United States Patent [19]

Dimick

[11] **3,767,195**

[45] **Oct. 23, 1973**

[54] **PROGRAMMED BICYCLE EXERCISER**

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[73] Assignee: **Lifecycle, Inc.,** Concord, Calif.

[22] Filed: **Mar. 3, 1969**

[21] Appl. No.: **803,820**

[52] **U.S. Cl.** .... **272/73,** 73/134, 73/379, 128/2.05 R, 272/DIG. 6

[51] **Int. Cl.** **A63b 21/24**

[58] **Field of Search** 272/73, 69; 73/134, 73/379; 124/2.05

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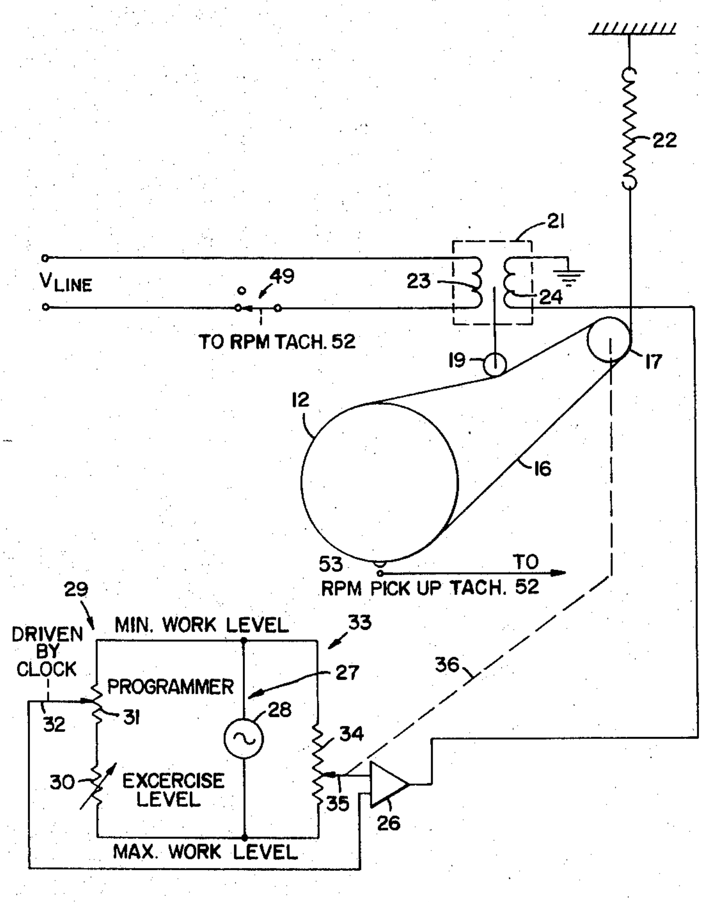
[57] **ABSTRACT**

Exercise apparatus in the form of a stationary bicycle in which the torque load on the pedals is adjusted through a predetermined cycle of operation by a servo motor applying a friction load to a flywheel driven by the pedals. A control loop includes a bridge circuit, coupled to the servo motor, sensitive to the amount of torque presently being applied by the servo motor and the control loop adjusts torque to a reference setting provided by a programming device. This device includes series connected resistors which are scanned by a moving contact coupled to a clock motor to provide for variation of torque load on the pedals.

