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
FIG_6
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 exercise.

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 24 mounted on frame 14 to adjust tension in the belt. Pulley 17 is biased in a counterclockwise 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. Concomitantly 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 in-
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 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 upward 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 "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 introduction 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.

A 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 multi-
vibrator 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 $V_{AC}$ 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 adjacent 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 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, 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 concomitant increase in maximal oxygen uptake. What is done here is that the bicycle pedals are programmed so that the load 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 top. 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 feedback and reference voltages to produce an error signal, means for coupling said error signal to said servo-motor whereby said torque load on said said 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 said 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.