United States Patent

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[54] **FRICTONAL TYPE EXERCISING DEVICE**
6 Claims, 19 Drawing Figs.

[52] U.S. Cl. **272/79R,** 73/351R, 73/379R, 272/DIG. 3, 272/DIG. 5, 272/DIG. 1, 280/252
[51] Int. Cl. **A63b 23/02,** A63b 23/04
[50] Field of Search .... 272/79, 80, 83, 82, 81, 72, 57, (DIG.) 3, (DIG.) 5, 57 (D), (DIG.) 1; 73/381 (R), 379 (R)

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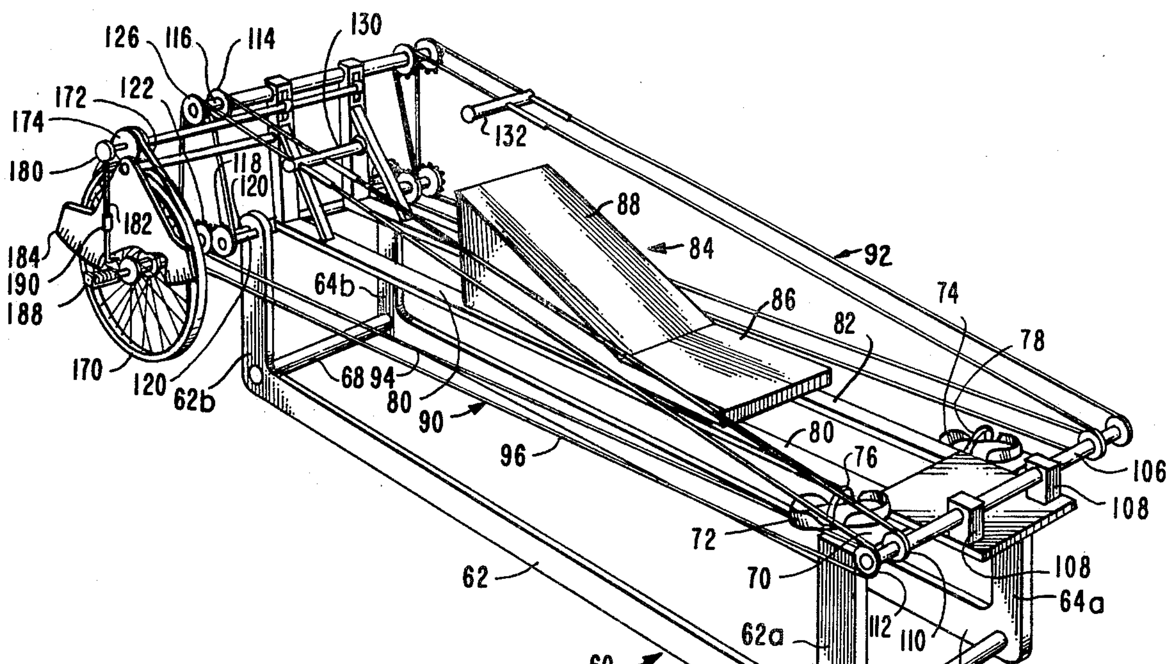
ABSTRACT: Exercising device providing time-distributed, continuously varying uses of a high proportion of body muscle masses, through individual exercise cycles employing bidirectional operation against a resistance between fully flexed and fully extended positions of the subject. Arm and body travel against the resistance successively involves agonist and antagonist musculature, the work output rate or total work output being measurable. Programs of exercises employing selected work rates and work quantities provide total body conditioning without undue strain or tendency to loss of motivation.