6 Claims, 7 Drawing Figures



Patented Oct. 23, 1973

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4 Sheets-Sheet 1

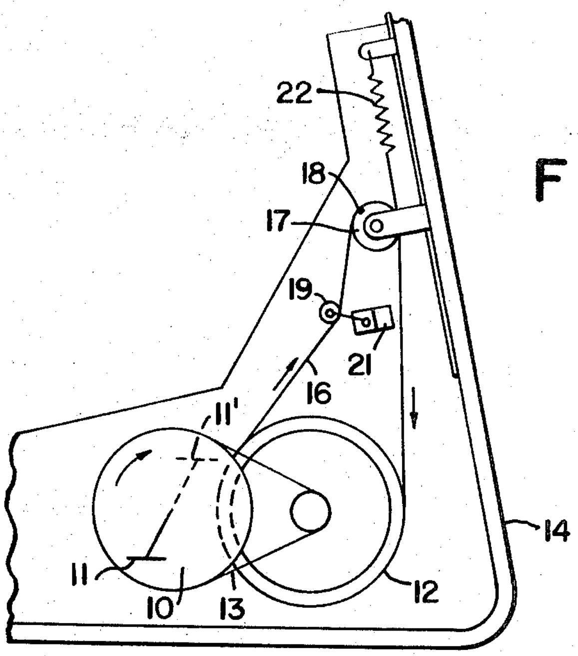

FIG_1

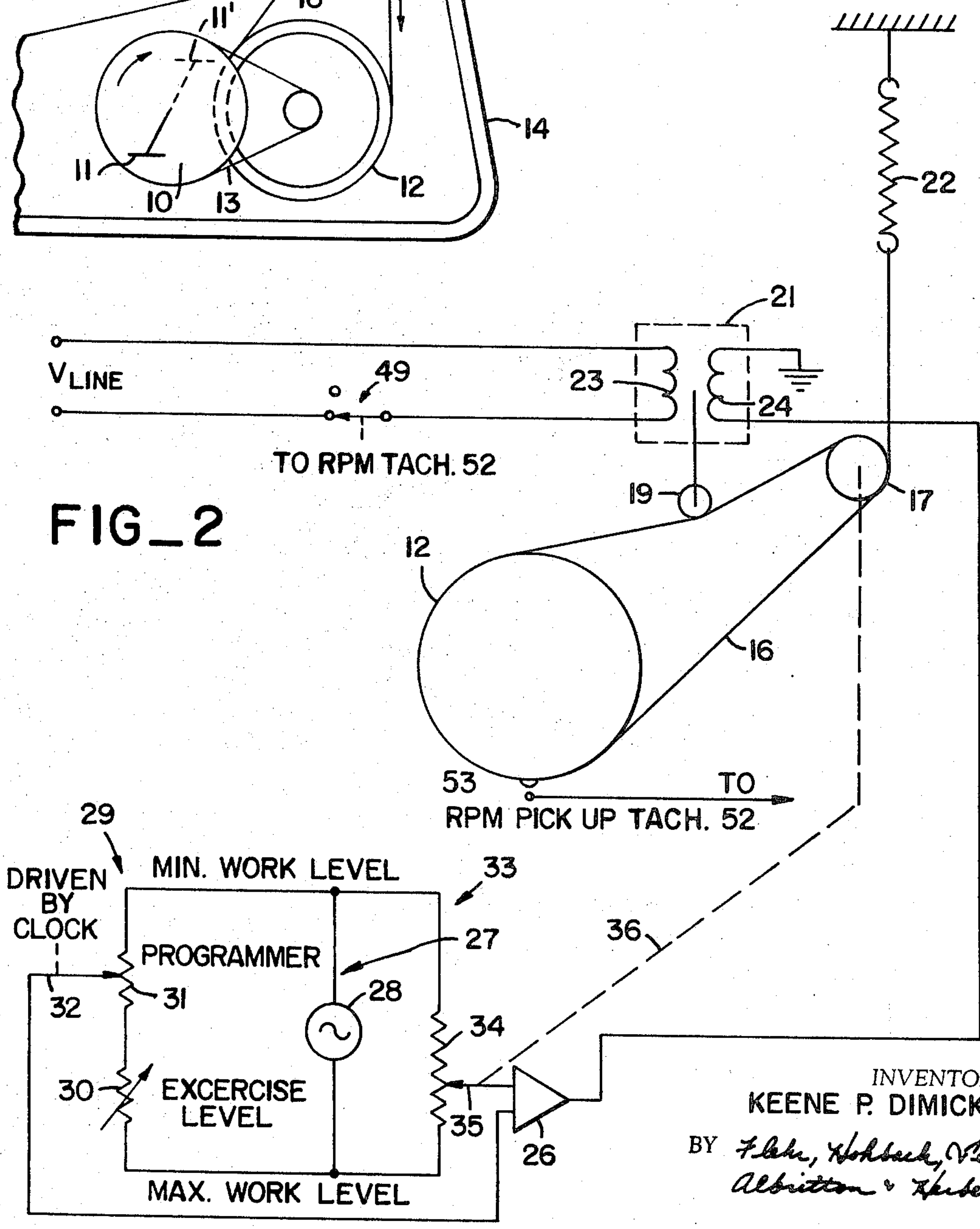

FIG_2

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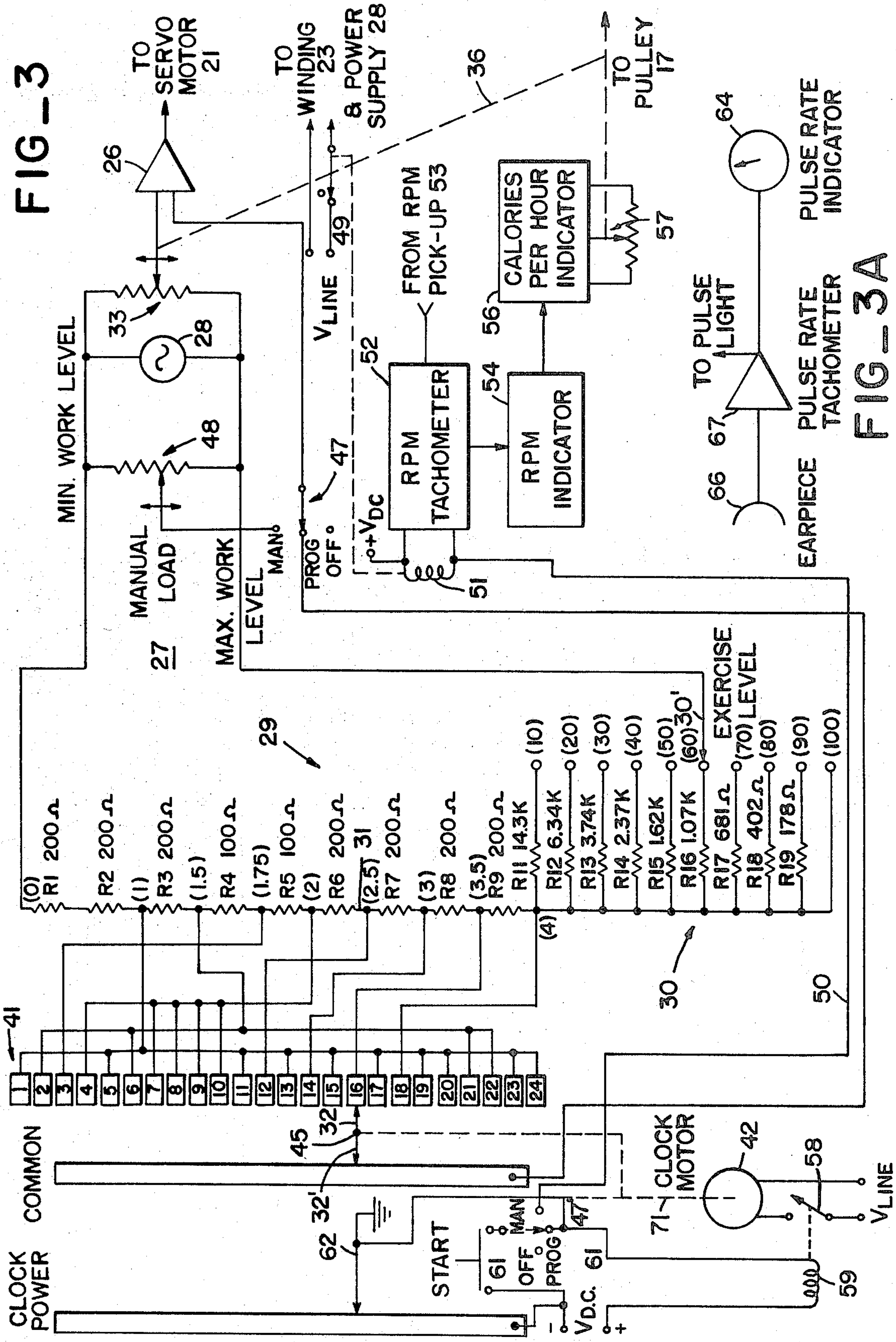
TO SERVO MOTOR 21
TO WINDING 23 & POWER SUPPLY 28
TO PULLEY 17
FROM RPM PICK-UP 53
RPM TACHOMETER
RPM INDICATOR
CALORIES PER HOUR INDICATOR
PULSE RATE INDICATOR
TO PULSE LIGHT
PULSE RATE TACHOMETER
EARPIECE
MIN. WORK LEVEL
MANUAL LOAD
MAX. WORK LEVEL
MAN
PROG
OFF
V_{LINE}
$+V_{DC}$
EXERCISE LEVEL
COMMON
CLOCK POWER
START
CLOCK MOTOR
$V_{D.C.}$
R1 200Ω
R2 200Ω
R3 200Ω
R4 100Ω
R5 100Ω
R6 200Ω
R7 200Ω
R8 200Ω
R9 200Ω
R11 14.3K
R12 6.34K
R13 3.74K
R14 2.37K
R15 1.62K
R16 1.07K
R17 681Ω
R18 402Ω
R19 178Ω

