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Burian et al.

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[45] **Apr. 9, 1974**

[54] **EXERCISE CONTROL SYSTEM**

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[73] Assignee: **Exercycle Corporation,** New York, N.Y.

[22] Filed: **Feb. 21, 1973**

(Under Rule 47)

[21] Appl. No.: **334,266**

Related U.S. Application Data

[63] Substitute for Ser. No. 14,741, Feb. 24, 1970, abandoned, which is a continuation of Ser. No. 631,048, April 14, 1967, abandoned.

[52] **U.S. Cl.** .... **272/57 R,** 128/2.05 T, 128/2.06 F, 272/73

[51] **Int. Cl.** **A63b 21/00**

[58] **Field of Search** 128/2.05; 272/57, 73

[56] **References Cited**

UNITED STATES PATENTS

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Attorney, Agent, or Firm—Curtis, Morris & Safford

[57] **ABSTRACT**

An exercise measuring system in which a person's pulse rate while exercising is electronically detected and compared against a desired level. Pickup electrodes are strapped to the person's chest to pick up his pulse rate while he is exercising and this pulse rate is then fed to an electronic indicating device which compares it with a preset rate, or level. Deviations above or below this level are indicated by respective lights. Lights are also provided to respectively indicate when the user's pulse rate is maintained at the preset level and when the pulse rate has been maintained at the preset level for a predetermined length of time.