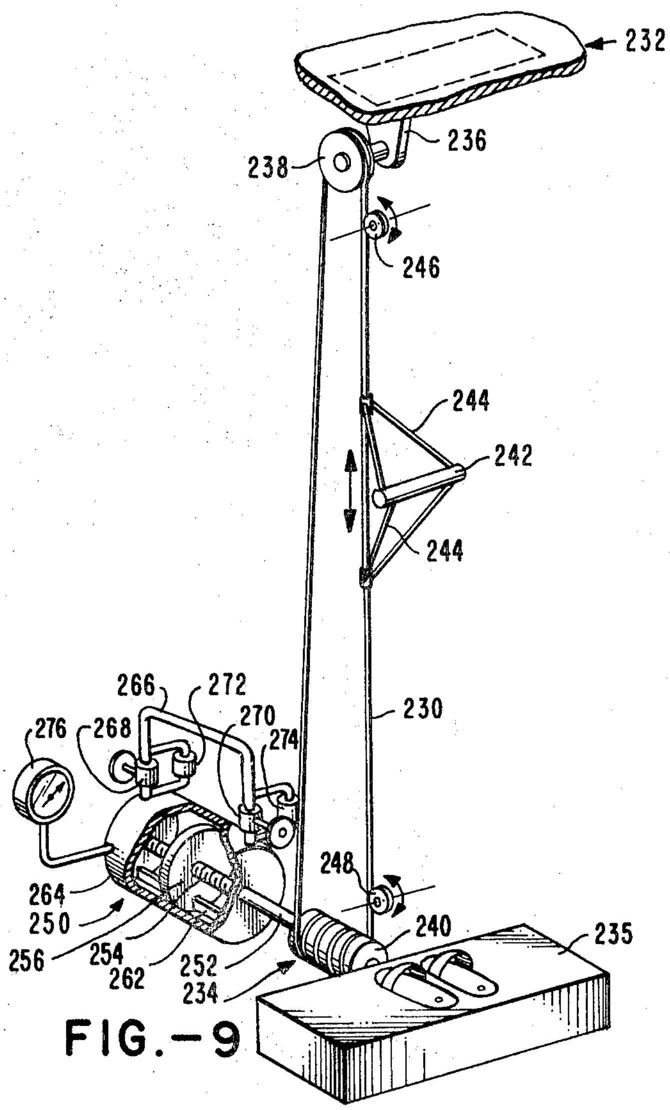


FIG.-9

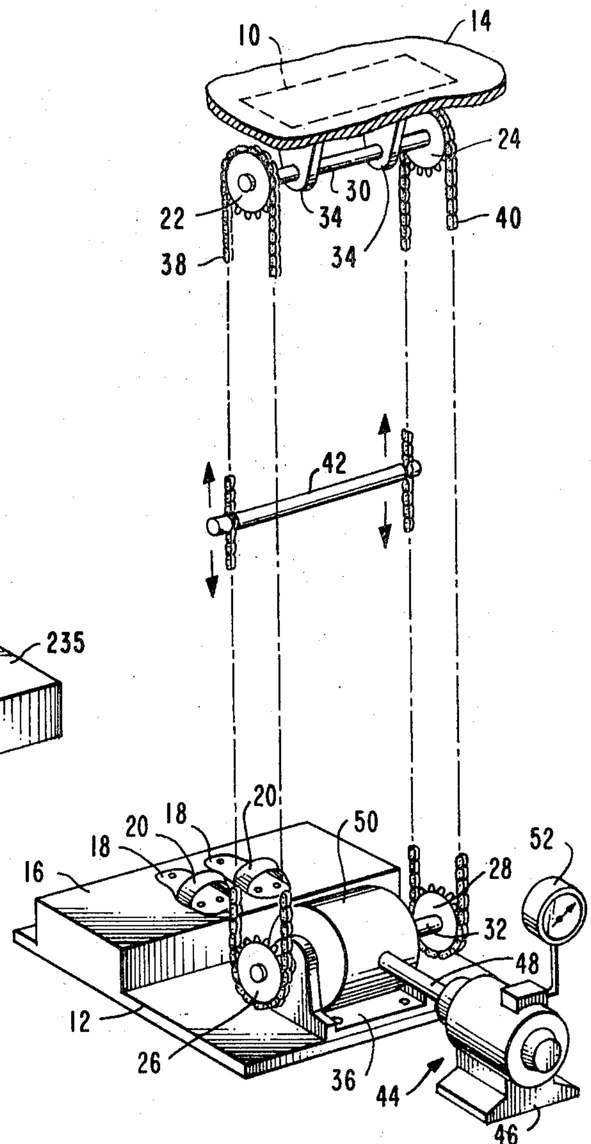


FIG.-1

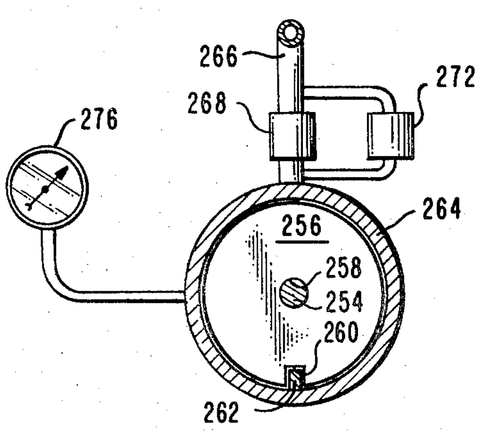


FIG.-10

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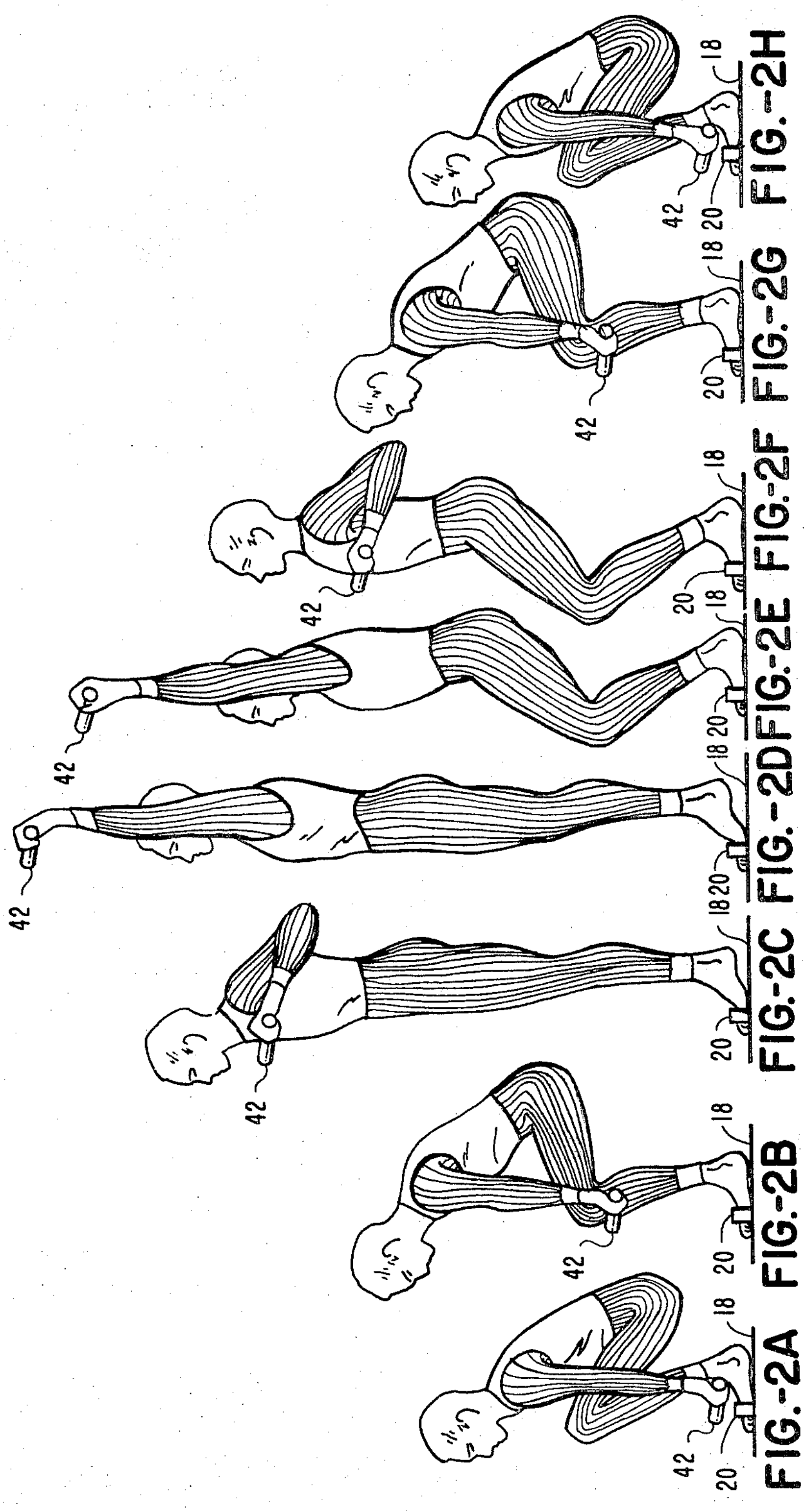

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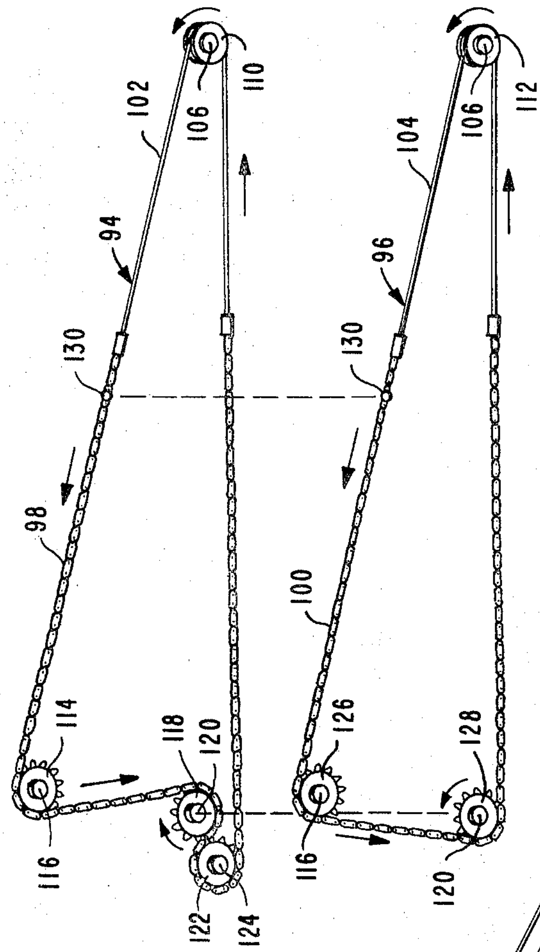