FIG_3

FIG_3A

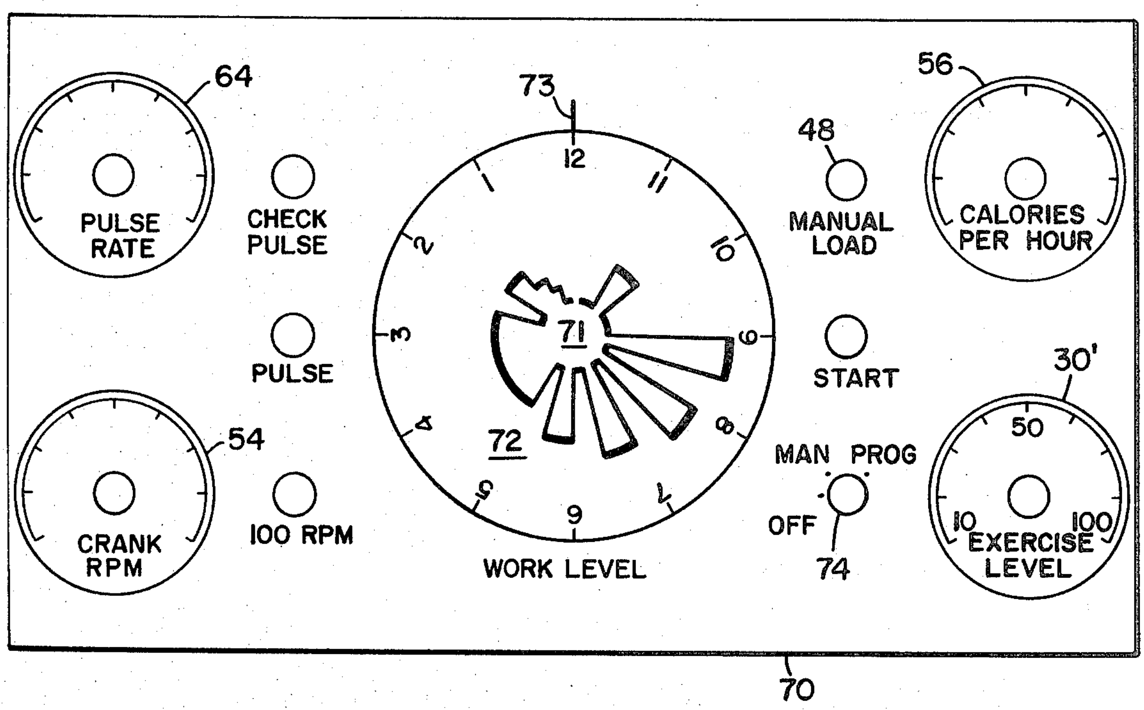

FIG_5

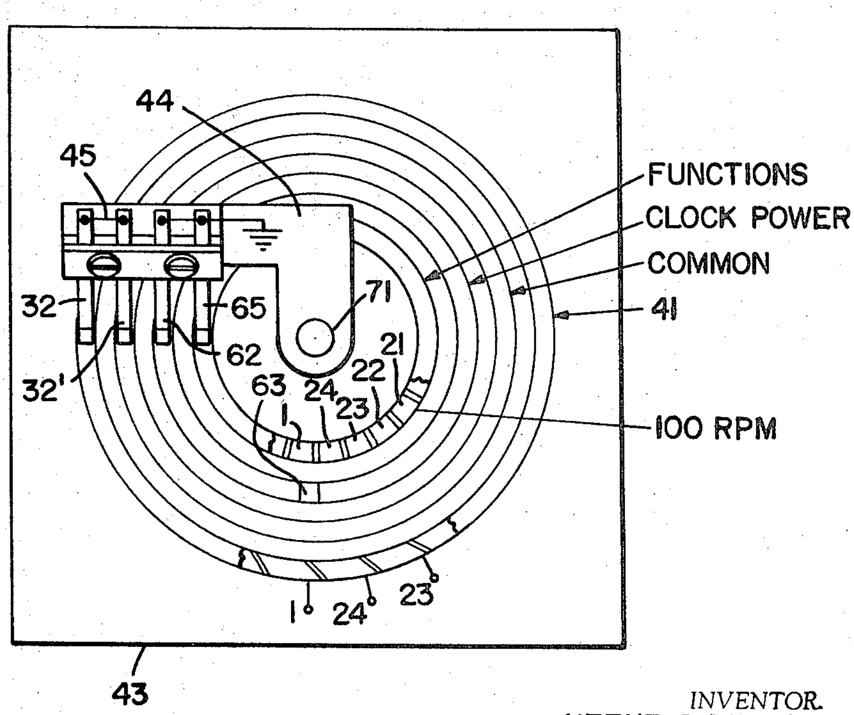

FIG_4

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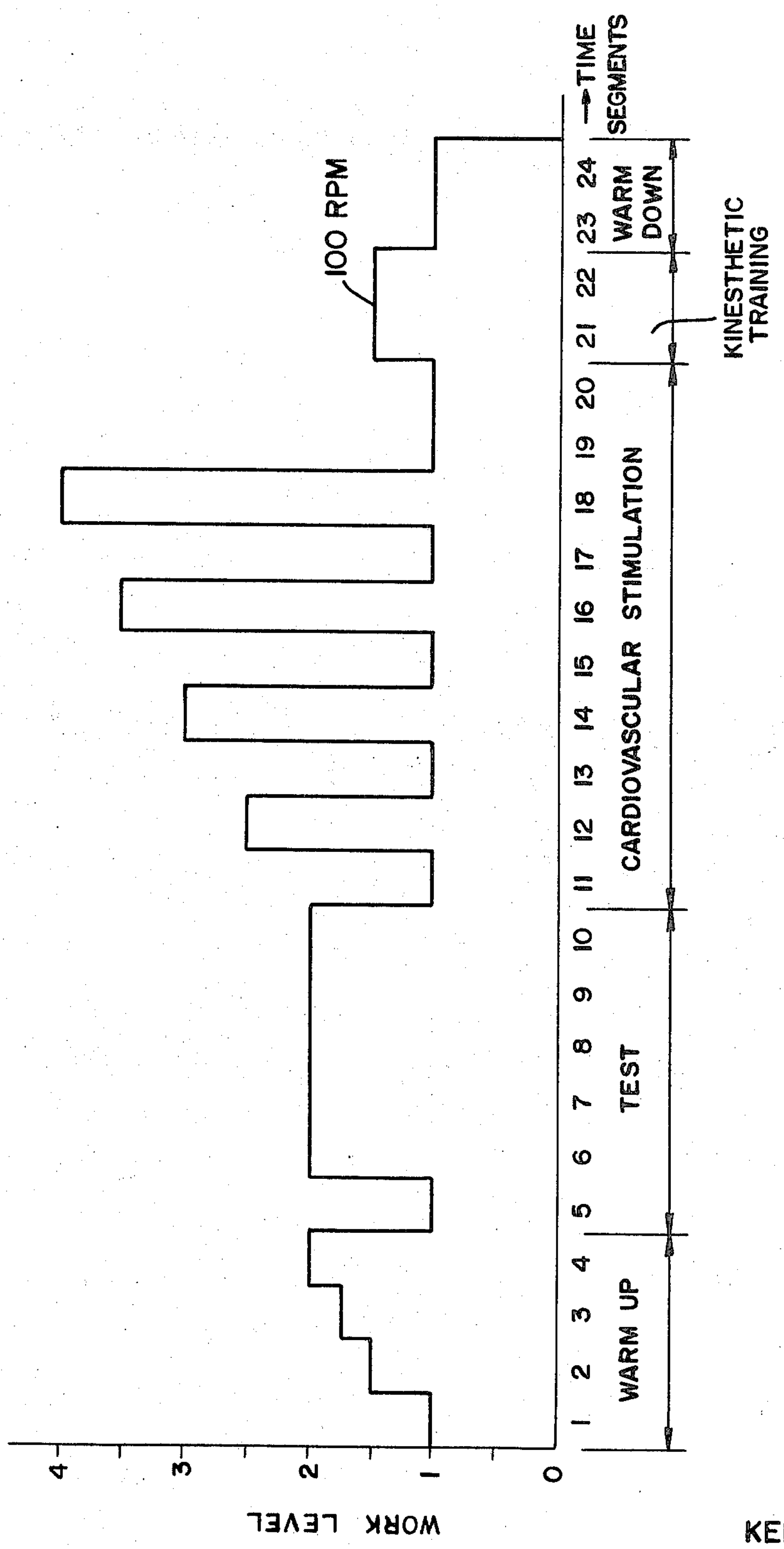

FIG_6

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PROGRAMMED BICYCLE EXERCISER

BACKGROUND OF INVENTION

The present invention is directed in general to exercise apparatus and more specifically to apparatus which automatically provides an optimum exercise period both physiologically and psychologically.

