June 6, 1967 T. L. DE LORME, JR., ET AL 3,323,366

MUSCULAR EXERCISING AND EVALUATION APPARATUS

Filed Oct. 7, 1963 5 Sheets-Sheet 1

Fig 1

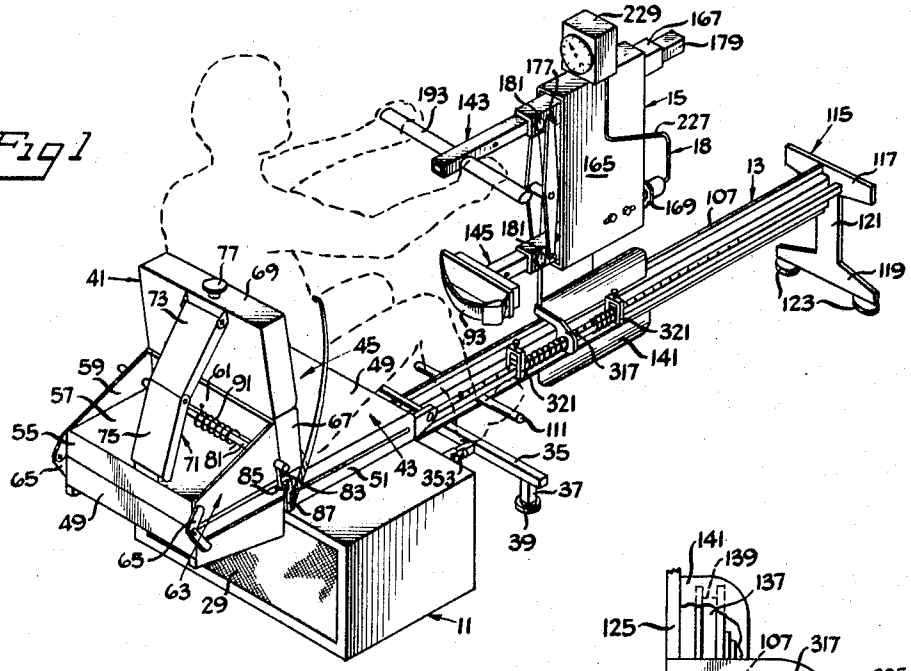


Fig 6

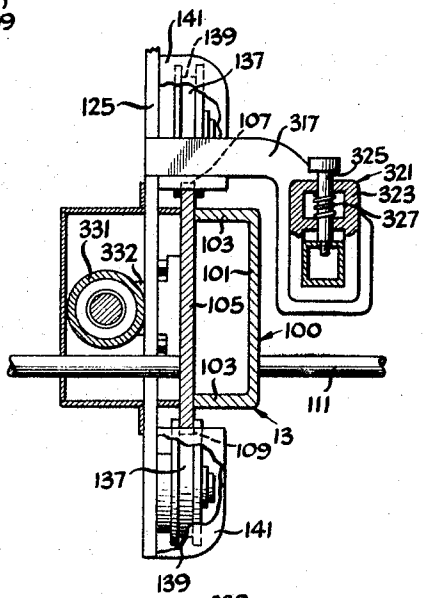
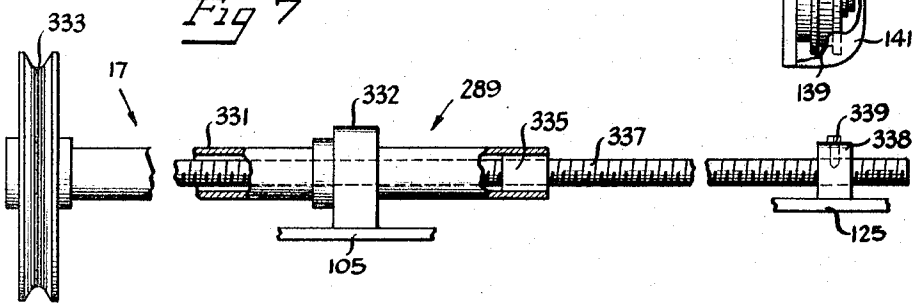


