiposition selector switch 36. Thus, an exerciser while exercising may by manipulating the selector switch 36 provide an input to the meter 27 directly representing the distance of effective distance. In this case, the meter 27 would be provided with a second scale which can be directly read in distance units.

The threshold clock pulse generator 20 has a second output, in the form of a train of pulses of fixed repetition rate, which is fed to a third accumulator 34. The third accumulator 34 is operatively arranged to count the number of pulses received from the threshold clock pulse generator 20 and provides a digital output signal indicative of the elapsed time of the exercise period. The digital output signal from the third accumulator 34 is fed to a digital-to-analog converter 35 which, in turn, produces an analog output signal representative of elapsed time. The output signal from the digital-to-analog converter 35 is fed to the third input terminal of the multiposition selector switch 36. During an exercise period, an exerciser, again by manipulating the selector switch 36, may select an input for the meter 27 which directly represents the elapsed time. The meter 27, in this case, has a third scale calibrated in time units.

A second from the accumulator 25, which appears whenever a given number of "aerobic" points, for example, one (1) or one-tenth (0.1), have been earned by the exerciser as determined by the accumulator 25, is fed to the input of a monostable multivibrator 28. In turn, the multivibrator 28 produces two pulse output signs in response to the output signal from the accumulator 25. The first output signal is fed to the inhibiting input of the inhibit gate 21 to prevent any enabling signal to pass to the low frequency audio-oscillator 22 from the comparator 18. This first output signal pulse from the multivibrator 28 is also fed to a high frequency audio-oscillator 30 as its enabling signal. The output of the high frequency audio-oscillator 30 is coupled to the drive coil 23 which drives the speaker 24. Thus, whenever an exerciser has earned the preprogrammed number of "aerobic" points, for example one (1) or one-tenth (0.1), the high frequency audio-oscillator 30 produces a distinct high frequency output signal which is reproduced by the speaker 24. In this manner, the exerciser determines that he has earned a given point level. If his goal is to earn three (3) points during one exercise period, for example, and the high frequency audio-oscillator responses to each earned point, he simply counts the number of times the high frequency tone is heard.

A second output signal pulse from the monostable multivibrator 28 is fed to a reset gate 31 which, in turn, produces a reset signal for resetting the accumulators 25, 32 and 34, and the digital-to-analog converters 26, 33 and 35.

The preferred embodiment of the exercise measuring and indicating device, as illustrated in FIG. 3, includes an accelerometer 37, an underdamped loaded cantilever piezo-electric crystal or the like. The accelerometer 37 is operatively arranged to ring and produces a series

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of damped oscillations, one damped oscillatory wave being produced for each step taken by an exerciser. The output signals from the accelerometer **37** are fed to an amplitude comparator **38** via a unity gain, high input impedance amplifier **39.** The function of the amplitude comparator **38** is to compare the first derivative of vertical acceleration (jerk) produced by the just-taken step with the first derivative of the vertical acceleration (jerk) of the preceding step. If the signal produced by the present step does not reach a predetermined level, for example 50 percent, of the signal produced by the previous step, the signal is rejected and not passed to a lockout circuit **40,** preferably a one-shot multivibrator. This comparison functions essentially as a variable amplitude discriminator to reject low level and spurious signals.

The amplitude comparator **38** essentially passes a portion of the highest magnitude half wave signal it receives from the amplifier **39** to the lockout circuit **40.** The lockout circuit **40** is a one-shot multivibrator which produces an output pulse of approximately 0.2 seconds duration for each signal it receives from the amplitude comparator **38.** This 0.2 second pulse is fed to a clock control circuit **41** which, in turn, in response to the pulses it receives produces, by integration, a variable direct voltage control signal, the magnitude of which is directly related to the repetition rate of the input pulses. The variable direct voltage control signal from the control circuit **41** is fed to the threshold clock pulse generator **42** and is effective to vary the pulse repetition rate of its signal output thereby providing that at higher exercise rates a single event sensed by the accelerometer **37** represents a greater contribution to an "aerobic" point than at the lower rates. The output pulses from the clock pulse generator **42** are fed to a counter **43** which, in turn, provides a divided-by-four output pulse train to the first input of a rate comparator **44.**

A function of the one-shot lockout circuit **40,** in addition to supplying an input to the control circuit **41,** is to assure that the device of the present invention is immune to noise signals and other spurious signals which otherwise may appear shortly after the piezo-electric crystal forming the active part of the accelerometer **37** rings and which otherwise would affect the output from the rate comparator **44.**