FIG. — 4

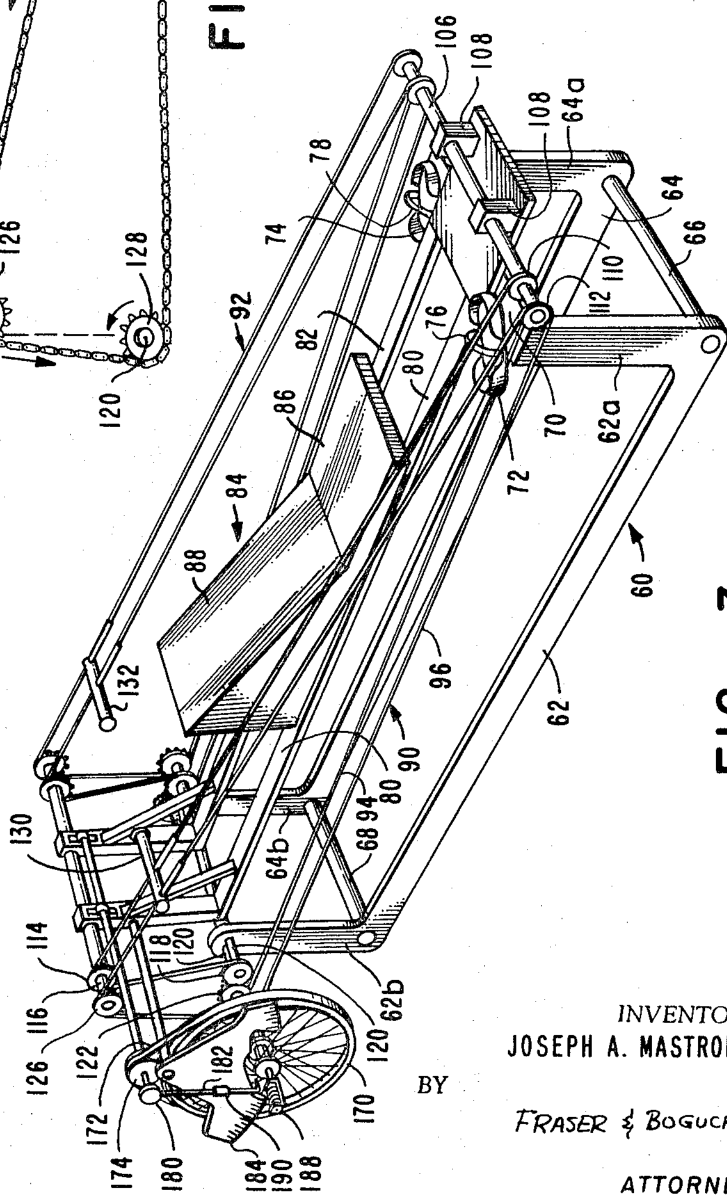

FIG. — 3

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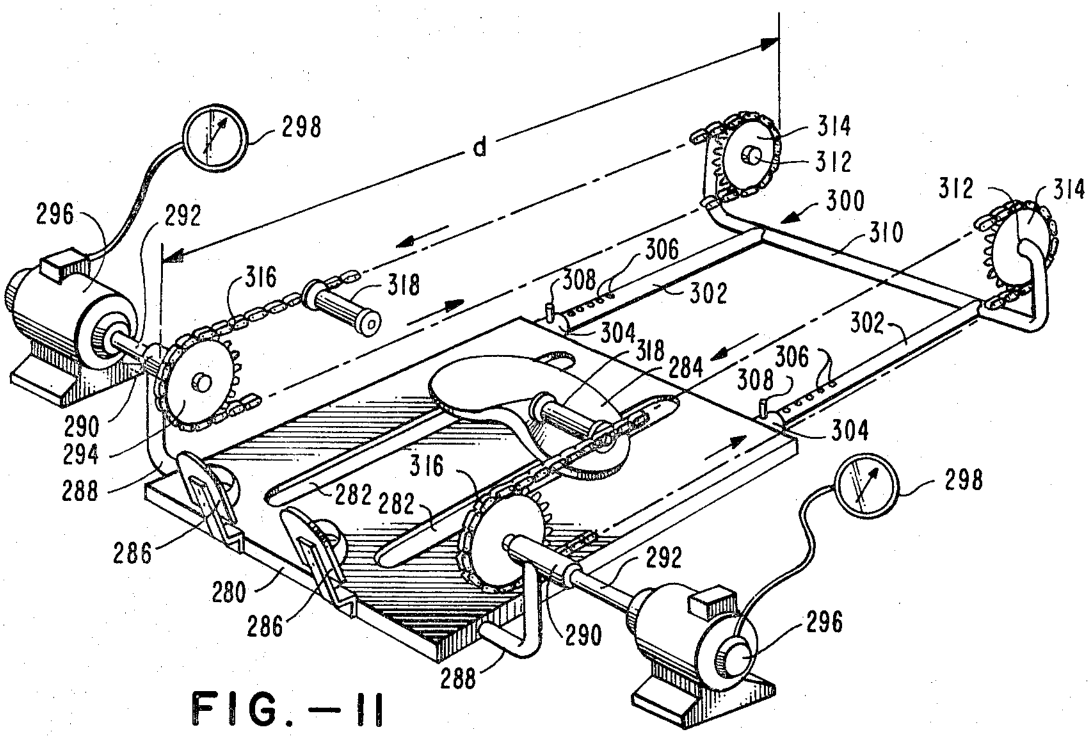
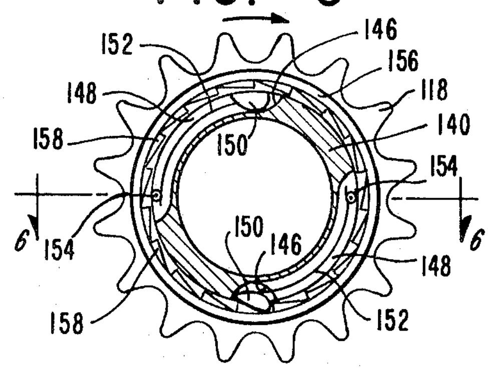


FIG.—11

FIG.—5



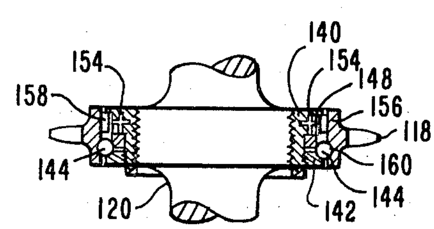


FIG.—6

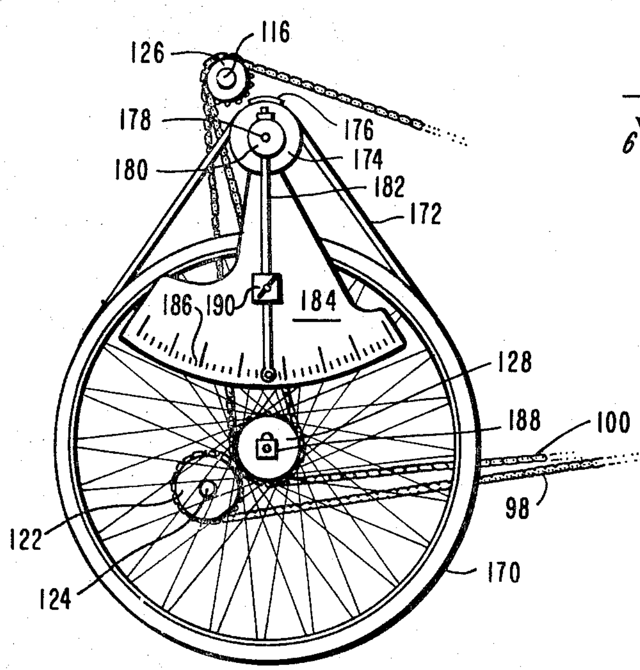


FIG.—7

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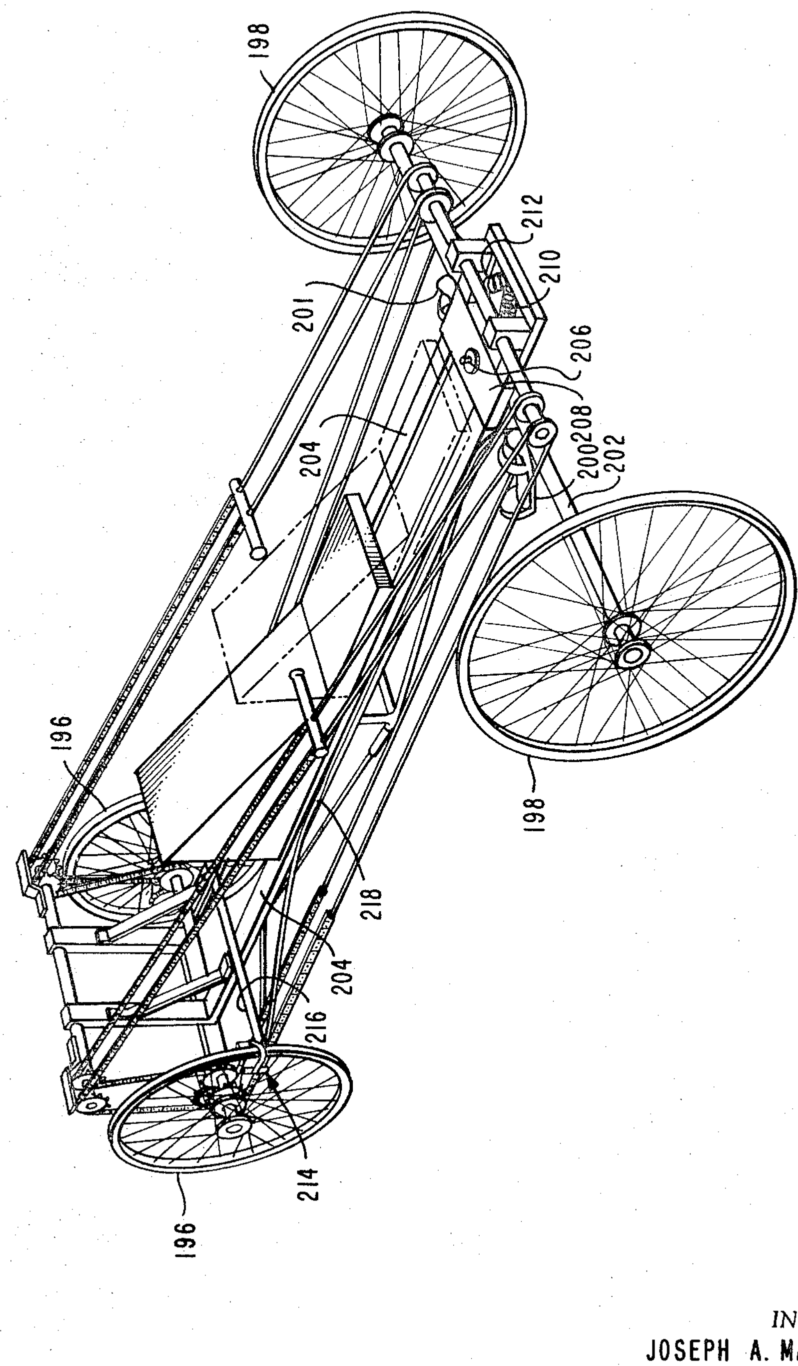