Fig 7



Inventors
THOMAS LANIER DeLORME, JR.
JESSE WAYNE GANNON
HENRY WILMOT McDONOUGH

By Anderson, Luedeka, Fitch, Even & Tabin
Attys

June 6, 1967 T. L. DE LORME, JR., ETAL 3,323,366

MUSCULAR EXERCISING AND EVALUATION APPARATUS

Filed Oct. 7, 1963 5 Sheets-Sheet 2

Fig 2

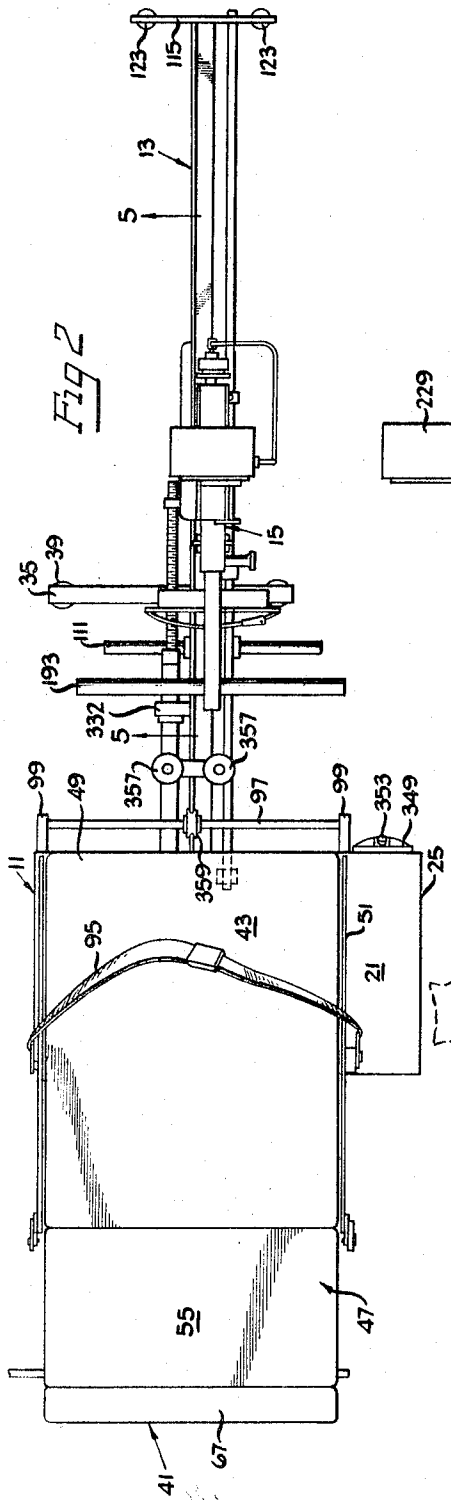
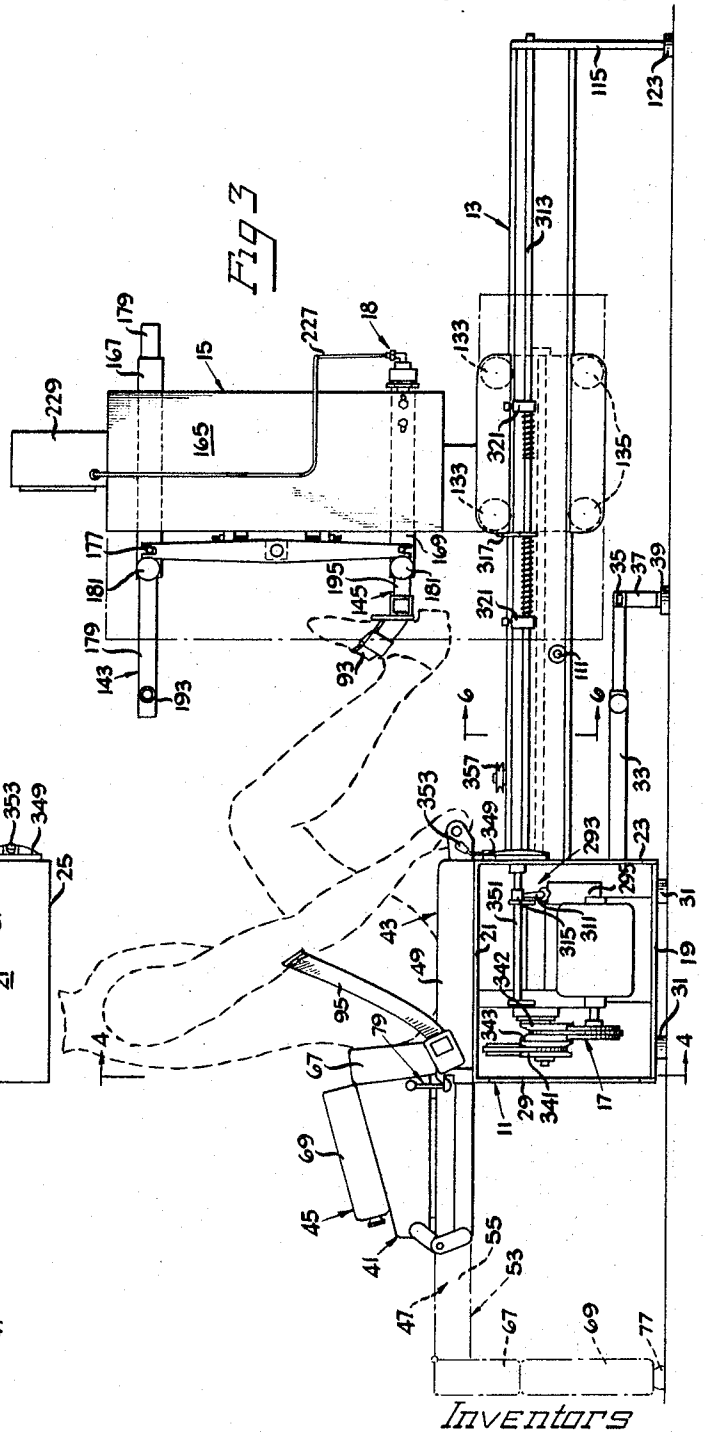