A second input of the rate comparator **44** is coupled to receive pulse signals from the one-shot lockout circuit **40.** The threshold clock pulse generator **42,** when not disabled by action of the control circuit **41,** generates a train of pulses having a predetermined repetition rate which corresponds to an exercise rate which is to be excluded from the computation of "aerobic" points. As in the embodiment shown in FIG. **2,** the threshold clock pulse generator **42** is a generator whose rate can be varied or set to one or another of three basic rates depending on the type of exercise involved, i.e., walking, jogging or running. As illustrated, the rate comparator **44** has two output signals. A first output signal, which appears only when the pulse repetition rate of the train of pulses from the lockout circuit **40** is less than the pulse repetition rate of the train of pulses from the counter **43,** is fed to a low rate tone generator **45** which produces a low frequency audio signal which is fed to an audio output driver **46** of a speaker **47,** the audio output driver **46** has two other inputs, which are to be explained below, and acts as a linear mixer. The speaker **47** and its associated coil (unnumbered) may be replaced, if desired, by a ceramic transducer. Wherever an exerciser is performing at too low a rate to accumulate "aerobic" points in a selected regimen, the tone generator **45** responds, signaling the exerciser, via the speaker **47,** to increase the rate of his activity, for example, his walking speed. It is to be understood that the tone generator **47** is not essentially element of this invention and may be omitted.

A second difference output signal, in the form of a train of pulses, from the rate comparator **44** is fed to a first accumulator **48.** This train of pulses has a repetition rate determined by the positive rate difference between the train of pulses supplied from the lockout circuit **40** and the train of pulses supplied from the threshold clock pulse generator **42** via the divide-by-four output from the counter **43.**

The first accumulator **48** is a digital counter which responds to the train of pulses it receives from the rate comparator **44** and provides, as its principal output, a coded digital signal, preferably in the form of a binary coded decimal signal representing one-tenth of an "aerobic" point. This binary coded decimal signal is fed to a decoder, In the form of a four-input AND gate **49,** which produces a pulse output signal for each accumulated tenth of an "aerobic" point. This pulse output signal is fed via a differentiator **50** to a three-input NOR gate **51** which gates on an audio oscillator **52** producing an audio tone of short duration, such as a tenth of a second, so as to provide a "beep" upon the accumulation of every one-theth of an "aerobic" point. The "beep" sound is audibly produced in the speaker **47** which receives an audio output from the gated audio oscillator **52** via the audio output driver **46.**

The decoder **49** also supplies a reset signal to the first accumulator **48** for resetting the accumulator **48** upon the occurrence of each tenth one of the accumulated tenths of an "aerobic" point. It is to be understood that the first accumulator **48** is preferably adjustable so as to be accommodated to an individual exerciser's stride.

The decoder **49** also supplies each of its pulse signals representing a tenth of an "aerobic" point to a second accumulator **53** which is a decade counter, responding to the train of pulses received from the decoder **49.** The second accumulator **53,** in turn, provides as its principal output a coded digital signal, in the form of a binary coded decimal representing tenths of an "aerobic" point. This binary coded decimal signal is fed, in bit parallel, to a decoder **54** which decodes the received binary coded decimal signal received from the second accumulator **53** into a seven segment coded signal which is fed to a conventional seven segmented liquid crystal display member **55,** a decimal number being produced in the display member **55** which allows the exerciser to read his currently earned tenths of an "aerobic" point during the period of exercising.

The second accumulator **53** is provided with an output circut which produces a pulse output signal for each full "aerobic" point. This pulse output signal is fed to a differentiator **56.** The output from the differentiator **50** is fed to the gated oscillator **52** via the NOR circuit **51.** In response to the output from the differentiator **56,** the gated oscillator **52** produces a distinct audio signal of greater duration that the duration of the tone produced for each tenth of an "aerobic" point. The duration of the audio signal produced by the gated oscillator **56** in response to the signal from the differen-

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tiator **56** may be, for example, of about one and one-half seconds in duration, as determined by the time constant of the differentiator **56.** This audio signal is also audibly produced in the speaker **47** used to produce the audible "beep" mentioned above.

The second accumulator **53** is not provided with an externally wired reset in the same manner as the first accumulator **48** since the second accumulator is a decade counter and essentially resets itself.

When a full "aerobic" point has been accumulated in the second accumulator **53,** the NOR gate **51** receives inputs from both the differentiator **50** and the differentiator **56,** but since the output from the differentiator **56** is of longer duration, the shorter duration output from the differentiator **44** is effectively masked, only the relatively longer duration audible tone signal being produced by the speaker **47.**

Each pulse signal representing a full "aerobic" point from the second accumulator **53** is fed to a third accumulator **57** which, like the second accumulator **53** is a decade counter which responds to the train of pulses received from the second accumulator **53.** The third accumulator **57** is preferably a digital counter which counts up to five, the number five being suitable simply because many exercise routines are designed to require the earning of five full "aerobic" points during one exercise period.