FIG. — 8

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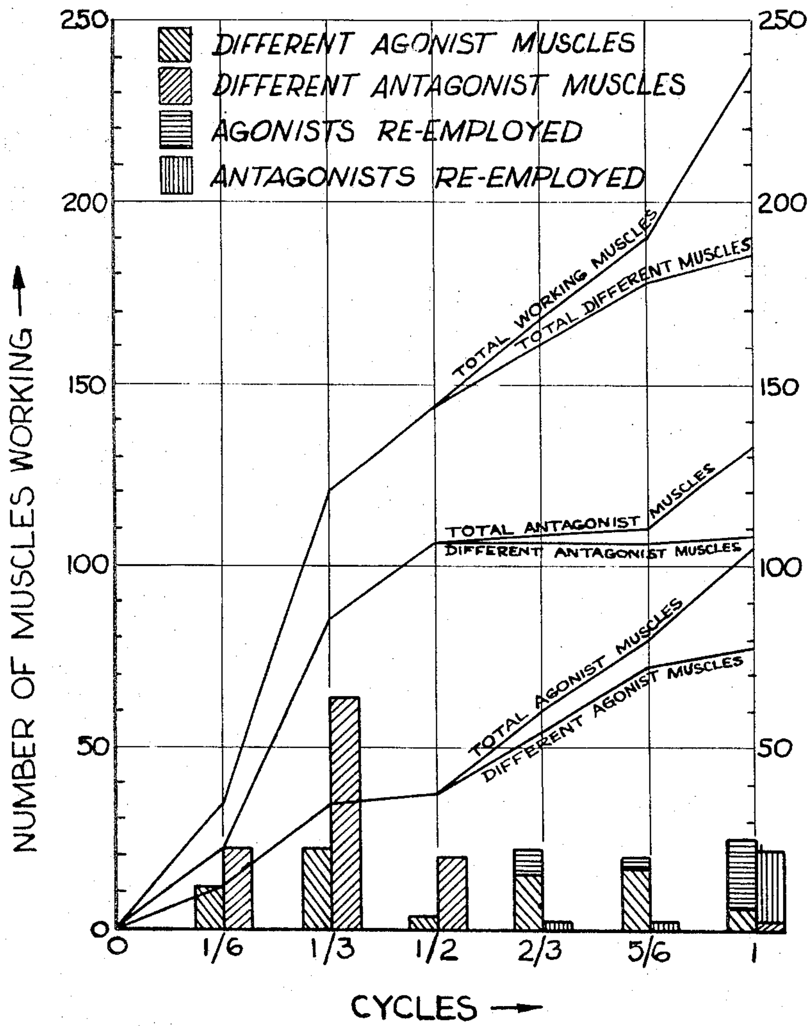

FIG. 12

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FRICTONAL TYPE EXERCISING DEVICE

Background of the Invention

This invention relates generally to apparatus for physiological conditioning and particularly to apparatus for conditioning significantly large muscle masses more efficiently than heretofore possible.

There is currently increased emphasis on physical conditioning, especially in view of growing evidence that "deconditioning" resulting, for example, from the sedentary nature of work engaged within technologically advanced societies, has deleterious effects on the cardiovascular, respiratory and musculo-skeletal systems. Further, it has been recognized for some time that the consequences of inadequate exercise to the national health are significant. More recently, with the advent of space flight and encounters with weightless environments, the problem of crew deconditioning has been the subject of intensive study and investigation.

For any program of exercise, the kinds of muscles exercised as well as the quantity are important. For example, an arm exercise should involve the biceps, an agonist muscle, as well as the triceps, the antagonist muscle. The human structure requires muscular balance not only to function well but for uniform overall development.

Although exercise in any reasonable quantity is often considered beneficial, it is well established that a regular exercise program is most desirable. This is essential not only to maintain a given state of the musculature but more importantly to increase one's ability to accomplish tasks, without untoward effects, that require greater development that is realized or appreciated.

There is a general tendency among adults to allow muscular degradation of degeneration to take place through the failure of proper exercise. Often, even where certain occupations require some form of physical exertion, it is quite limited in scope and involves only a relatively small percentage of total body musculature. For these reasons, many adults find it difficult to perform intermittent leisure work tasks or engage in physical recreation without some degree of bodily discomfort or even risk of injury.

Despite general insistence on the need for physical fitness, the classes of individuals most in need of exercise lack sufficient motivation to expend the required time and effort. Even the motivated person is, however, required to engage in a variety of sports or exercises or use several types of exercising apparatus to achieve the desired kinds and amounts of muscle exercise. Loss of motivation under these circumstances often occurs when a good state of health is enjoyed and there is no immediate need for regular exercise.

Persons who are physically handicapped by loss or restricted use of some portion of their musculature and who require some form of conditioning therapy usually engage in an exercise for strengthening the injured portion of the body. General exercise for the remainder of their muscular system, however, is often neglected or at least limited, resulting in failure of uniform conditioning and development.

It is well established, from a physiological conditioning standpoint, that the greater the number of muscle masses involved in an exercise the more beneficial the exercise is to the overall body musculature improvement and development. Total physical fitness requires the employment of the greatest skeletal muscle mass in heavy endurance exercise. In order to involve great masses of musculature, the major body segments, and the agonists and antagonists (e.g., flexors and extensors) in these segments, must be involved vigorously in the exercise. The work load must be heavy to improve strength and continuous to improve the cardiovascular and respiratory systems. The greater the muscle mass over which the work is spread, the less the strain and fatigue per unit of muscle and the greater the ultimate level of work and fitness achievable. Further, the greater the muscle mass involved and the greater the level of work, the greater will be the development and the fitness of the systems carrying oxygen to the muscles. Thus, in this approach to total fitness, the aim is to effect the highest fitness in the greatest number of cells directly and indirectly involved in the exercise. The benefits of a program of this type are apparent not only aesthetically but practically, in giving the individual a greater freedom to participate in a broader variety of physical activities with much less danger of bodily injury.

Many types of exercise have been suggested for improvement of body musculature which do not involve the use of exercise equipment or devices. Although beneficial, such exercises should be engaged in with care or professional advice in order to prevent injury as a result of overtaxing underdeveloped muscles. Also, a variety of different exercises are needed to involve a sufficiently large proportion of musculature and the benefits are accompanied by proportionately greater tedium and tendency to lose motivation. No continually observable measurement of improvement is available, except for increasing the number and difficulty of repetitions, and even carefully advised exercise programs often fail as the individual eventually becomes bored.

Many varieties of exercising and conditioning apparatus have been devices in the past. Such devices are not only beneficial from a physiological standpoint, but act to stimulate the user's interest. The exercise equipment now widely used includes cycling devices, rowing and cranking machines of various kinds, isometric tension mechanisms and treadmills. Each of these types of equipment has certain disadvantages and limitations, and in particular each exercises only relatively small numbers of body muscle masses. For example, bicycling employs only 10 antagonist muscles in each leg for a total of 20 antagonist muscles, and has a relatively short power stroke of about 12 inches. As another example, rowing exercisers involve only about 74 muscles at most. In another exercising device, combining cycling and cranking movements, 72 antagonist muscles are utilized in each arm, which together with the extensor muscles of the legs, provides exercise for a total of 64 antagonist muscles.

Other exercise devices such as barbells and weighted pulley systems exercise only 34 agonist and 100 antagonist muscles. Considering that there are about 131 major agonist muscles and 137 major antagonist muscles in the human body, it is evident that these devices by themselves fail to exercise large masses of agonist musculature. In addition, as a result of their design, these devices generally do not provide proper cardiopulmonary development because the antagonist musculature employed to lift the weight must stay contracted to keep the weight up and to let the weight down thereby interferring with circulation and respiration to muscles. This leads to ischemic fatigue of the musculature involved, attending discomfort and lack of motivation, and an inherent inability of these muscles to perform continuously.

Thus, to involve substantially all of the skeletal muscles in properly timed contraction and relaxation cycles, a person would have to engage in many different types of monodirectional exercises of comparatively light loads. Where the amount of room is limited, such as that in a home or within a space vehicle, a number of exercisers cannot be accommodated. It would be most desirable to have a single, compact and preferably portable exercising device which would exercise a relatively large amount of the body musculature.

Summary of the Invention

The present invention for the first time provides a physical fitness apparatus having the capability of exercising substantially all of the skeletal musculature of the human body as a single dynamic system. The apparatus employs a movement pattern which, besides affecting virtually all skeletal muscles, places essentially equal emphasis on agonist muscles and antagonist muscles. The present invention permits specialized muscle development without change of the equipment. The total work output can be monitored and work rate as well as total work can be selected. In addition, the subject can shift to other exercises as fatigue occurs so as to maintain physiologic functions at the same rate. These factors greatly enhance motivation by permitting substantial variety to be observed within a consistent development program.

Broadly, the apparatus of the present invention includes a frame or support means provided at one end with feet restraint means. A load means or force resistance device is mounted on the frame means and operated continuously by a drive mechanism reciprocated by the subject. The apparatus may be oriented vertically, horizontally, or at any intermediate tilt angle, and may include a slidable body support carriage. The drive mechanism is arranged so that a handgrip is movable through a span substantially equal to or greater than that which can be covered by the subject.

In using one specific form of apparatus of the present invention for maximum muscular exercise, the feet are secured in the restraint means and the subject grasps the handgrip on the drive mechanism. The handgrip of the drive mechanism is then reciprocated between alternate extremes of movement, against the force resistance device in each direction of movement.

By providing both pushing and pulling strokes in succession, both agonist and antagonist muscles are equally exercised. Movement begins with the slow, strong muscles and links to weaker, faster muscles at zero acceleration and maximum velocity. During the first half of the stroke cycle, 106 different antagonist muscles and 38 agonist muscles take part in principally extension type movements. During the second half of the stroke cycle, 68 different agonist muscles and 26 different antagonist muscles take part in mainly flexion movements. For the entire power cycle, 186 different agonist and antagonist muscles take part once and 52 of these are involved twice in both flexion and extension movements.