Fig 3



Inventors
THOMAS LANIER DeLORME, JR.
JESSE WAYNE GANNON
HENRY WILMOT McDONOUGH

By Anderson, Luedeka, Fitch, Even & Tabin
Attys

June 6, 1967 T. L. DE LORME, JR., ETAL 3,323,366

MUSCULAR EXERCISING AND EVALUATION APPARATUS

Filed Oct. 7, 1963 5 Sheets-Sheet 3

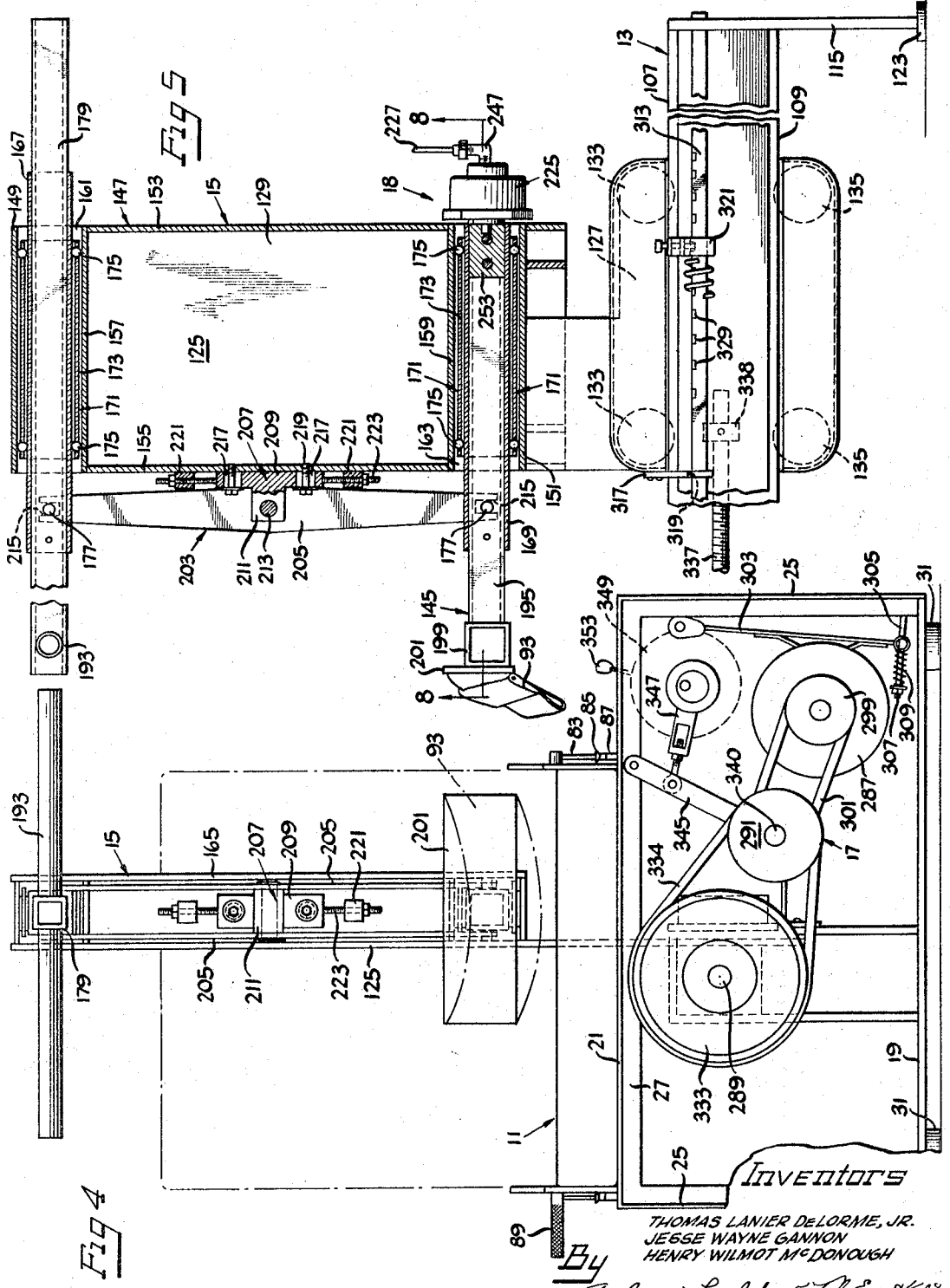


Fig 5

Fig 4

Inventors

THOMAS LANIER DeLORME, JR.
JESSE WAYNE GANNON
HENRY WILMOT McDONOUGH

By Anderson, Luedeka, Fitch, Even & Tabin

Atty's

June 6, 1967 T. L. DE LORME, JR., ETAL 3,323,366

MUSCULAR EXERCISING AND EVALUATION APPARATUS

Filed Oct. 7, 1963 5 Sheets-Sheet 4

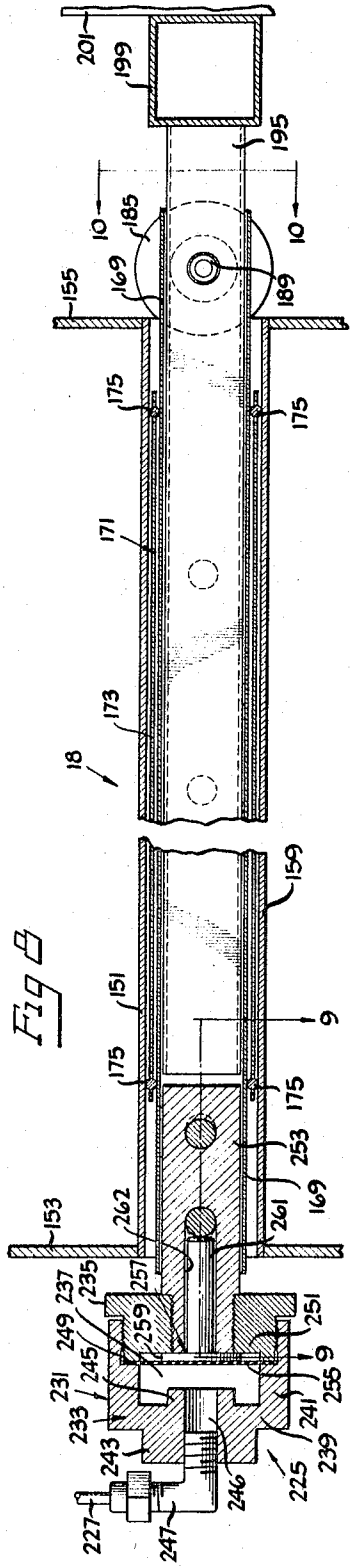


Fig 8

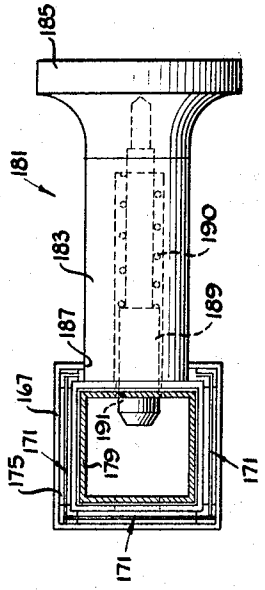


Fig 10

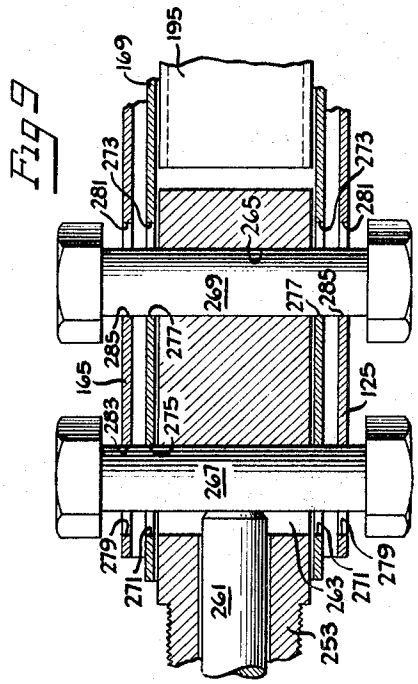


Fig 9

Inventors
THOMAS LANIER DeLORME, JR.
JESSE WAYNE GANNON
HENRY WILMOT McDONOUGH

By Anderson, Luedeka, Fitch, Even & Tabin
Attys

June 6, 1967 T. L. DE LORME, JR., ETAL 3,323,366

MUSCULAR EXERCISING AND EVALUATION APPARATUS

Filed Oct. 7, 1963 5 Sheets-Sheet 5

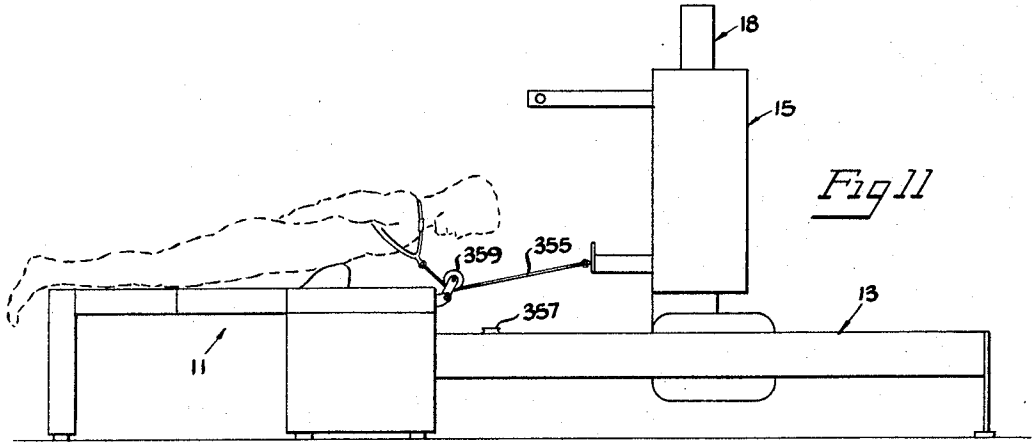


Fig 11

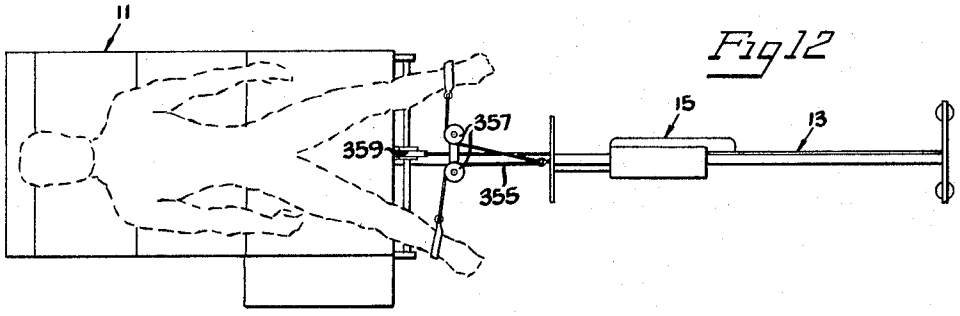


Fig 12

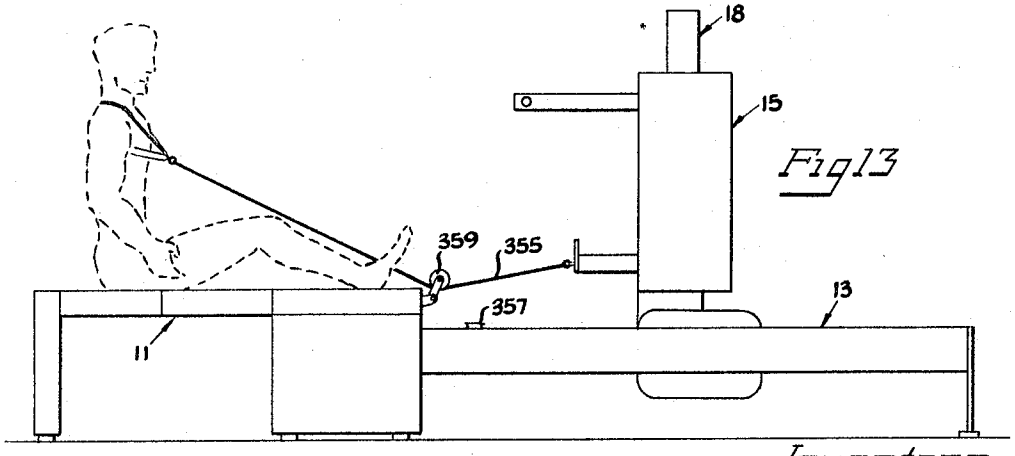


Fig 13

Inventors
THOMAS LANIER DeLORME, JR.
JESSE WAYNE GANNON
HENRY WILMOT McDONOUGH

By Anderson, Luedeka, Fitch, Even & Tabin
Atty's

United States Patent Office 3,323,366 Patented June 6, 1967

3,323,366

MUSCULAR EXERCISING AND EVALUATION APPARATUS

Thomas Lanier De Lorme, Jr., Milton, Mass., and Jesse Wayne Gannon, Elgin, and Henry Wilmot McDonough, Dundee, Ill., assignors to Elgin Elmac Enterprises, Inc., a corporation of Illinois

Filed Oct. 7, 1963, Ser. No. 314,116
5 Claims. (Cl. 73—379)

This invention relates to apparatus which may be utilized in conjunction with a program of physical exercise and muscular development.

It is a well-known fact that the force exerted by a muscle results from a contraction of the muscle, whether the body be engaged in exercise, work, or normal physical activity. There are two basic types of muscular contractions, namely isotonic contractions and isometric contractions. Isotonic contractions occur when the muscular fibers undergo a change in length while developing tension against a constant load or resistance. If the muscle fiber shortens while contracting, as when an object is moved toward the body with the arms, the