The third accumulator **57** provides an output signal, in the form of a binary coded decimal signal representing full "aerobic" points. This output signal is fed, in bit parallel to a decoder **58** which, in turn, decodes the received signal into a seven segmented coded signal which is fed to a seven segmented liquid crystal display member **60.** A decimal number appears in the display member **60** representing full "aerobic" points.

The third accumulator **57** provides a second output signal indicating that five "aerobic" points have been earned. This second output signal is fed to an AND gate **59** which has a second input connected to a divide-by-two output from the counter **43,** which is a square wave having a 50 percent duty cycle. The output from the AND circuit **59,** which can be considered a warble control signal, is fed to the gated oscillator **52** via the NOR gate **51.** Thus, the gated oscillator **52** produces a warbled output signal which is audibly reproduced by the speaker **47** upon the completion of exercise equal to five earned "aerobic" points. The gated oscillator **52** continues to produce its distinct warbled audio signal, until the device is either turned off or manually reset, by means of a push button switch or the like, as indicated diagrammatically by the numeral **61.**

The audio output driver **46** includes a battery check input which functions as a check of battery voltage each time a tone is sounded during routine operation. If the battery voltage falls below a certain level, the audible tone signals cease.

It is to be understood that the device illustrated in FIG. **3** may include a selector switch, further accumulators, similar to the accumulators **32** and **34** of FIG. **2,** and associated digital-to-analog converters which could be alternatively connected to the decoders **54** and **58** to provide directly readable distance and elapsed time data. Thus, this addition data could be available to an exerciser on demand via the selector switch.

In the event an elapsed time data readout is desired, the device of FIG. **3** would be provided with a separate timing oscillator as its source of timing signals. This is necessary because the threshold clock pulse generator **42** is not fixed as to its output signal repetition rate.

It is to be understood that the decoders **54** and **58** can be eliminated provided that the second accumulator **53** and the third accumulator **57** are operatively arranged to provide output signals in a seven segmented code. Such accumulators are known in the art. In this instance the digital coded signals from the accumulators **53** and **57** would be fed respectively directly to the liquid crystal display members **55** and **60.**

In FIGS. **4***a* and **4***b*, detailed circuit diagrams are seen for the circuit elements **37–44, 46–53, 56, 57, 59** and **61** of FIG. **3,** these circuit elements being enclosed in dotted lines and provided with corresponding reference numerals. Numeral values for the significant resistors and capacitors are set out in FIGS. **4***a* and **4***b*, other circuit parts being designed as to type on the drawings.

While there has been shown and described above possible embodiments of this invention, it is to be understood that the invention is not limited thereto and that various changes, alterations and modifications can be made without departing from the spirit and scope thereof as defined in the appended claims.

It is claimed:

1. A device for measuring and indicating physical exercise achievement in accordance with a predetermined exercise regimen involving a series of repetitive energy-consuming events comprising in combination: means for sensing each of said repetitive energy-consuming events performed, means for establishing a threshold rate, means coupled to said means for sensing and to said means for establishing a threshold rate and responsive to outputs therefrom for providing a positive rate difference output, accumulator means coupled to said means for providing a rate difference and responsive to its rate difference output for accumulating its output over time up to a given maximum for developing an output representative of degree of exercise achievement of said exercise regimen, and signaling means coupled to said accumulator means and responsive to output therefrom for indicating levels of achievement of said exercise regimen.

2. A device as defined in claim **1** wherein said accumulator means includes at least one digital accumulator counter.

3. A device as defined in claim **1** wherein said threshold means includes an internal clock.

4. A device as defined in claim **1** wherein said device is portable and adapted to be carried on the person of an individual while walking, running or jogging.

5. A device as defined in claim **1** wherein said means for sensing includes an accelerometer adapted to generate an electrical impulse signal in response to each step taken by an individual while running, walking or jogging.

6. A device as defined in claim **1** wherein said device has a self-contained power source.

7. A device as defined in claim **5** wherein said accelerometer includes a mass loaded cantilevered piezoelectric crystal for converting mechanical impulses into electrical signals.

8. A device as defined in claim **1** wherein said signaling means comprises an audible alarm.

9. A device as defined in claim **1** wherein said signaling means comprises a visual indicator.

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10. A device as defined in claim 9 wherein said visual indicator includes at least one liquid crystal element.

11. A device as defined in claim 1 further comprising means for determining elapsed time.

12. A device as defined in claim 1 further comprising means for determining effective distance traveled by an exerciser.

13. A device as defined in claim 11 including means for indicating elapsed time.

14. A device as defined in claim 12 including means for indicating distance.

15. A device as defined in claim 1 wherein said signaling means comprises digital display means.

16. A device as defined in claim 15 wherein said digital display means comprises liquid crystal means.

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