Exercise techniques in the past have been time consuming, boring, inefficient, and many times ineffective. In addition where, for example, a technique such as jogging or running is used, the location and time of day available are often inconvenient. Presently available exercise apparatus does not provide proper motivation to the user and are on the whole ineffective for the average person.

In any exercise program it is desirable to be able to start at a level which will not dangerously exhaust the user and thereafter to accurately measure progress in the program. This, of course, is an important psychological incentive. Present programs and apparatus do not provide a sufficient measure of progress except under laboratory circumstances where, for example, actual oxygen consumption is measured during exertion.

While running or jogging is believed to provide a cumulative improvement in physical fitness which Kenneth H. Cooper in his book *Aerobics*, (M. Evans and Co., 1968) terms the "training effect," it is time consuming and inconvenient, especially in colder areas where outside temperatures make running inadvisable, and may have a low motivational quality for many persons. However, this "training effect" is a desired goal in any exercise program since as stated by Cooper it increases the efficiency of the lungs, increases the efficiency of the heart in that in a conditioned person the heart will pump at a slower rate for the same work or energy output, and the training effect has other beneficial side effects.

OBJECTS AND SUMMARY OF INVENTION

A general object of the present invention is to provide an improved exercise apparatus.

It is another object of the invention to provide an exercise apparatus which provides a scientifically maximum exercise benefit within the minimum amount of time.

It is another object of the invention to provide an improved exercise apparatus which motivates the user to improve his progress.

It is another object of the invention to provide an exercise apparatus as above which is convenient and easy to use both in time and in place.

It is another object of the invention to provide an exercise apparatus which produces the "training effect."

It is another object of the invention to provide an exercise apparatus in which the progress of the user is easily measured.

It is another object of the invention to provide an exercise apparatus where the user's work level can be easily measured whereby the user's maximal oxygen uptake can be calculated.

It is another object of the invention to provide an exercise apparatus which allows the user to maintain an identical work effort from day to day.

It is another object of the invention to provide an exercise apparatus which automatically provides interval training with progressive overload.

In accordance with the above objects there is provided an exercise apparatus to be used by a human being which comprises pedal means adapted for rotation by the human being. The pedal means are loaded with torque load to consume the human being's energy. Means controlling the loading automatically provide a plurality of different successive torque loads in time. Each of such loads is separated by time periods of relatively low torque loads.

From another aspect the invention provides at least three different successive torque loads of increasing magnitude.

BRIEF DESCRIPTION OF A DRAWING

FIG. 1 is an elevation view of an exercise apparatus partially cut away and simplified embodying the present invention;

FIG. 2 is a simplified presentation of FIG. 1 including a circuit schematic;

FIG. 3 is a detailed circuit diagram of the circuit schematic of FIG. 2;

FIG. 3A is a block diagram of apparatus used in conjunction with the present invention;

FIG. 4 is a plan view of a portion of the apparatus of FIG. 3;

FIG. 5 is a plan view of a control panel used in conjunction with the present invention; and

FIG. 6 is a graph useful in understanding the present invention.

DETAILED DESCRIPTION OF INVENTION

Referring now to FIG. 1 there is illustrated an exercise bicycle with only the essential portions shown including a drive sprocket **10** with pedals **11** and **11'**. The sprocket is coupled to a flywheel **12** by a chain **13**. Both the sprocket and flywheel are mounted on a frame **14**. A belt **16** extends around the flywheel and is in the form of a continuous band which is fixed to a pulley **17** mounted on frame **14** at point **18**. A cam **19** rides on belt **16** and is rotated by a loading means **21** mounted on frame **14** to adjust tension in the belt. Pulley **17** is biased in a counter-clockwise direction by a spring **22** having one end mounted to the pulley **17** and the other end to the frame **14**.

In operation the pedals **11** and **11'** are loaded with a torque load by adjusting the tension on belt **16** by means of roller **19** and loading means **21**. The greater the tension applied, the greater friction force present on the surface of flywheel **12**, and thus the greater torque load present at the pedals **11**. Concommitantly the greater friction load on belt **16** causes the belt to tend to turn in the direction shown by the arrows which rotate the pulley **17** in a clockwise direction against the tension of spring **22**. The greater the friction or torque load applied to flywheel **12**, the greater the degree of rotation of pulley **17**. Thus the angular movement or position of pulley **17** is an indication of the amount of torque load on pedals **11**. As thus far described the exercise bicycle shown in FIG. 1 is well known in the art and it is termed an ergometer. Load adjusting device **21** would normally be a mechanical handwheel which is adjusted by the user of the bicycle as he sits on its seat pedalling.

In accordance with the invention there are provided means for controlling the loading means **21** to automatically provide a plurality of different successive torque loads in time. FIG. 2 illustrates such means which includes the elements of FIG. 1 where loading means **21** is illustrated schematically now as a servo-mechanism type motor. Power is coupled to a winding **23** from V_{Line} and a control winding **24** which is coupled to an amplifier **26.** Any output signal from amplifier **26** causes activation of servo motor **21** to move cam **19** until such error signal is eliminated or reduced to substantially zero.