contraction is known as a concentric isotonic contraction. If, on the other hand, the muscle fiber lengthens while contracting, as when an object is gradually moved away from the body with the arms, the contraction is said to be an eccentric isotonic contraction. An isometric contraction consists of the development of tension in the muscle against a constant load or resistance without any appreciable change in the length of the muscle fibers, i.e., the muscle fibers neither shorten or lengthen during the contraction. An example of such a contraction is the development of tension in a muscle when an attempt is made to move an immovable object.

When a portion of the body is assisted in its movement through its range of motion, the exercise imparted to the associated muscles is said to be "passive." Passive exercise is frequently utilized to strengthen muscles weakened through injury or disease and may be achieved by counterbalancing much or all of the weight of the portion of the body being moved. Passive exercise is also beneficial to healthy muscles, however, in that it tends to stretch muscles beyond their normal resting length. It has been found that skeletal muscles develop a greater force after being previously stretched.

The strength of a muscle can be augmented most rapidly by contracting the muscle against a degree of resistance that calls forth maximal effort, such a resistance being known as a "maximal" resistance. Ideally, then, a maximal resistance should be utilized in all strength exercises. Exercises may, of course, be undertaken under a submaximal resistance, as in weight lifting. However, there can be no significant increase in strength as a result of such exercises until the muscles become fatigued to the point at which the load becomes a maximal load for the muscle in the fatigued state.

The maximal resistance for a single contraction of a non-fatigued muscle is, of course, difficult to predict. Such a resistance will vary, for example, with each particular muscle being exercised, and with the speed at which the contraction is undertaken. The maximal resistance also varies throughout the range of motion of the body part associated with the muscle, since the lever arm lengths and advantages of muscle pull differ depending upon the position of the body.