The load means or force resistance device against which the subject works in the present apparatus may comprise any of a variety of mechanisms such as frictionally retarded wheels, electrical generators or dynamometers or hydraulic energy dissipators. The inclusion of an ergometer device for measuring work is generally preferred, and another feature of the invention resides in the fact that the resultant measurement may be used for physiological testing and a consistent development program.

Other aspects of the invention relate to improved, manually-driven vehicles employing actuating force distributing systems in accordance with the invention. Through utilization of input force from many muscle masses, a vehicle may be manually powered at higher speeds or for longer distances than heretofore.

Brief Description of the Drawings

A better understanding of the invention may be had by reference to the following description taken in conjunction with the accompanying drawings in which:

FIG. 1 is a perspective view of a vertical exerciser in accordance with the invention;

FIGS. 2A—2H are simplified representations of a subject during one complete cycle of exercising on the apparatus of the invention;

FIG. 3 is a perspective view of a stationary, horizontal exerciser in accordance with the invention including a pendulum ergometer for measuring work output;

FIG. 4 is a fragmentary, partially schematic, side elevation view of a portion of drive apparatus employed in the exerciser of FIG. 3;

FIG. 5 is a side elevation view, in section, of a unidirectional drive unit which may be utilized in the exerciser of FIG. 3;

FIG. 6 is a front elevation view, in section, of the unit of FIG. 5 along the plane 6—6;

FIG. 7 is an enlarged, side elevation view of the pendulum ergometer of the apparatus of FIG. 3;

FIG. 8 is a perspective view of a land vehicle in accordance with the invention;

FIG. 9 is a perspective view of a vertical exerciser in accordance with an alternative embodiment of the invention utilizing a hydraulic ergometer for measuring work output;

FIG. 10 is a front elevation view, in section, of the hydraulic ergometer depicted in FIG. 9;

FIG. 11 is a perspective view of a horizontal exerciser in accordance with another alternative embodiment of the invention; and

FIG. 12 is a kinesiologic analysis, in graphical form, showing the number of muscles working during various portions of one exercise cycle.

Detailed Description of the Invention

Referring to FIG. 1, there is shown a vertically disposed and particularly compact and simplified form of an exerciser in accordance with the invention wherein the support means comprises a plate 10 at the upper or head end of the apparatus and a base member 12 at the lower or foot end. The plate 10 may be attached to or suspended from a ceiling 14 or other structural supporting member. At the foot end of the exerciser is a foot tethering plate 16 having feet resting positions 18, each position 18 having a foot-restraining strap 20.

Positioned at the head and foot ends of the exerciser are pairs of sprocket wheels 22, 24 and 26,28, respectively, interconnected by upper and lower shafts 30 and 32. The shafts 30 and 32 are carried by brackets 34 and 36, respectively, suitably fastened to the ceiling 14 and base 12. Connecting the sprocket wheels 22 and 26 is an endless roller chain 38; similarly, the sprocket wheels 24 and 28 are connected by an endless roller chain 40. A handgrip 42, extending transversely between the chains and attached thereto on the side adjacent the foot resting positions 18, provides a gripping means for the subject whereby the chains may be vertically reciprocated in accordance with the exercise cycle to be described. The handgrip 42, shown in FIG. 1 as a single bar may instead consist of two independent hand grips, one being secured to each chain.

The distance between the two sprocket chains 38 and 40 is such that the subject can comfortably hold the handgrip 42 with hands and arms spread apart in a normal fashion in a position approximating the width of the upper portion of the subject's body. It is evident that where a single handgrip 42 is utilized, the hands can then be placed closer or further apart as desired throughout the exercise. For most efficient exercise of the arm musculature, it is preferred to have the hands positioned somewhat further apart than the width of the subject's body.

As an alternative to the sprocket and roller chain drive depicted in FIG. 1, any continuous drive media, including belts, cables, or similar means, cooperating in a substantially nonslip fashion with appropriate pulleys or the like in place of the sprocket wheels, may be utilized. A chain drive is preferred, however, because there is no slippage and no initial tensioning is required. Further, as is well-known, torque applied to such a drive through the handgrip, tending to twist the chain, is inherently resisted by the links and link pins forming the chain.

At the foot end of the exerciser of FIG. 1, attached to the base plate 12, is a bidirectional load means connected to be driven by the shaft 32 whereby any up or down movement of the handgrip 42 is resisted by the load. In the embodiment of FIG. 1, the load means comprises an electric dynamometer 44 consisting of a generator 46 connected by a shaft 48 to a transmission 50. The transmission 50 has suitable gearing for transmitting the force applied to the handgrip 42 to the generator shaft via the chains 38 and 40 and the sprocket wheels 26 and 28. Connected to the generator 46 is a meter 52 for indicating the work being done by the subject.

The transmission 50 may be of any suitable type for converting the bidirectional, reciprocating motion of the shaft 32 into unidirectional motion of the generator shaft 48. For example, ratchet and pawl means which are directionally opposed may be incorporated in the transmission 50 so that when the handgrip 42 is moved in either direction, one of the ratchet and pawl means is engaged to drive the generator 46 in a single direction.

The specific load means used may consist of any of a number of devices, including the mechanical and hydraulic load components which will be described later in connection with alternative embodiments. In any event, it is preferred that the load can be varied and that the load can be measured in some manner. Consequently, the exerciser can be tailored to individuals having different physical capacities and the work output from the exercise can be monitored. The load variation is particularly useful in a program for increasing a subject's musculature capabilities. The variable load in combination with a work output reading device provides a substantially complete understanding of the state of muscle development and conditioning of a given subject inasmuch as rates and capacities can be defined. These can then be used in conjunction with medical and physiological considerations to define a realistic improvement program.

A subject exercises in accordance with the invention. Individual cycles are defined by the succession of positions shown in FIGS. 2A through 2H, it being understood that reasonably continuous movements are ordinarily employed.

FIG. 2A shows the starting position which will be designated as the fully flexed position, in which the subject is in a crouched position with his feet spread apart and held in the foot restraining devices 18 and 20, his arms extended and his hands gripping the handgrip 42 in the vicinity of the feet. The arms are extended substantially fully downwardly with the elbows almost rigid and the back straight but leaning slightly forward. As shown in FIG. 2B, the subject then begins to work against the load means via the handgrip 42 by pulling the buttocks upwardly with the leg musculature while maintaining the arms straight and extended downwardly with the back also held straight. In this segment of the exercise cycle, the antagonists of the foot, lower leg and upper leg and the agonist muscles of the hand and lower arm are exercised. The extension from the fully flexed position may be carried out in different fashion (e.g., pulling up the arms first) but the same muscle masses are called into play during this part of the cycle nonetheless. As the subject continues to straighten his legs, movement against the resistance is transferred partially to the arm and back muscles until he reaches the full leg extension of standing position shown in FIG. 2C in which the handgrip 42 is located high on the chest at approximately the level of the shoulders. To attain this position of the exercise, the agonists of the upper leg, the lower arm and the upper arm, and the antagonists of the upper leg, hip and back are being exerted. The transitions between the uses of the various muscle masses are smooth and overlap in that some muscle masses are, at least for a time, used concurrently.

Thereafter, the subject continues to raise his hands and arms against the resistance until the arms are at the highest possible position over the subject's head with the arms fully extended upwardly and the feet arched, as shown in FIG. 2D. This position will be referred to as the full extension length or span of the subject. This position of the exercise requires the use of antagonist muscle masses of the hand, lower arm, upper arm, back, and agonists of the shoulder girdle. At this point the arms have changed substantially 180° in direction from the initial position of FIG. 2A. Then, with the arms remaining fully extended, the subject begins the downward movement against the load resistance by bending the knees as shown in FIG. 2E with the feel flattened thereby exercising agonist muscles of the feet, lower leg and upper leg. Once the knees are somewhat bent as shown in FIG. 2E the subject then pulls downwardly with the arms as shown in FIG. 2F thereby requiring the exercise of the agonist muscles of the hand, lower arm, upper arm and shoulder.

Continuing the exercise, the hands are moved downwardly so that the arms return to the fully downwardly extended position, and at approximately the same time the buttocks are lowered by utilizing the agonist muscles of the upper leg, hips, head, chest and abdomen, respectively. When the arms are in the fully downwardly extended position as shown in FIG. 2G, by the action of the antagonist muscles of the lower arm, and the agonists and antagonists of the upper arm and shoulder girdle, the legs are flexed against the resistance until the subject returns to the position shown in FIG. 2H which corresponds to the starting position of FIG. 2A. A full cycle is thereby completed, the span between the fully flexed position and fully extended position having opened and closed, with an amount of work having been performed that is determined by the span of movement and the resistive force. The extent of exertion is determined additionally by the rate at which the cycle is carried out, and the capacity of the given subject to overcome the resistance. An exercise sequence consists of a series of successive exercise cycles carried out in a programmed manner whereby the work output potential of the subject may be determined.