More specifically, the control loop for motor **21** includes a bridge circuit, generally indicated at **27,** which is supplied a relatively low AC voltage by a source **28.** One leg **29** of the bridge includes a programmed resistor **31** (which will be shown in greater detail in FIG. 3) having a moving contact **32** which is driven by a clock motor. In series with resistor **31** is a variable resistance means **30** designated "exercise level." The other leg **33** of the bridge **27** consists of a potentiometer **34** having a moving contact **35** which is coupled by linkage **36** to pulley **17.** As discussed previously, the amount of angular rotation of pulley **17** is a measure of the torque load being applied to flywheel **12.** Linkage **36** senses this rotation and moves moving contact **35** accordingly.

Bridge circuit **27** in operation causes a difference of potential to appear across moving contacts **32** and **35** and thus at the input to amplifier **26** when the moving contacts are not at the same relative locations on their respective resistances **31** and **34.** Of course in the case of resistance **31** the exercise level adjustable resistor **30** would be theoretically included as a part of resistor **31.** Thus the location of moving contact **32** which is independently determined by the clock motor (shown in FIG. 3) acts as a reference to which moving contact **35** must ultimately be moved by the control which includes amplifier **26,** servo-mechanism motor **21,** cam **19** and pulley **17,** and linkage **36.**

As moving contact **32** is moved upwardly toward "minimum work level," contact **35** will necessarily follow to thus cause cam **19** to release much of its pressure on the belt **16.** Thus friction is reduced on flywheel **12** and there is a minimum work load or torque load on the pedals **11** coupled to flywheel **12.** Conversely, movement of the moving contact **32** downwardly toward the "maximum work level" produces a maximum tension in belt **16.**

FIG. 3 is a more detailed diagram of FIG. 2 in which leg **29** of the bridge circuit **27** includes a series string of program resistors **31** designated R1 through R9 and having values as indicated in ohms. The values in parentheses at the junctions of the resistors indicate the relative torque load (or work level assuming a constant rotary speed) the present exercise apparatus is producing when all of the resistors above that particular number in parentheses are in the circuit. Thus, for example, where no resistors are in the circuit the work level would theoretically be (0) as is indicated at the very top of the drawing. The absolute work levels as represented by the resistor string **31** are all proportionately reduced by the exercise level variable resistance or potentiometer means **30** which includes nine selectable resistors R11 through R19, each of which has its value indicated in ohms. At the contact side of each resistor, with which the moving contact **30'** makes connection, there is indicated the relative percentage of the absolute work level which is produced with the exercise level switch in that particular position. Thus where moving contact **30'** is in the 100 percent position there is of course a direct connection to the program resistors **31.** The above absolute work levels (which, of course, represent a 100 percent exercise level) are chosen to provide a reasonable challenge for a well conditioned athlete.

Series resistor string **31** is coupled to moving contact **32** via a series of segmented contacts **41** designated **1** through **24** which are coupled in various combinations to the resistor string **31** to produce work levels as shown in FIG. **6.** The **24** segmented contacts **41** represent the horizontal axis of the graph and the work level in increments **1, 2, 3** and **4** the vertical axis. These work levels correspond to those shown in parentheses on resistor string **31.** Thus, for example, when moving contact **32** is in contact with the segment designated **16,** the work level on the graph is 3.5 and this corresponds to the location of the resistor string **31** to which the segment is connected. The horizontal axis of the graph of FIG. **6** also represents time since moving contact **32** is driven by a clock motor **42** at a predetermined and constant speed. Preferably this speed is one revolution every 12 minutes which means that each time period as shown in FIG. **6** represents 30 seconds.

In order to provide a continuous repeat of the cycle in which the contacts **41** are utilized, such contacts are put in a circular band as best shown in FIG. **4** on an insulating substrate **43.** Each segment is in the form of a parallelogram so that moving contact **32** momentarily (1 second) contacts two adjacent segments at the same time while moving between contacts. This prevents the insertion of an infinite resistance in the circuit which would tend to cause, depending on system load, response, a transient heavy torque. On the other hand, the simultaneous contact of two adjacent contacts is not disturbing even though at this time resistance is reduced (and torque load) due to the effective parallel connection. This is so since, referring to FIG. **6,** a change in load is already occurring during most of the time periods.

A rotary arm **44** is coupled to clock motor **42** and driven at the constant speed mentioned above. Moving contact **32** actually includes a second branch **32',** coupled by connector **45** which makes contact with a "common" band, so labeled in FIGS. **3** and **4.** The "common" band is coupled through switch **47** as shown in FIG. **3** to the input of amplifier **26.** Switch **47** is shown in its "program" position where the moving contact of bridge leg **29** is coupled to amplifier **26** and has an "off" position to disconnect amplifier **26** and a "manual" position where amplifier **26** is coupled to a manual load potentiometer **48** which in essence substitutes for the leg **29** of the bridge **27.** This allows for manual adjustment of the specific work level as an alternative to the automatic programmed adjustment provided by the clock motor **42** and bridge leg **29.**

Relay switch **49** provides for both complete shutdown and the minimum work level. Switch **49** is in series with the power leads to servo motor **23** (see FIG. **2**) bridge power supply is also coupled to V_{Line} (not shown). Switch **49** is normally open until activated into a closed condition by a coil **51** when a predetermined minimum rotary speed is reached. Coil **51** is coupled to a tachometer **52** which receives an indication of the rotary speed of flywheel **12** from a pickup **53** (FIG. **2**). Such a pickup is well known in the art and may include, for example, a reed switch activated by a magnet mounted on flywheel **12.** In addition the tachometer **52** is well known and may include a one shot multivibrator which receives the pulses from the pickup **53** and then integrates such output of the multivibrator to form an analog voltage of a magnitude representative of the speed of the device.