It is a principal object of the present invention to provide an improved apparatus for use in conjunction with a program of physical exercise and muscular development.

Another object of the invention is to provide an apparatus which can be utilized for exercises involving either isotonic or isometric contractions.

A further object of the invention is to provide an apparatus which can be utilized for exercises involving both concentric and eccentric isotonic contractions.

A still further object of the invention is to provide an exercising apparatus which can be utilized to apply a submaximal, maximal or supra-maximal resistance to muscles during the contraction thereof.

Another object of the invention is to provide an exercising apparatus which can be utilized to provide either assistance or resistance to muscles during the contraction thereof.

An additional object of the invention is to provide an apparatus which can be utilized in conjunction with exercises involving the isotonic contraction of a muscle at a constant controlled speed, and which is capable of effecting a selective variation in the speed of the contraction.

A further object of the invention is to provide an apparatus which can be utilized in conjunction with exercises involving the isotonic contraction of a muscle throughout the range of motion of the bodily parts associated with the muscle.

Still another object of the invention is to provide an improved exercising apparatus which may be used to increase, as well as to evaluate, the strength of various muscles and muscle sets of the body.

A further object of the invention is to provide an apparatus which is capable of evaluating the strength of a muscle or muscle set during movement of the associated portion of the body.

An additional object of the invention is to provide an apparatus which is adapted to provide an isometric evaluation of the strength of a muscle or muscle set at any point in the range of motion of an associated bodily part.

A still further object of the invention is to provide an apparatus which is adapted to evaluate the strength of a muscle or muscle set at any point in the range of motion of an associated bodily part.

Other objects and advantages of the invention will become apparent with reference to the following description and the accompanying drawings.