Additionally, in accordance with the invention, complete total body conditioning methods are provided by relating cycle sequences to physiological capacities and needs of a subject. Work output capacity or potential can be measured by maximum rate and duration tests, that is, tests not exceeding the fatigue capability of any individual muscle mass, on apparatus in accordance with the invention. In one example, the maximum work rate achievable may be accurately determined by measuring and charting the maximum work achieved during fixed time intervals against one, or preferably against several different load resistances with sufficient intermediate rest intervals. Degradation of performance with time under continuous operation may also be measured. The present status of conditioning of the subject is thus fully identified in terms of total body conditioning, and a program of cyclic sequences may then be adapted that provides consistent improvement without strain or any risk of injury.

Variations can also be introduced in each complete cycle, to accentuate particular muscle masses. Arm movements can be increased, by alternating between the positions shown in FIG. 2C and FIG. 2D, that is, between the full leg extension position and the full extension length of the subject. This same arm exercise can also be accomplished by turning the hands so that the palms face toward the subject. Likewise, exercise of the leg, back and abdomen musculature can be accomplished by holding the arms in the fully downwardly extended, starting position of FIG. 2A and raising and lowering the handgrip 42 solely by movement of the body and legs. Obviously, a great number of variations of exercises may be accomplished on the apparatus of the invention and will be appreciated by those skilled in the art. However, because the handgrip movement requires a substantially constant force to overcome the load as has been described herein, the full body exercise as shown in FIGS. 2A—2H is preferred for exertion of practically total body musculature thereby giving maximum exercise benefit to the subject.

A kinesiologic analysis of the exercise cycle illustrated in FIGS. 2A—2H is shown, in graphical form, in FIG. 12 in which the number of muscles working is plotted as a function of the position of the subject in terms of the fraction of completion of one cycle. The instantaneous number and kinds of working muscles at succeeding one-sixth intervals of the cycle are shown by means of a bar graph and the total agonist, total antagonist and total working muscles are depicted in the form of continuous plots.

It should be understood that muscular activity, even in the performance of simple tasks, is extremely complex because of the interaction between muscles and muscle groups and because certain muscles, although exerted, do not participate completely, or at all, in accomplishing the external work performed by the subject. Thus, the graphical representation of FIG. 12 should be considered as a rough approximation and is subject to a number of limitations. Thus, only "major" working muscles have been considered because "minor" working muscles have comparatively small bearing on the external work accomplished. Likewise, the analysis does not report any muscles which perform primarily in lengthening, stabilizing or respiratory functions. Furthermore, muscles reported at a particular instant should be considered as having "phased in" at some previous time.

It will be observed from FIG. 12 that during the first half of the cycle (corresponding to FIGS. 2A—2D, already discussed), the majority of the muscles employed, 74 percent, are the antagonists; in contrast, during the second half of the cycle (corresponding to the movements progressing from the position shown in FIG. 2D back to the initial position of FIG. 2H), most of the muscles employed, about 72 percent, are the agonists. The total number of agonist and antagonist muscles used is 238 of which 186 different agonist and antagonist muscles are employed once and 186 twice. This significantly exceeds the total number of muscles employed in working any other single known exercise device. This also exceeds the total number of muscles in balanced employment (agonists as well as antagonists) in working any other known exercise device. Further, this device should permit the greatest maximal oxygen consumption of which an individual is capable and the greatest improvement in maximal oxygen consumption from training. For any given level of work, the strain should be less than that on other devices because the work is spread over a greater muscle mass. The corollary should also be true: given any level of physiologic strain, a greater amount of work should be possible from this device than from any other.

A different form of the exerciser in accordance with the invention is shown in FIGS. 3—7. The mechanism shown in FIGS. 3—7 comprises a work output device specifically arranged for operation and use as a total fitness exerciser. An elongated base frame **60**, here disposed in a horizontal position, comprises a pair of extended, generally U-shaped base members **62** and **64** which are joined in spaced apart, parallel relation by a pair of transverse support rods **66** and **68**. The longitudinally spaced, upstanding legs **62***a*, **62***b* and **64***a*, **64***b* of the U-shaped base members **62** and **64**, respectively, provide terminal points for the frame that are far enough apart to enable a user to be fully horizontally extended along the frame in the fully extended position. At one end of the frame **60**, hereinafter referred to as the foot end, is a transverse support member **70** coupled to the upper end of the legs **62***a* and **64***a* and including a pair of footrests **72** and **74**, spaced apart for convenient placement of the feet of the user. Each footrest **72**, **74** includes a stirrup or strap **76**, **78**, respectively, for restraining the inserted foot from any substantial movement relative to the footrest.

The frame structure **60** also includes a pair of longitudinal channel guideway members **80** and **82** on the upper side, extending parallel to the horizontal portions of the members **62** and **64**. A slidable body support **84**, having a horizontal seat portion **86** and an inclined backrest portion **88**, is disposed on the channel guideway members **80** and **82** so as to slide therealong. For this purpose, the channel guideway members **80** and **82** may be provided with a relatively low friction surface, such as a smoothly machined metal surface, a low friction synthetic coating or a lubricated surface. Roller, needle, or air bearings (not shown) may be utilized on the slidable support **84** if desired to reduce friction, the prime considerations being the avoidance of excessive frictional drag or resistance between the support **84** and the guideways **80** and **82**, as well as avoidance of substantial frictional variations in the travel of the support **84** along the length of the guideways. Although the sliding support is shown elevated relative to the bottom of the frame **60**, and movable in a horizontal direction, a wide variety of expedients may be used. As pointed out herein, a frame need not in fact be employed, inasmuch as the significant consideration is the provision of separate foot and head end anchor structures having minimum spacing between them corresponding to the desired total extension distance. The guideways for the body support may constitute the principal elements of the base, or may be separate from the remainder if the structure has sufficient static restraint.

A force resistance drive mechanism, mounted between the foot and head ends of the frame structure **60**, includes separate cable pairs **90** and **92** on each longitudinal side of the upper portion of the frame. Inasmuch as the drive mechanism is substantially identical on both sides, only one need be described in detail, this being the cable system, comprising cable pair **90**, disposed on the right-hand side of a subject seated in the slidable support **84**. This cable system is shown in more detail in FIG. 4, to which reference should also be made.

Cable pair **90** includes an inboard cable **94** and an outboard cable **96**. The cables **94** and **96** form endless loops and include chain portions **98** and **100** employed for drive purposes with the remainder of the cables comprising wire portions **102** and **104**. A first axle **106**, disposed at the foot end of the structure, is transversely supported across the frame by brackets **108** fixedly mounted on the frame **60**. The axle **106** carries a pair of spaced-apart idler pulleys **110** and **112** about which the wire portions **102** and **104** are looped. The chain portion **98** of the cable **94** is looped about an idler sprocket **114** mounted on an upper axle **116** at the head end of the structure, a drive sprocket **118** fixed to an output or drive axle **120**, and a reverse idler sprocket **122** mounted on a lower axle **124** at the head end of the frame. The chain portion **100** of the cable **96** is looped about an idler sprocket **126** mounted on the axle **116** and a drive sprocket **128** fixed to the drive axle **120**. Axle **116** is carried by risers **130** extending upwardly from the frame **60**; axles **120** and **124** are carried by the upper portions of legs **62***b* and **64***b* of the base members **62** and **64**, respectively. Handles **130** and **132** are connected to the cable pairs **90** and **92**, respectively, so that the subject can reciprocate each cable pair in unison through the full extension distance.

From FIG. 4, it will be seen that the respective chain portions **98** and **100** are positioned about the drive sprockets **118** and **128** so as to cause contrarotation of these sprockets relative to one another for a given direction of motion of the handle **130**. Thus, as shown by the arrows, when the handle **130** is translated rearwardly by the subject, the sprocket **118** rotates clockwise while the sprocket **128** rotates counterclockwise. The reverse directions of rotations will occur when the handle **130** is moved in a forward direction, that is, toward the foot end of the frame.

The sprockets **118** and **128** are connected to drive the axle **120** through suitable mechanisms so that irrespective of the direction of movement of the handle **130**, drive torque is always applied to the axle **120** in the same direction. FIGS. 5 and 6 show an example of an elementary unidirectional drive unit used with the drive sprocket **118** and which, when paired with an identical unit driven by the sprocket **128**, imparts a single direction of rotation to the axle **120** regardless of the direction of movement of the cable pair **90**. It will be understood that a similar set of bidirectional-to-unidirectional drive elements are utilized in connection with the cable pair **92**; because all of these units are essentially the same, only the unit actuated by sprocket **118** will be described in detail.

The unit shown in FIGS. 5 and 6 comprises the well-known "free wheel" bicycle drive mechanism; other devices, having the same or similar capabilities, will suggest themselves to those skilled in the art and are to be regarded as equivalents for purposes of the definition of the present invention by the appended claims. The "free wheel" bicycle unit has certain advantages, however, in that it is a simple, low cost, readily available and compact device.