8 Claims, 4 Drawing Figures

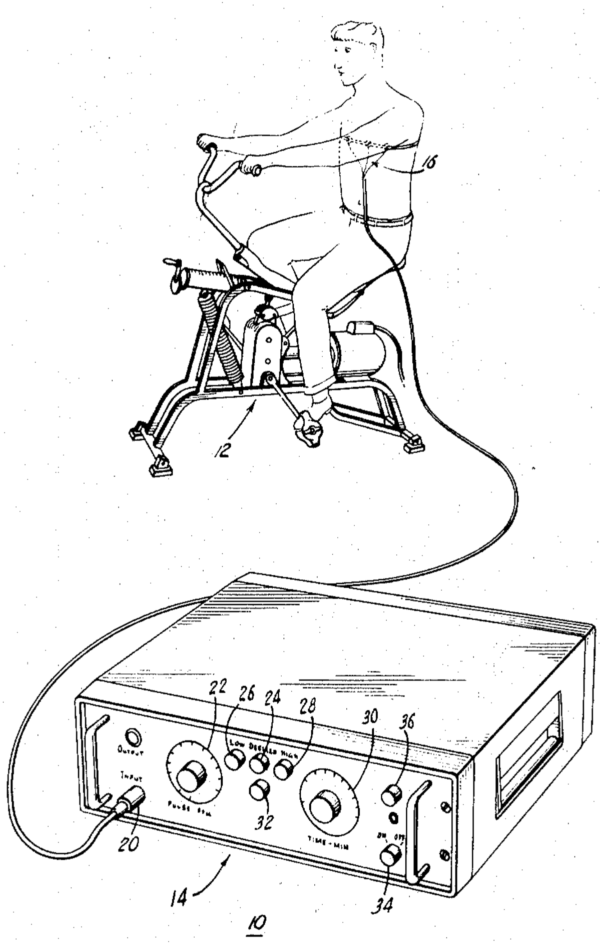
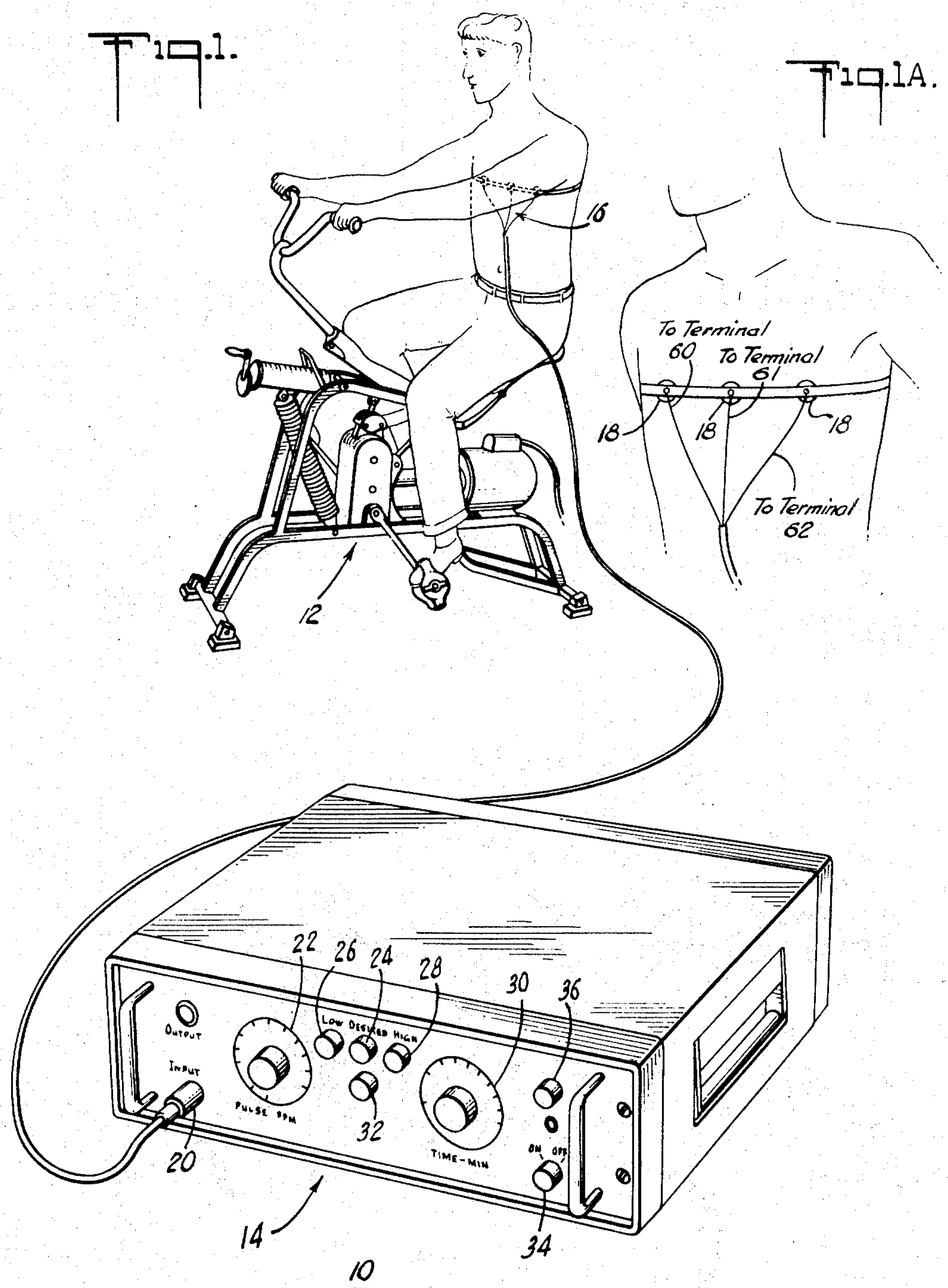


Fig. 1.