In the drawings:

FIGURE 1 is a perspective view of an apparatus showing various of the features of the invention;

FIGURE 2 is an enlarged, partially broken-away plan view of the apparatus of FIGURE 1, but showing the body-supporting portion thereof in an alternate position;

FIGURE 3 is a partially broken-away side elevational view of the apparatus as seen in FIGURE 2;

FIGURE 4 is an enlarged partially broken-away rear end view of the apparatus as viewed in the direction of the arrows 4—4 of FIGURE 3;

FIGURE 5 is an enlarged fragmentary partially broken-away sectional elevational view taken along line 5—5 of FIGURE 2;

FIGURE 6 is an enlarged fragmentary partially broken-away sectional end view taken along line 6—6 of FIGURE 3;

FIGURE 7 is an enlarged fragmentary partially broken-away plan view of a portion of the apparatus shown in FIGURE 2;

FIGURE 8 is a fragmentary sectional elevational view taken along line 8—8 of FIGURE 5;

FIGURE 9 is an enlarged sectional plan view taken along line 9—9 of FIGURE 8;

FIGURE 10 is an enlarged sectional view taken along line 10—10 of FIGURE 8; and

FIGURES 11 through 13 are diagrammatic views illustrating a manner in which the apparatus of FIGURE 1 may be utilized.

Very generally, in a specific embodiment of an apparatus formed in accordance with the present invention, there is provided a body support **11**, a rail or track **13** extending outwardly from the body support, a carriage **15** mounted on the rail for movement therealong toward and away from the body support within fixed limits, and power means **17** for effecting movement of the carriage along the rail at a constant speed.

An individual utilizing the apparatus assumes a position on the body support **11** and effects a connection between a portion of the body and the carriage **15**. For example, the user may assume a seated position on the body support and engage the carriage with the hands (FIG. 1), or with the feet (FIG. 3). If, as the carriage moves, the user exerts no force thereon but merely permits the body to be moved by the carriage, a passive exercise or stretching is accomplished.

If the user chooses, he may resist the movement of the carriage by exerting a force thereon through a contraction of the related muscles. Since the carriage is moving both toward and away from the user, these contractions will effect both a shortening and a lengthening of the muscle fibers and, thus, will be both concentric and eccentric isotonic contractions. As will be seen shortly, these contractions may be caused to encompass any desired selected segment of the range of motion of the associated portion of the body by a selective variation in the distance through which the carriage travels.

The capacity of the power means **17** is such that the force exerted by the user is not sufficient to hinder its traveling movement. Hence, the resistance provided by the carriage is supra-maximal, although a sub-maximal or maximal force may be applied to it by the user. The power means **17** is capable of moving the carriage at selectively variable speeds so that the speed of the contractions and, hence, the power applied by the user, may be varied.

A gauging unit or indicating means **18** is mounted on the carriage and provides an indication to the user of the energy which he is expending and, when the speed of the carriage and the distance through which it moves are held constant, the gauge reading provides an accurate indication of the force applied by the user during isotonic contractions. If the movement of the carriage is halted at any given point, an isometric evaluation of the strength of the muscles can be obtained at that point. Further, while the carriage is stationary, the user may accomplish isometric contractions as well.

Referring now more specifically to the structure of the apparatus as shown in the drawings, the body support **11** is in the form of a generally rectangular hollow box formed of interconnected sheet metal bottom, top, forward and end walls **19**, **21**, **23** and **25** respectively, and is reinforced internally by a rigid frame **27**. The sheet metal box, in addition to providing a support for the body of the user of the apparatus, also encloses the power means **17**, soon to be described, and is closed at its rearward end by means of a metallic screen **29** to provide for the ventilation of its interior. Floor-engaging pads **31** adjacent the lower surface of the bottom wall **19** elevate the box above a supporting surface and are preferably formed of a resilient material so as to dampen vibrations of the power means **17**.

A rod **33** extends forwardly a short distance from the frame **27** of the box and has a cross arm **35** attached to its outer end which is adapted to provide a foot brace for the user. A member **37** provided with a floor-engaging pad **39** depends from each end of the cross arm and is adjustable in height so as to permit adjustment of the height of the forward end of the brace **33**. In addition to providing a foot brace, the above structure serves to stabilize the apparatus during traveling movement of the carriage along the rail.

Secured to the top wall **21** of the sheet metal box is an arrangement of body-supporting cushions **41** which

may assume the position shown in FIGS. 1 and 3, in which they define a seat **43** and backrest **45**, or which may be moved into the position shown by the broken lines of FIGURE 3 in which they define an elongated platform **47**. The cushion arrangement **41** includes an elongated stationary horizontally disposed cushion **49** carried on a plate (not shown) having a configuration substantially the same as that of the cushion **49** and provided with an upstanding flange **51** along its longitudinal edges to provide lateral support for the cushion. Both the cushion and plate have a length greater than the forward to rearward depth of the box and are disposed on the box with their rearward portions, i.e., the portions of each farthest from the carriage **15** and rail **13**, overhanging the rearward wall **29** of the box in cantilever fashion. The forward portion of the cushion **49** defines the sheet **43**, previously referred to.

A second section **53** of body-receiving cushions is supported on the overhanging portion of the horizontally disposed cushion **49** and comprises a first cushion **55** backed by a rigid plate **57** and skirted on three sides by a pair of arms **59** and a web **61** of a U-shaped frame **63** (FIG. 1). The ends of the arms **59** of the frame **63** are pivotally attached to the rearward ends of the flanges **51** of the plate of the cushion **49** by ears **65** projecting from each of the arms and flanges and, when the cushions are arranged in seat-forming position, is disposed so as to cause the cushion **55** to overlie the cushion **49** in inverted relationship. When the cushions are in a platform-defining position, the cushion **55** faces upwardly and defines the rearward end of the platform **47**. A second cushion **67** is secured to the web **61** and forms the lower portion of the backrest **45** when the cushions are arranged in seat-forming position. Preferably, the frame **63** is constructed so that when the cushions are in the latter position, the cushion **67** will be inclined rearwardly slightly to thereby add to the comfort of the user.