Briefly, the mechanism of FIGS. 5 and 6 includes an annular hub member **140** threadedly secured to the axle **120** which in turn is connected to a load applying means to be described later. The hub member **140** carries a split inner race **142** of a ball bearing which includes ball elements **144**. The hub member **140** is also provided with two shaped, transverse notches **146**, spaced 180° apart and two, oppositely directed, arcuate slits **148** each subtending an angle of about 90° and communicating with the notches **146**. A pawl **150** is loosely seated within each notch **146** and is biased radially outwardly by a lead spring **152** carried within the slit **148**. The leaf springs **152** have free ends bearing against the inner surfaces of the pawls **150** and fixed ends held by transverse pins **154** spanning the slits **148** and anchored to the hub member **140**.

A ring member 156, carrying the sprocket wheel 118, forms the outer, bidirectionally rotatable housing of the drive unit. Formed in its inner surface are ratchet teeth 158 and a circumferential track 160 comprising the outer race of the ball bearing. The ratchet teeth 158 are oriented so that torque is transferred to the hub member via one or the other pawl 150 when the sprocket wheel 118 turns in the clockwise direction as indicated by the arrow. Counterclockwise rotation of the sprocket 118 causes pawls 150 to ride over the gently sloping back surfaces of the ratchet teeth and no drive torque is transmitted. During counterclockwise rotation of wheel 118, sprocket wheel 128, being an identical unit, rotates clockwise and transmits torque to the output drive axle 120.

It will be noted in FIG. 5 that the teeth 158 are spaced so as to be out of phase with the driving edges of the pawls 150, that is, with one pawl engaging a ratchet tooth in the driving condition, as for example, the lower pawl in FIG. 5, the remaining pawl rests on top of the adjacent tooth. This relative spacing is desirable so that although only one pawl drives at a time, a stronger ratchet tooth is possible while the ability to quickly engage the drive is preserved when the sprocket direction is changed to clockwise. This, in effect, produces a ratchet drive of much finer pitch than the tooth spacing would indicate. Obviously, more than two pawls may be used to provide even less slack through a finer effective pitch.

A constant resistance mechanism, comprising an ergometer or work measuring device, best seen in FIGS. 3 and 7, is coupled to the output or drive axle 120. The ergometer is of the pendulum type, and provides an indication of the work output rate. A tireless bicycle wheel 170 is mounted securely on the axle 120 and driven thereby. The wheel is braked mechanically by an adjustable band 172 frictionally and slidably engaging a substantial arcuate portion of the wheel rim. The band 172 is also fixedly connected to a pendulum drive shaft drum 174 by a locking clamp 176. Thus, the band 172 can be tightened or loosened by disengaging the locking clamp 176 and adjusting the tautness of the band so that the desired amount of slippage between the wheel rim and the band is attained. The band 172 is preferably constructed of any material which will resist friction abrasion and expansion or shrinkage due to variations of humidity and temperature conditions.

A short, horizontal shaft 178 is attached to the drum 174 and a pendulum arm ring 180 is fixedly mounted on the end of the shaft 178. A pendulum arm 182 depends from the ring 180.

As the subject places the apparatus in motion by exerting force on the handles 130 and 132, the rotating wheel 170, acting on the band 172, deflects the pendulum arm 182 to a point at which the difference in tension at the ends of the band is balanced by the torque produced by the angularly displaced pendulum arm. The extent of the deflection of the pendulum arm 182 depends on several factors, including the sliding friction between the band 172 and the wheel rim. Adjacent the pendulum arm is a fixed plate 184 having a pendulum scale 186 graduated in units of braking force (lbs., for example). The distance (feet) over which the force is applied may be obtained from a counter 188 attached to the axle 120. The work done by the subject, in foot-pounds may be computed simply by multiplying the pendulum arm indication by the counter reading. If the distance is expressed on a per unit time basis, then the rate of work, or horsepower, may be computed. It is preferred to have an adjustably positionable weight 190 connected to the pendulum arm 182 by which more precise adjustments and calibration of the pendulum arm deflection can be made. Thus, the tautness of the band 172 can initially be roughly adjusted and then fine adjustments can be made by lowering or raising the weight 188.

Different types of exercise training programs can be accomplished on the apparatus of FIGS. 3—7. An exemplary training program begins with the subject exercising at a work rate that requires, for example, 40 percent of his initial maximum oxygen consumption and heart rate, as determined by physiological tests, at steady exercise. Of course, it will be desirable for each different subject to determine or estimate his initial maximum oxygen consumption and heart rate by a metabolism test or equivalent from which the maximum initial rate of work which can be accomplished by the subject is determined. Accordingly, the subject then exercises at 40 percent of maximum indicated by the ergometer at a rate of approximately 20 complete cycles per minute.

As training at this level is continued, the subject's heart rate begins to decrease for that amount of work accomplished. With a decrease in heart rate, a greater rate of work can be undertaken, for example 50 percent and this process is repeated until the subject is promoted to a work rate that elicits a heart rate of 97 percent of his initial maximal heart rate or oxygen consumption. In continuing the exercise program, the subject is given another maximal oxygen consumption test which is used as the basis for further training.

In another program, the subject may exercise for a standard duration, for example, 30 minutes, at a suitably steady work rate. This type of program can develop great cardiorespiratory dimensions and is feasible up to work rates well in excess of the subject's initial maximum oxygen consumption and heart rate.

Another training program uses a progression of work rates without stopping during the training session, for example, 40 percent of maximum,60 percent and 80 percent. The lowest work rate serves as a warmup and the last few minutes are spent at the highest work rate. Progress is judged by total work done and highest work rate achieved. The training session is characterized by progressive intensity of exercise.

Still another type of training program uses discontinuous exercise such as two minutes working and one minute resting, for a certain session duration, for example, 30 minutes. For the work accomplished, the signs of stress, for example, blood lactate, are least in this training program.

FIG. 8 illustrates the present invention embodied in a four wheel land vehicle whereby the work output is utilized for directly driving the vehicle through rear wheels 196. The drive components and mechanism are identical to those described in connection with FIG. 3 and, therefore, that description will not be repeated here. The front wheels 198 of the vehicle of FIG. 8 can be steered by the exerciser's feet which are tethered in foot restraints 200 and 201 attached to the front axle 202. The front axle 202 pivots in relation to the frame 204 about a pin 206 anchored to a plate 208 secured to the vehicle frame. The front axle 202 is normally held substantially perpendicular to the longitudinal axis of the frame 204 by a pair of springs 210 and 212 connected to the front of the frame 204 at a central point and to the axle 202 at spaced points on either side of the longitudinal central axis of the frame. Thus, the vehicle is driven substantially straight ahead unless a force is exerted in opposition to one or the other spring 210 or 212 by applying more pressure against one or the other foot restraint 200 or 201. Caliper type braking means 214, mounted on a transverse frame member 216, are also provided. The braking means 214 are actuated by exerting a downward force on the heel of the foot restraints 200 and 201 which force is transmitted via brake cables 218 to the braking means 214. It will be appreciated that the apparatus can be used for driving other types of vehicles such as manpowered boats and aircraft by substituting different drive elements such as paddles, propellers, and so forth, for the wheels shown in FIG. 8.

A relatively simple and inexpensive arrangement in accordance with the invention and which also provides a direct indication of total work output, is illustrated in FIGS. 9 and 10, to which reference is now made. In this arrangement, a cable 230, under moderate tension, is looped between upper and lower support assemblies 232 and 234. The upper support assembly 232 comprises a bracket 236 upon which a pulley 238 is rotatably mounted, and the lower support assembly 234, positioned adjacent a footrest platform 235, comprises a drum 240 about which the cable 230 is wrapped with a number of turns. A handle 242 for use by the subject is attached to the cable 230 and spaced therefrom by a set of braces 244. A pair of guide rollers 246 and 248, attached to fixed supports (by means not shown), may be used to provide tracking of the cable 230 between the upper and lower positions. Various other cable and flexible or rigid systems may be employed to permit the mechanism to be operated up and down with freedom of movement by the subject.

The desired frictional or mechanical restraint against the operative movement, together with the work output reading, are provided by a simple hydraulic mechanism 250 coupled directly to the drum 240. A shaft 252 concentric and rotated with the drum 240 includes a threaded portion 254. A piston 256, including an interiorly threaded central aperture 258, is mounted on the threaded portion of the shaft 252 and includes a keyway 260 engaged by an elongated key 262. The piston 256 reciprocates within a cylinder 264 filled with hydraulic fluid. The reciprocation of the piston 256 within the cylinder 264 drives the hydraulic fluid toward one end of the cylinder or the other, the fluid being circulated externally of the cylinder within a bypass line 266 connected to opposite ends of the cylinder. The amount of flow within the bypass line 266 is controlled by a pair of orifices, the size of which is each controlled by an associated needle valve 268, 270. A pair of needle valves are employed to permit variation in the resistance in the two alternate directions of movement, although it will be apparent that a single, fixed orifice may be used for this purpose, or that a single adjustable device at some intermediate point in the bypass line 266 may be employed. When utilizing a pair of needle valves, secondary bypasses around the needle valves incorporating check valves 272, 274 are employed to ensure free flow in one direction around the associated needle valves.