16
12
22
26
24
28
30
36
OUTPUT
INPUT
LOW DESIRED HIGH
PULSE PPM
TIME-MIN
ON OFF
20
32
34
14
10
Fig. 1A.
To Terminal 60
To Terminal 61
18
18
18
To Terminal 62

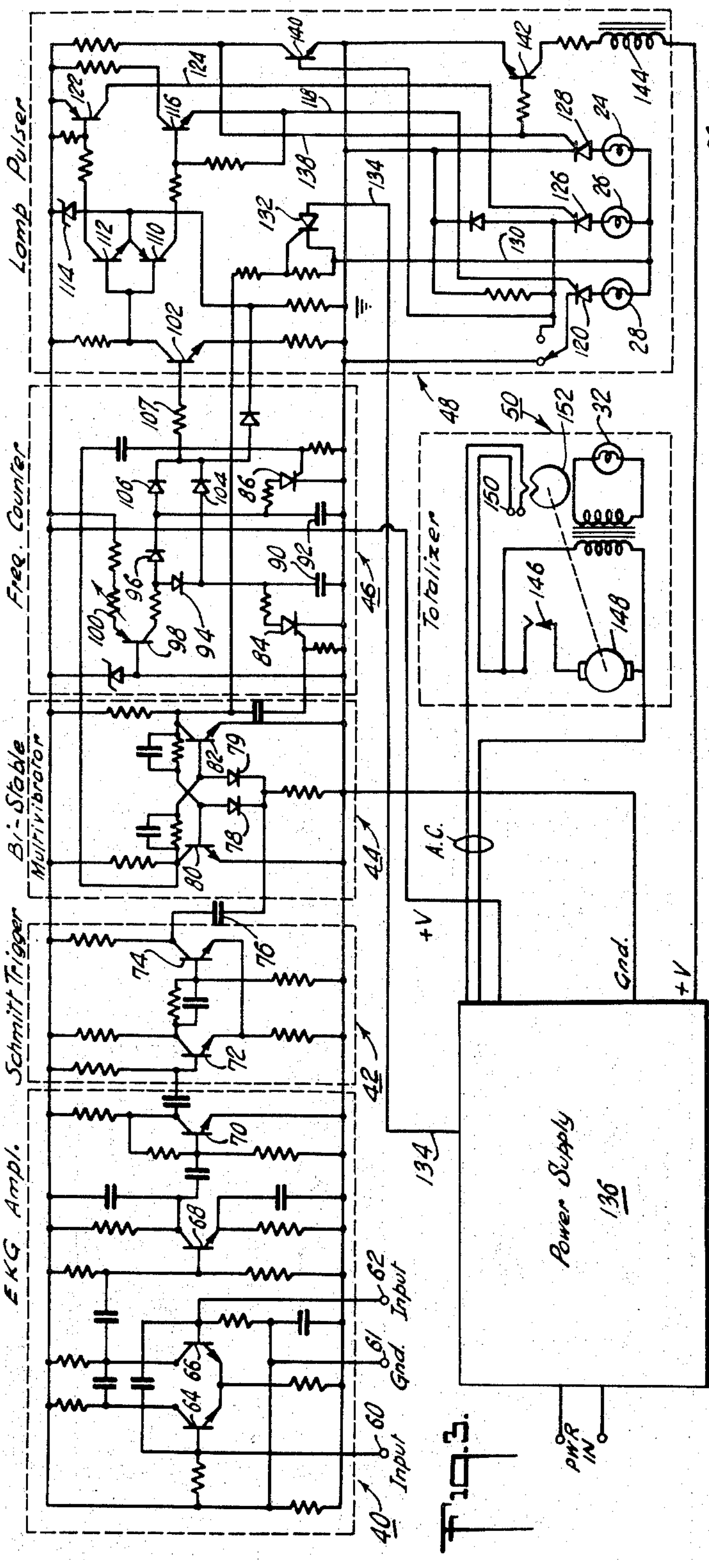

Lamp Pulser
Freq. Counter
Bi-Stable Multivibrator
Schmitt Trigger
EKG Ampl.
Totalizer
Power Supply
136
Input
Gnd.
Input
A.C.
+V
Gnd.
PWR IN

Fig. 3.