Relay coil **51** closes switch **49** at a predetermined minimum speed to complete the power circuits to bridge **27** and motor **23**. This speed is preferably from 15 to 18 R.P.M. and allows the user of the exercise apparatus to start rotation of the pedals **11** before and load is applied.

Tachometer **52** is coupled to R.P.M. indicator **54** to indicate to the user his actual speed.

To provide an indication of the actual amount of work being done, calories-per hour indicator **56** has an input from R.P.M. indicator **54** and in addition the torque load from pulley **17** which is coupled to a potentiometer circuit **57** by linkage **36**. These two inputs when multiplied together provide an indication of work or energy expended and are easily converted to calories per hour.

Clock motor **42** is energized from a voltage source designated V_{Line} through a switch **58** activated by a relay coil **59**. One side of coil **59** is coupled directly to one terminal of a source of DC voltage, V_{DC}; its other side is coupled to a grounded moving contact **62** which makes contact with a "clock power" band. The negative terminal of the DC voltage source is initially coupled to coil **59** through a start switch **61** and thereafter through the "clock power" band coupled to the moving contact **62**. This is best shown in FIG. **4** where contact **62** is on the "clock power" band which has a gap at **63** to provide an automatic stop after a cycle of operation. Thus the start switch **61** serves to move the rotary arm **44** out of the stop location and thereafter rotation of the arm is maintained to the end of that cycle by the "clock power" band. In actual practice contact **62** is grounded through a shaft **71** on which arm **44** is mounted for rotation.

The negative terminal of the DC voltage supply is also coupled by start switch **61** through a ganged portion **47'** of switch **47** which has similar contacts. Normally with switch **47** in its "PROGRAM" position the circuit is completed to relay coil **59**. However in the "MANUAL" position switch portion **47'** couples, on a lead **50**, the negative DC potential to relay coil **51** when start switch **61** is closed. Switch **49** is closed due to $+V_{DC}$ on the on terminal of coil **51**. If manual load control **48** is now set to a minimum work level the pedals of the exercise apparatus are easily operated to clear any lock in the servo system. Thus switches **47** and **47'** at a manual setting in combination with start switch **61** provide a reset function.

Now referring to FIG. **4** the innermost band designated "functions" is segmented and coupled to ground through a moving contact **65**. Each segment may be coupled to a source of D.C. voltage in the same manner as the "clock power" band. This allows a desired function to be performed at the time at which the segment is scanned; for example the segment labeled 100 R.P.M. turns on a light to indicate that the user of the exercise apparatus should pedal at this speed at this time. The segment labeled "Check Pulse" also turns on an indicating light so that the user may check his pulse at that time in the exercise program. Other function which are not shown could also be accomplished such as turning on a cooling fan, etc.

The exercise apparatus of the present invention also includes as illustrated in FIG. 3A a pulse rate indicator **64** which is coupled to the user of the device by an earpiece **66** which senses the pulse rate in the ear lobe which is processed and amplified by pulse rate tachometer **67** and coupled into indicator **64**. Such devices are well known. A lead labeled "To Pulse Light" extends from the tachometer **67** to an indicator light which flashes at the prevailing pulse rate of the user. Alternative techniques for observing pulse rate which may be used in place of the earpiece are EKG and the finger plethysmographic technique.

All of the indicators and controls of the exercise apparatus of the present invention are placed on a convenient control panel **70** on the apparatus as illustrated in FIG. **5**. Included on the control panel is pulse rate indicator **64**, revolutions per minute or crank RPM indicator **54**, calories per hour indicator **56**, a 100 revolutions per minute light, exercise level control **30'** and a manual load control **48**. "Check Pulse" and "Pulse" light indicators are also on the panel. In addition, to indicate the work level being required by the exercise apparatus, the graph of FIG. **6** is converted to a cutout **72** in polar coordinates and mounted for rotation by the clock motor **42** on shaft **71**. Index mark **73** indicates the present work level depending on what part of cutout **72** is adajcent the index mark. Control knob **74** provides the control functions of off, manual and auto (PROG.) and is coupled to switches **47** and **47'** of FIG. **3**. The start pushbutton is a portion of switch **61**.

OPERATION

The initial use of the exercise apparatus of the present invention should be at a relatively moderate exercise level of perhaps 20 percent of the maximum. Thus, the user would turn the exercise level dial **30'** to the 20 percent level. This is a relatively low level with more typical levels being from 50 percent to 80 percent; a top athlete as discussed above is at the 100 percent level. Switch **74** is turned "automatic" and the start pushbutton pressed. Cutout **72** begins to move and the exercise cycle begins.

Referring specifically now to FIG. **6**, during the warm-up period the torque load begins at the relative level of one and builds up to two over a 2-minute time period which is indicated as exercise periods **1–4**. Speed should be maintained at 80 r.p.m. by observing R.P.M. indicator **34**. After the warm-up period is a rest period, **5** where the work level drops down to a relatively low value to give the user a slight "breather."