To complete the cushion arrangement **41**, a third section in the form of a single cushion **69** is hingedly connected to the upper edge of the web **61** of the frame **63** so as to be movable between a generally upright position (FIG. 3) in which it is disposed in the same plane as the cushion **67** and thereby provides support for the upper portion of the back of the user, or a folded out-of-the-way position in which it allows freedom of movement for the arms and shoulders of the user.

The cushion **69** is maintained in the upright position by an over-center linkage **71** which locks in the position shown in FIGURES 1 and 3 and includes hingedly interconnected upper and lower arm members **73** and **75** respectively, one of which is pivotally mounted on the under surface of the cushion **55** and the other of which is pivotally mounted on the rearward surface of the cushion **69**. The linkage **71** is preferably biased toward the over-center position of FIGURES 1 and 3.

The relative position of the cushions when in the platform-forming position are best seen in FIGURE 3 wherein it will be noted that the cushions **49** and **55** are co-planar and define a flat horizontal surface upon which the outstretched body of the user may be supported. When the cushions **49** and **55** are so disposed, the cushions **67** and **69** depend therefrom in a generally vertical disposition and are of such a length as to engage the floor and support the cushion **55** in generally co-planar relation to the horizontally disposed cushion **49**. The edge of the cushion **69** which is lowermost when the cushion is in the depending position is provided with a pad **77** which engages the floor and eliminates wear on the edge of the cushion.

The cushion arrangement **41** is maintained in the seat-forming position by a latch mechanism **79** which includes a rod **81** extending through the arms **59** adjacent the web **61** of the U-shaped frame **63**. Each of a pair of vertically disposed latch bolts **83** is keyed at its upper end to one of the ends of the rod **81** and has an enlarged

head portion 85 at its lower end which is adapted to be engaged by a hook-shaped bracket 87 supported on the top wall 21 of the hollow box from which the bolt can be easily released by merely rotating the rod 81. With the latch mechanism 79 in the locked position, the second and third cushion sections 53 and 69 are prevented from pivoting into the platform-forming position. Rotation of the rod 81 to release the latch is facilitated by a knurled extension 89 on the left hand side thereof (FIG. 4). A coil spring 91 encircles the mid-portion of the rod 81 intermediate the arms of the frame 63 and biases the latch toward the locked position.

From the foregoing discussion of the cushion arrangement, it should be apparent that the apparatus may be operated with the user in either the sitting or the lying position. In the sitting position, supported by the backrest 45, the user can place his feet firmly on the carriage and push with his legs in a manner similar to a leg press (FIG. 3), thus exercising and evaluating the anterior thigh muscles. Alternatively, the carriage may be engaged only with the toes or forward portion of the feet and thus exercise and evaluate the calf muscles as well. Still further, the feet may be fastened to the carriage, as with a harness 93 (FIG. 3), so that the user can exert a pulling force with the legs, thereby exercising and evaluating the hamstring muscles and the anterior muscles of the lower leg.

Also in the sitting position, the user may grasp the carriage with the hands and exert either a pushing or pulling force so as to exercise and evaluate the arm, chest, abdominal and back muscles.

When the cushions defined a platform, the user may assume an outstretched, face down position with the head disposed farthest from the carriage, secure the feet to the carriage by means of the harness 93 and exert either a pushing or a pulling force. When lying on the back with the head nearest the carriage, the user may grasp the carriage and exert a pulling or a pushing force. Alternatively, the user may lie on the back with the head furthest from the carriage, engage the carriage with the feet, and exert either a pushing or a pulling force with the legs.

An additional manner of using the apparatus is shown in FIGURES 11 through 13 and will be described in further detail shortly.

In order to stabilize the user when exerting a pulling force on the carriage, a seat belt 95 is preferably provided for the seat 43. To enable the user to maintain balance when in the sitting position and exerting a force on the carriage with the legs, a hand grip in the form of a horizontally disposed bar 97 is provided adjacent the forward edge of the seat 43 and is supported by means of mounting plates 99 secured to the flanges 51 of the plate of the cushion 49.

Referring now to the rail 13 (FIG. 6), there is provided a channel beam 100 including a vertically disposed web 101 and horizontal flanges 103. A vertically disposed plate 105 is secured to the outer edges of the flanges, as by welding, and includes upper and lower horizontally extending edges which are disposed above and below the flanges 103 and define tracks 107 and 109 on which the carriage rides and is guided. A foot bar 111 extends transversely through the rail 13 adjacent the body support 11 and is adapted to support the feet of the user during those exercises and evaluations performed from a seated position with the carriage 15 engaged by the hands (FIG. 1).

The rail 13 extends forwardly of the rectangular sheet metal box generally centrally of the cushion arrangement 41 so that the legs of the user may straddle the rail and rest either upon the foot bar 111 or the carriage 15 when the user is in the sitting position. The rail is relatively long, e.g., six feet, and is supported in an elevated position by suitable connection at one of its ends to the frame 27 of the sheet metal box and at the other of its ends to an I-support 115 having a pair of upper arms 117 and a pair of lower arms 119 interconnected by a web 121. Foot members 123 are provided adjacent the lower edges of the lower arms 119 to stabilize the unit, these members being preferably resilient to dampen any vibrations which the traveling of the carriage or operation of the power means may induce.

As previously mentioned, the carriage 15 is supported on the rail 13 for traveling movement toward and away from the body support 11 and, hence, toward and away from a user disposed thereon in either a sitting or a lying position. The carriage comprises a vertically disposed, generally L-shaped plate 125 which includes a horizontally extending base portion 127 and an upright standard 129. The plate is positioned with the base 127 thereof disposed adjacent the vertical plate 105 of the rail 13 opposite the channel beam 100, with approximately equal portions of the base projecting above and below the edges of the plate 105 defining the upper and lower tracks 107 and 109 respectively of the rail.