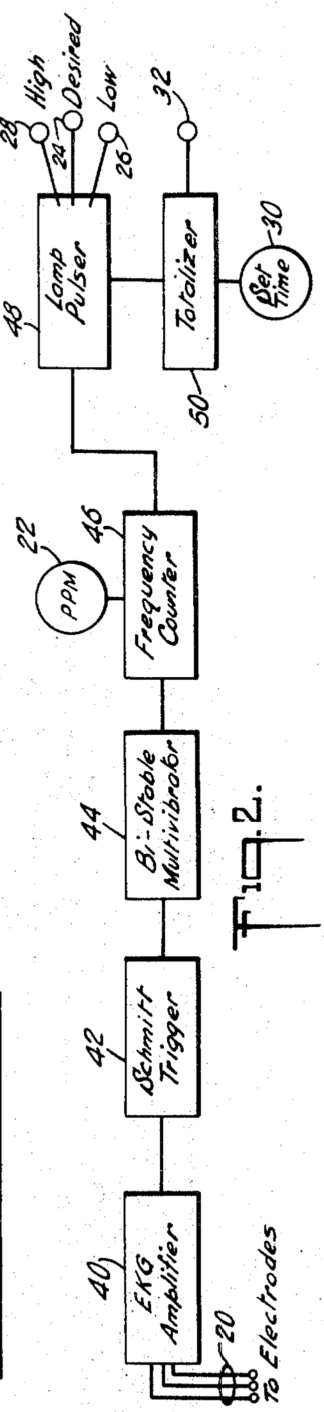

EKG Amplifier
Schmitt Trigger
Bi-Stable Multivibrator
Frequency Counter
PPM
Lamp Pulser
Totalizer
Set Time
High
Desired
Low
To Electrodes

Fig. 2.

EXERCISE CONTROL SYSTEM

This application is a substitute for U.S. Patent Application Ser. No. 14,741 filed Feb. 24, 1970, a continuation of U.S. Patent Application Ser. No. 631,048 filed Apr. 14, 1967, both of which are now abandoned.

This invention relates to a system for controlling the degree and duration of exercise of a person.

An object is to provide an exercising system including a machine, such as an "Exercycle" brand machine, and an electronic measurer by which a person can exert himself to any desired level as determined by a given pulse rate during exercising.

A more specific object is to indicate when a predetermined length of time a person exercises while his body sustains a given pulse rate has elapsed.

The present invention is suitable for use in evaluating and monitoring programmed exercise or conditioning regimes on the basis of pulse rate and not physical work loads. Thus a conditioned athlete may be able to give a higher work output than a person not used to exercise, and the present invention permits this to be taken into account. During exercising with the present system, a person is required to raise his pulse rate to a predetermined level and maintain this level for a prescribed period of time.

Direct indication of deviation from the person's predetermined desired cardiac rate is provided by a panel light flashing synchronously with his pulse. Negative or positive deviation of pulse rate from a pre-set level is indicated by two panel lights, marked "low" and "high" respectively. When the desired rate is attained, a third light flashes. The latter is positioned in the center between the "low" and "high" lights and is marked "desired." Thus, a decrease in pulse rate is indicated by the flashing of the "low" light, an increase in pulse rate is indicated by the flashing of the "high" light, while the correct pulse rate is indicated by the flashing of the "desired" light.

Before starting to exercise with the present system, a person straps pickup electrodes to his chest in the vicinity of his heart. These in turn are connected to the electronic measurer. Then, starting with a relaxed pulse rate, he begins to exercise on the machine more and more to raise his heart beat to a desired level. When this is attained the "desired" indicator light will flash, and continue to do so for as long as the desired rate (within a small range of deviation) is maintained. An elapsed time indicator, operating in conjunction with the rate counting circuitry is provided to give a quantitative measure of total time of exercise at the desired level.

A better understanding of the invention together with a fuller appreciation of its many advantages will best be gained from the following description given in conjunction with the accompanying drawings in which:

FIG. 1 shows an exercise measuring system embodying the invention;

FIG. 1A shows an enlarged detail of the pickup electrodes;

FIG. 2 is a logic diagram of the electronic measuring portion of the system; and

FIG. 3 is a schematic diagram of the electronic circuitry and time indicator.