The next phase is the test phase as indicated by time periods **5** through **10**. At this time in response to activation of the "Check Pulse" light, the pulse rate should be observed during the **9** to **10** time periods by looking at heart rate indicator **64**. This will be an indication of the progress made in the overall exercise program. If the exercise apparatus of the present invention is used diligently daily, the "training effect" as discussed above will occur which will cause the heart rate to become slightly slower each day or each week during the test period. If the rate drops below a certain value, depending upon the physical condition of the user, then the exercise level should be increased and the program gone through in the same manner as before. In addition the maximal oxygen uptake will increase. This is a well known reference standard of cardiorespiratory fitness usually expressed as milliliters of oxygen per kilogram of body weight multiplied by minutes. During the test period the pulse rate is necessarily increased to balance the amount of work being done. From this information (pulse rate and work) and using weight, age, and sex of the user, it is possible to estimate the maximal oxygen uptake. A method for such estimation is described in an article by Dr. Astrand published in *J. Appl. Physiol.* 7218 (1954) in the form of a series of tables. These tables can be converted to a slide rule format to enable the user of the apparatus of the present invention to easily calculate his maximal oxygen uptake.

The next and most important phase of the exercise cycle are time periods **11** through **20** designated cardiovascular stimulation. This is the portion of the cycle which produces the "training effect" and the concommitant increase in maximal oxygen uptake. What is done here is that the bicycle pedals are programmed so that the user rides over four imaginary hills in time periods **12, 14, 16** and **18,** each hill being higher than the previous hill and requiring in actual practice **30** seconds to climb to the tip. Between each of the relatively high torque loads are rest or "breather" periods designated **13, 15,** and **17** which are at level one. These "breather" intervals also enable the user to regain his oxygen balance if an oxygen debt was incurred on the previous hill. To achieve a proper "training effect" and improvement in maximal oxygen uptake the exercise level should be set so that at least the "top hill" at time period **18** produces some oxygen debt. However there should not be a severe deprivation of oxygen. In addition the hill at time period **16** may produce also some oxygen debt while the lowest hill at time period **12** is low enough (2.5 relative work level) to allow oxygen balance to be maintained. Thus in this manner motivation is also maintained since the initial hill is not overly difficult or impossible for the average user of the exercise device.

Following the last "hill" the work load is again decreased to a low level in time periods **19** and **20.** In time periods **21** and **22** a kinesthetic training is provided where muscles and nerve ends are stimulated by the slightly increased work load. At this time pedal speed is increased to 100 R.P.M. and the "100 RPM" light is illuminated. This increase of speed from 80 to 100 R.P.M. is believed to enhance the kinesthetic training. The last two time periods **23** and **24** are used for the remainder of the warm-down period.

In addition to using the test periods **5–10** to estimate progress, the pulse rate may also be observed at the peak of the hills and recorded if desired. If a record is kept of these readings the pulse rate should decrease as the "training effect" comes about. In addition the pulse rate indicator **64** can be used to limit the exercise level to, for example, a pulse rate below **150** beats per minute depending upon the health and medical advice given the particular person using the exercise apparatus.

Thus the present invention by use of the technique of successive "hills" provides an effective mode of exercise, produces a "training effect" and improvement in maximal oxygen uptake, provides the user with a measure of progress by use of the test periods, and by reason of the automation of the device provides an easily used exercise apparatus.

I claim:

1. Exercise apparatus for use by a human being comprising, pedal means adapted for rotation by said human being, means for loading said pedal means with a torque load including a servo-motor to consume said human being's energy, means for controlling said loading means to automatically provide at least three different successive torque loads of sequentially increasing magnitude, such controlling means forming a control loop and including electrical bridge means having two legs, one leg having first potentiometer means programmed to provide three reference voltages corresponding to said torque loads, the other leg having second potentiometer means coupled to said loading means and responsive to said torque load to produce a feedback voltage proportional thereto, said bridge combining said feed-back and reference voltages to produce an error signal, means for coupling said error signal to said servo-motor whereby said torque load on said pedal means is automatically controlled; and means included in said first leg for varying said reference voltage for concurrently varying said three torque loads by the same proportion.

2. Exercise apparatus for use by a human being comprising, pedal means adapted for rotation by said human being, means for loading said pedal means with a torque load to consume said human being's energy, means for controlling said loading means to automatically provide at least three different successive torque loads of sequentially increasing magnitude, said means for controlling said loading means including an electrical bridge having two legs one leg having first potentiometer means having a first output terminal with a predetermined voltage thereon and the other leg having second potentiometer means having a second output terminal with a voltage thereon determined by said torque load, said first potentiometer means including a series string of resistors coupled to segmented contacts to provide said different loads and in which said first output terminal is a moving contact scanning said segmented contacts to vary said torque load.

3. Exercise apparatus as in claim **2** together with means for concurrently varying said three torque loads by the same proportion, such means including potentiometer means in series with said string of resistors.

4. Exercise apparatus as in claim **2** in which said segmented contacts are arranged in a circular configuration to provide cyclical operation of said means for controlling said loading means.

5. Exercise apparatus as in claim **2** in which said segmented contacts are in the form of parallelograms so that said moving contact is in simultaneous contact with adjacent segmented contacts during movement between contacts.

6. Exercise apparatus for use by a human being comprising, pedal means adapted for rotation by said human being, means for loading said pedal means with a torque load to consume said human being's energy, means for controlling said loading means to automatically provide at least three different successive torque loads of sequentially increasing magnitude, and for providing a fourth torque load at a predetermined time after said three loads of a magnitude lower than any of said three loads, means for sensing the rotary speed of said pedal means, means for indicating such rotary speed whereby said pedal means may be rotated at a first constant speed with said three different torque loads, indicating means responsive to said means for controlling said loading means for indicating a desired change to a higher second constant speed when said fourth torque load is provided.

* * * * *