With appropriate insulation about the cylinder 264 to approximate adiabatic conditions, a measurement of total work output may be provided directly by measuring the temperature increase of the hydraulic fluid. For this purpose, a temperature responsive device, such as a thermocouple or bimetallic spring, which, under the conditions stated functions as a calorimeter, is exposed to the hydraulic fluid, and an indicator 276, preferably calibrated in energy units such as calories or foot-pounds, is visible to the operator. The indicator face may include a movable background, so that adjustments may be made in the start point reading to compensate for ambient temperature variations.

The orientation of the continuous loop of cable 230 about the drum 240 remains the same irrespective of the displacement of the cable during exercise by a subject. The extent of movement of the cable is sufficient, as in the devices previously described, to encompass the full range desired for a subject. As the subject moves between the fully flexed position and the fully extended position, rotation of the shaft 252 causes the piston 256 to reciprocate, forcing the hydraulic fluid through the small orifices within the valves 268, 270, the mechanical work thereby being converted to heat energy which raises the temperature of the fluid. The direct indication of total work output therefore enables the subject to be assured that a certain exercise program involving given total increments of work, is being performed in each sequence. The work rate may, of course, be adjusted by varying the size of the orifices.

In FIG. 11, a variation of the invention, shown in somewhat simplified form, is illustrated in perspective. The apparatus of this embodiment includes a horizontal platform 280 incorporating a pair of spaced, parallel, longitudinally oriented, grooved tracks 282. A body support for the subject, which support may simply be a seat 284, is mounted on rollers (not shown) disposed within the tracks 282 whereby the seat 284 is adapted to travel longitudinally in either direction along the platform 280. Mounted on one end of the platform 280, which will be referred to as the foot end, are foot restraints 286 of the type already described in connection with other embodiments. Secured to the sides of the platform 280 near the foot end thereof, are projecting L-shaped, tubular support members 288, the upright segments of which carry transverse bearings 290. Journaled within the bearings 290 are shafts 292, the inboard extremities of which are fixed to sprocket wheels 294. The outer ends of the shafts 292 are connected to suitable load devices such as electrical dynamometers 296 coupled to indicator means 298. It will be appreciated that the sprockets 294 operate completely independent of one another so that the exercising subject may actuate one and not the other or may actuate both at different load levels.

Projecting rearwardly from the platform 280 is an adjustably positionable, rear tubular frame 300 having longitudinal tube elements 302 received, in telescoping fashion, within sleeves 304 mounted in the platform 280. The tube elements 302 are provided with a series of longitudinally spaced apertures 306, which, in cooperation with pins 308 carried by the sleeves 304, fix the longitudinal position of the frame 300 relative to the platform 280.

Attached to the elements 302, at their rearmost extremities, is a generally U-shaped cross member 310 the vertical portions of which have inwardly directed axle portions 312 rotatably supporting idler sprocket wheels 314. A chain 316 connects each sprocket wheel 294 at the foot end with the corresponding sprocket wheel 314 at the rear, or head, end. Handles 318, secured to the chains 316 provide gripping means for the subject. The full extension distance of the subject extends between outer extremities of paired sprocket wheels 294, 314 as indicated by "*d*" in FIG. 11.

In the operation of the exerciser of FIG. 11, the subject imparts motion to the chains 316, and thereby to the dynamometers 296, in a single direction as indicated by the arrows. Along the upper course, movement may be in a forward direction, that is, toward the foot end and along the lower course, the direction of movement will then be toward the head end. The direction may be reversed if desired. In any event, during an entire cycle, the force applied by the subject to the handles is resisted in each direction by the dynamometers 296 and thus, essentially, the apparatus operates the same as previously discussed embodiments.

The overall length of the apparatus may be adjusted to accommodate subjects of various sizes by withdrawing the pins 308, sliding the frame 300 in or out and reinserting the pins 308 in the appropriate apertures 306. Chain links may be added or subtracted as required to adjust the length of the chains 316.

Although there have been described above and illustrated in the drawings various forms of exercise systems, devices and methods in accordance with the invention, it will be appreciated that the invention is not limited thereto but encompasses those forms and variations falling within the scope of the appended claims.

I claim:

1. A total body exerciser for providing substantially balanced and successive exercising of both agonist and antagonist musculature of a subject comprising:
- a horizontal frame means;
- individual foot restraints mounted on one end of the frame means;
- a carriage for supporting the body of the subject and slidably mounted on the frame means for reciprocation relative to the foot restraints;
- means supported by the frame means for providing a load;
- said load means comprising a rotating friction developing energy device;
- means including endless chain drive means mounted on the frame means for manual reciprocation relative to the foot restraints and connected for driving the load means continuously and unidirectionally during operation of the exercise by the subject; and
- individual hand grips secured to the endless chain drive means for reciprocation of the hand grips by the subject between a position adjacent said foot restraints and a position at which the subject is substantially fully extended, with the subject's body being supported by the carriage and the subject's feet held by the foot restraints,

providing exercise in which both flexion and extension movements are continuously resisted by the load means.

2. An exerciser, as defined in claim 1, in which:

the drive means includes transmission means connected to drive the rotatable energy dissipation device and convert the reciprocating motion of the drive means to unidirectional rotary motion of the rotatable energy dissipation device.

3. A total body exerciser comprising:

an elongated, horizontal frame;

a first axle projecting horizontally outwardly from said frame at one end thereof;

a second axle, parallel to the first axle, projecting horizontally outwardly from said frame at the other end thereof;

rotatable idler means mounted at the ends of both axles, the rotatable idler means at said one end of the frame being in alignment with the rotatable idler means at said other end;

foot restraints mounted at said one end of the frame in between the rotatable idler means of said first axle;

a carriage for supporting the body of the subject and mounted on the frame for reciprocation relative to the foot restraints;

rotatable frictional load resistance means mounted on the frame;

first endless drive cable means disposed about the rotatable idler means on one side of the elongated frame and connected to drive the frictional load means;

a transmission means;

second endless drive cable means disposed about the rotatable idler means on the other side of the frame and connected to drive the frictional load means; and

a hand grip mounted on each cable means, the cable means rotating the frictional load means through a transmission means which converts reciprocating motion of the cable means into unidirectional rotation of the frictional load means, the distance between the foot restraints at the one end of the frame and the second axle at the other end of the frame being sufficient to accommodate a fully extended subject, said hand grips being movable between a first extreme at which said hand grips are located substantially at said foot restraints and a second extreme at which said hand grips are located a distance from said foot restraints approximately equal to the fully extended length of the subject.

4. An exerciser, as defined in claim 3, in which, the first and second cable means each include dual sprocket chains connected to the load means through sprocket wheels, the first of the dual chains driving the load means in one direction of reciprocation of the hand grips and the other of the dual chains driving the load means when the hand grips are moved in the opposite direction.

5. An exerciser, as defined in claim 3, in which; said frame includes rails slidably engaging said carriage.

6. A total body exerciser comprising:

an elongated frame, said frame being oriented horizontally and including rails disposed therealong and a carriage slidably mounted on said rails for supporting the body of a subject;

a first axle projecting horizontally outwardly from said frame at one end thereof;

a second axle, parallel to the first axle, projecting horizontally outwardly from said frame at the other end thereof;

rotatable idler means mounted at the ends of both axles, the rotatable means at one end of the frame being in alignment with the rotatable means at said other end;

foot restraints mounted at said one end of the frame in between the rotatable idler means of said first axle;

rotatable energy dissipating means mounted on the frame;

first endless drive cable means disposed about the rotatable means on one side of the elongated frame and connected to drive the energy dissipating means;

second endless drive cable means disposed about the rotatable means on the other side of the frame and connected to drive the energy dissipating means said carriage being located between the said first and second endless drive chain means; and

a transmission means, a hand grip mounted on each cable means, the cable means rotating the energy dissipating means through said transmission means which converts reciprocating motion of the cable means into unidirectional rotation of the energy dissipating means, the distance between the foot restraints at the one end of the frame and the second axle at the other end of the frame being sufficient to accommodate a fully extended subject.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,572,700 Dated March 30, 1971

Inventor(s) Joseph A. Mastropaolo

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 31, "that" (second occurrence) should read --than--. Column 2, line 23, "devices" should read --devised--; line 35, "72" should read --22--. Column 7, line 13, "186" should read --52--. Column 8, line 72, "lead" should read --leaf--. Column 14, line 22, after "at" and before "one" insert --said--; lines 34 and 35 should read:

--chain means;
a transmission means; and
a hand grip mounted on each cable--

Signed and sealed this 19th day of October 1971.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Acting Commissioner of Patents