The exercise measuring system **10** shown in FIG. **1** comprises an "Exercycle" brand exerciser **12**, and an electronic console **14**. The person riding the exerciser has strapped to his chest an electrode pad **16**, with three, spaced apart electrodes **18** in direct contact with his skin. These electrodes are respectively connected by a "ground" wire and two "input" wires to the input **20** of the console.

The front panel of the console includes a calibrated knob **22** by which a given pulse rate per minute (from 40 to 210 ppm) can be set. When the person's pulse reaches this pre-set level, the "desired" light **24** on the console panel will start to flash. Below this level the "low" light **26** will indicate, and above the level, "high" light **28** will be turned on. On the panel to the right of the rate indicator lights is another calibrated knob **30** by which a given elapsed or running time at the desired pulse level can be dialed into the console. While this time is running, a fourth light **32** shines steadily; when the set time is up, this light goes out. The console of the system is turned on or off by a panel knob **34**. Finally, a dial knob **36** will set the circuit to measure elapsed time only when the "desired" light is flashing, or alternatively when either the "desired" or "high" light is flashing.

FIG. **2** is a logic diagram of the electronic measurer showing in simplified form the various stages of the circuit. The first stage comprises a pulse amplifier **40**, which is driven by the low level signals from the electrodes at input **20**, and whose output of a much higher level is applied to a Schmitt trigger stage **42**. The latter provides constant amplitude pulses whose repetition rate is controlled by the rate of pulses applied to input **20**. The output of the Schmitt trigger is applied to a next stage **44** comprising a bi-stable multivibrator, which generates a square wave the frequency of which is one half that of the signals from the Schmitt trigger.

The multivibrator stage applies its output to a frequency counter **46** which generates a direct voltage proportional to the multivibrator frequency. The counter is capable of producing a change in voltage for only one pulse of a different repetition rate in a pulse train.

The direct voltage produced by the frequency counter is, in effect, compared against a settable reference voltage; deviation on the low side of the desired pulse rate results in the flashing of the "low" indicator light **26**, deviation on the high side results in lighting of the "high" light **28**, while approximate matching of the levels results in the flashing of the "desired" light **24**. To this end, the output of frequency counter **46** in FIG. **2** is applied to a lamp pulser stage **48** which drives a selected one of the three indicator lights.

Connected to lamp pulser **48** is a totalizer stage **50** which, while the "desired" light is actuated, measures total elapsed time, the length of time to be measured being settable by panel knob **30** previously described.

FIG. **3** shows the complete details of the circuitry shown in logic form in FIG. **2**. For convenience, the various stages enumerated in FIG. **2** have been enclosed in dotted outlines and given corresponding reference numerals in FIG. **3**. Amplifier **40** in FIG. **3** has input **20** comprising the three terminals **60**, **61**, and **62**, which are connected to respective ones of electrodes **18**. Terminals **60** and **62** connect to transistors **64** and **66** which are differentially connected, and terminal **61** is a neutral point, or ground, with respect to terminals **60** and **62**. This arrangement allows a balanced input and provides a degree of common mode rejection of noise and unwanted signals. The output of transistors **64** and **66** is amplified by a transistor **68** and then by a transistor **70.** Thus, a 2 millivolt signal at terminals **60, 62** produces about a two volt signal at the output of transistor **70.**

Schmitt trigger stage **42** includes a transistor **72** and a transistor **74.** The former is biased to saturation while the latter is cut off. When a negative pulse from transistor **70** is applied to the base of transistor **72,** it turns off and transistor **74** turns on and is clamped into saturation for as long as transistor **72** is off. This produces at the output of transistor **74** a constant amplitude pulse whose width is the base width of the pulse from amplifier stage **40.**

The constant amplitude pulse from trigger stage **42** is differentiated through a coupling capacitor **76** and the spikes are applied to a pair of steering diodes **78** and **79** in multivibrator stage **44.** One or the other of these diodes conducts, depending upon which of the transistors **80** and **82** is then conducting. Assuming that transistor **80** and diode **78** are at the moment conducting, a negative going spike of voltage from capacitor **76** will turn off transistor **80,** which in turn will cause transistor **82** to turn on. The next negative spike from capacitor **76** will turn off transistor **82** and turn on transistor **80,** and so on. Thus the multivibrator produces a square wave whose frequency is directly proportional to one half the pulse rate from electrodes **18.**

Frequency counter stage **46** includes two silicon controlled rectifiers (SCRs) **84** and **86** respectively connected to the outputs of multivibrator transistors **80** and **82.** SCR **84,** when triggered on, discharges a storage capacitor **90;** similarly SCR **86** is arranged to discharge an identical storage capacitor **92.** These capacitors are charged through respective diodes **94** and **96** from a constant current source including a transistor **98.**

Assume that in the multivibrator transistor **80** now goes off and transistor **82** goes on. A positive pulse from transistor **82** will be applied to the gate of SCR **86.** This turns the latter on and discharges capacitor **92.** When the discharge current falls below the minimum "hold on" current of SCR **86,** it will then turn off. Capacitor **92** will now begin to charge through its diode **96** and in so doing will reverse bias diode **94** (assuming a charge on capacitor **90** from the previous cycle) thereby stopping the charging of capacitor **90.** Capacitor **92** will charge according to the relation $V = TI \div C$, where V is voltage, T is time, I is current, and C is capacity. Both current and capacity are constant and so voltage is a linear function of time. In similar fashion, when SCR **84** is turned on, capacitor **90** will be discharged and will stop the charging of capacitor **92.** The voltages on these two capacitors in their non-charging states are thus a linear function of the switching rate of the multivibrator. Connected in the constant current source in series with transistor **98** is an adjustable resistor **100,** whose setting is controlled by the PPM knob **22** on the panel of the console. This setting also controls the levels of the voltages on capacitors **90** and **92.**

Capacitors **90** and **92** are connected to the base of a transistor **102** in lamp pulser stage **48** via respective ones of diodes **104** and **106** and a resistor **107.** These diodes alternately sense the more positive of the voltages on capacitors **90** and **92** and transfer this voltage to the base of transistor **102,** which is connected as an emitter-follower with a gain of unity. Connected to transistor **102** are transistors **110** and **112** which are arranged as a differential pair connected as shown to a Zener reference diode **114.** When the voltage from counter stage **46** rises above or falls below a level determined by Zener diode **114,** transistor **110** or **112** will conduct.

Connected to transistor **110** is an amplifer transistor **116** which is connected via a lead **118** to the gate of an SCR **120.** The latter is in series with its anode "high" indicator lamp **28.** Similarly, transistor **112** is connected to an amplifier transistor **122** which via lead **124** controls an SCR **126.** This has in series with itself "low" indicator lamp **26.** Next to SCR **126** is a third SCR **128** which is in series with "desired" lamp **24.**

The three indicator lamps are connected via a common lead **130** to the output of an SCR **132,** whose gate is triggered by signals from the multivibrator. The anode of SCR **132** is supplied with D.C. pulsating at power line frequency via lead **134** from the power supply **136.** Thus, whichever indicator lamp is on flashes at the pulse rate output of multivibrator **44.**

As mentioned previously SCRs **120** and **126** are respectively turned on by transistors **116** and **122.** The pulsating current from SCR **132** automatically turns off the SCRs and allows them to be again turned on by their respective control transistors. SCR **128** is controlled via a lead **138** from a transistor **140.** The latter is allowed to turn on when neither of SCRs **120** and **126** is being turned on. Thus "desired" lamp **24** automatically lights when lamps **26** and **28** go out.

Whenever SCR **128** is turned on, an adjacent transistor **142** is also turned on. This energizes a relay coil **144** which in turn closes a switch **146** in the totalizer stage **50.** Switch **146** is in series with a timing motor **148** and another switch **150.** The latter is controlled by a rotary cam **152** driven by the motor and settable by panel knob **30.** When switches **146** and **150** are closed, motor **148** runs, and simultaneously running lamp **32** is lighted. After a pre-set time, cam **152** opens switch **150** and stops the motor.

Elements of the circuit in FIG. **3** which have not been described in detail will be readily understood by those skilled in the art. The above description is intended in illustration and not in limitation of the invention. Various changes in the embodiment set forth may occur to those skilled in the art.

We claim:

1. An exercise control system adapted for use with means for a person to exercise on, comprising, means for detecting his actual pulse, means for converting the detected pulse rate to a first electrical signal proportional to said detected pulse rate, means for setting and producing a reference electrical signal proportional to a single desired pulse rate, and means for comparing said first electrical signal to said reference signal and for indicating deviation on either the low side or the high side of said desired pulse rate, said comparing and indicating means having no connection to said exercising means.

2. An exercise control system as defined in claim **1** wherein said converting means produces a pulsating signal and includes wave forming and shaping means connected to the output of said detecting means for forming a pulsating square wave whose repetition rate is proportional to the detected pulse rate and means for converting said square wave to said electrical signal, said signal comprising, a d.c. voltage proportional to said detected pulse rate, said setting means being adapted to produce a reference signal comprising a preset reference voltage, said means to indicate deviation including two lamps operatively connected to said comparing means for providing respective light signals proportional to the actual pulse rate, when said d.c. voltage is lower than said reference voltage, and when it is higher than said reference voltage.

3. An exercise control system as defined in claim **2** wherein said indicating means includes a third lamp adapted to produce a light signal when said d.c. voltage matches said reference voltage.

4. The exercise control system as defined in claim **2** in further combination with timing means operatively connected to said comparing and indicating means for actuation thereby when said d.c. voltage matches said reference voltage, including means for indicating the termination of a preselected time period during which said d.c. voltage matches said reference voltage.

5. An exercise control system of the character described including, an electronic transducer to detect a person's pulse rate while exercising and to provide a signal proportional to the pulse rate, said transducer comprising electrode means to sense a person's heart beat, wave forming means to convert the pulse so detected into a repetitive wave whose repetition rate is determined by the frequency of said pulses, and means to convert said repetitive wave into a variable d.c. voltage signal the level of which is proportional to said repetition rate, said system further including comparing means, operatively connected to said means to convert, for comparing said variable d.c. voltage with a predetermined voltage value, and three switch means including "desired," "high," and "low" circuits which respectively control "desired," "high," and "low" indicators, said switch means being operatively connected to said comparing means for selective actuation in response to said comparing means in accordance with whether a said voltage signal is above, below or equal to said predetermined voltage value.

6. The exercise control system in claim **5** wherein said wave forming means includes a Schmitt trigger followed by a bystable multivibrator, and said switch means includes three switch SCR's and a fourth SCR operatively connected with said first three which supplies them with pulsating direct voltage to automatically extinguish any SCR after it is on, said comparing means including means for actuating a particular one of said switch SCR's depending on the ratios of the variable d.c. voltage produced by said means to convert to said predetermined voltage value.

7. An exercise monitoring system comprising, an exercising machine on which a person can exercise at varying levels of exertion, means to detect his pulse rate, and electronic means to convert his pulse rate into light signals proportional to his pulse rate, said electronic means having means for setting a single desired pulse rate and means operatively connected to said setting means and said detecting means for comparing said desired pulse rate with the detected pulse rate and for producing a light signal when said detected pulse rate is at said desired rate, and timing means for indicating that said desired pulse rate has been maintained at the desired level for an indicated time period.

8. An exercise monitoring system as defined in claim **7,** wherein a moving part thereof includes means for stopping said timing means after a settable elapsed time.

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