An upper and a lower set 133 and 135 respectively of horizontally spaced wheels are rotatably mounted on the upper and lower portions respectively extending beyond the tracks, and each wheel is grooved, as at 139 (FIG. 6). The grooves of the upper set 133 of wheels 137 receive the upper track 107 of the rail 13, and the grooves of the lower set 135 of wheels 137 receive the lower track 109. It will be seen, therefore, that the plate 125 and, hence, the carriage 15, is adapted for rolling movement along the rail 13 by the provision of the wheels 137, the side walls of the grooves serving to maintain the carriage on the rail. Preferably, the clearance between the wheels and the tracks 107 and 109 of the rail is sufficiently small such that the wheels are maintained in close rolling contact with the tracks, thereby preventing shifting or wobbling of the carriage as it travels. The sets 133 and 135 of wheels are each enclosed by guard shells 141 (FIG. 6) to enhance the appearance of the apparatus and to prevent clothing or the like from being engaged by the wheels.

The carriage 15 is provided with means for assisting a user in exerting either a pulling or a pushing force on the carriage, which means comprise generally a hand grip assembly 143 and a foot plate assembly 145. These assemblies are interconnected such that a force applied to one assembly is transmitted to the other. The foot plate assembly is in turn connected to the gauging means 18 which indicate the magnitude of the force applied.

More specifically, a generally rectangular frame 147 (FIG. 5) formed of narrow elongated strips is affixed to the central portion of the standard 129 of the carriage plate 125, with longitudinally extending edges of the strips being secured, as by welding, to the face of the plate nearest the rail 13. The frame includes a top strip 149 disposed in vertically spaced relation to the upper edge of the standard 129, a bottom strip 151 spaced downwardly therefrom a substantial distance, and forward and rearward side strips 153 and 155 respectively extending between the top and bottom strips.

Disposed adjacent the top and bottom strips 149 and 151 of the frame 147 and in vertically spaced relation thereto are an upper and lower strip 157 and 159 respectively. As will be seen in FIGURE 5, the top strip 149 of the frame and upper strip 157 define therebetween an upper channel 161, and the bottom strip 151 of the frame and the lower strip 159 define therebetween a lower channel 163. The upper and lower channels 161 and 163 receive portions of the hand grip assembly 143 and foot plate assembly 145 respectively, as hereinafter described. A face plate 165 extending between the upper strip 157, the lower strip 159, and the side strips 153 and 155, and secured to each, completes the supporting portion of the carriage.

Carried within the upper channel 161 is a tube 167 of rectangular cross section and dimensioned so as to be freely slidable within the channel. A similar tube 169 is positioned within the lower channel 163. To permit es-

sentially frictionless sliding movement of the tubes within the channels, a bearing member **171** is interposed between each of the faces of the tubes **167** and **169** and the adjacent walls of the channels, and each bearing member comprises a thin plate **173** having a transverse slot adjacent each of its ends to receive a cylindrical roller **175**. Each of the tubes **167** and **169** is provided with a pair of opposing lugs **177** which project outwardly from opposite sides thereof and facilitates the interconnection of the tubes, as hereinafter described.

Each of the tubes **167** and **169** has telescopically disposed therein a second tube of rectangular cross section which is adapted at one end for engagement by the body of the user. More specifically, a tube **179** is disposed within the upper tube **167** of the carriage and projects past each of the ends of the tube. The tube **179** is of such a dimension as to be slidable within the tube **167** so as to be adjustable relative to the carriage, but may be secured against relative movement, as when a desired position of adjustment has been achieved, by a latch mechanism **181**. A cross bar **193** serving as a hand grip is affixed to the rearward end of the tube **179** to enable the tube to be grasped with the hands by the user.

A tube **195** is disposed within the lower tube **169** and projects from tube **169** at the rearward end thereof. The tube **195** is adjustable within the tube **169** and a latch mechanism **181** is also provided to interlock the tubes **169** and **195** after the desired position of adjustment has been achieved. A cross bar **199** of rectangular cross section is secured to the rearward end of the tube **195** and has a foot plate **201** secured thereto, thereby providing a flat surface which can be engaged by the feet of the user.

The latch mechanism **181** comprises a hollow stud **183** (FIG. 10) projecting from a side wall of the tube **167** (or **169**) in encircling relation to a hole **187** in the side wall. A cap **185** is carried at the outer end of the stud and is connected to a bolt **189** which is urged inwardly of the tube by a compression spring **190**. The bolt **189** projects through the hole **187** in the side wall of the tube **167** or **169** and through one of a plurality of holes **191** which are provided in the adjacent side wall of the tubes **179** and **195** and which are alignable with the hole **187**. Disposition of the bolt **189** in a hole **191** prevents relative sliding movement between the tubes but, when the bolt is withdrawn, any of several positions of adjustment may be achieved.

The hand grip assembly **143** comprising the tubes **167** and **179**, and the foot plate assembly **145** comprising the tubes **169** and **195**, are interconnected by means of a linkage **203** so that a force exerted on one of the assemblies will be transmitted to the other assembly. Thus, the gauging unit **18** need be responsive to a force exerted on only one of the assemblies which, in the illustrated embodiment, is the foot plate assembly **145**. The linkage **203** comprises a pair of rockers **205** disposed on opposite sides of, and extending between, the tubes **167** and **169** and engageable at their outer ends with the lugs **177** which project from each of the sides of the tubes. The rockers are in turn pivotally mounted intermediate their ends to the carriage **15** by means of a mounting unit **207**.

More specifically, the mounting unit **207** comprises a generally flat plate **209** disposed adjacent the rearward side strip **155** of the frame **147**. A block **211** integral with the plate and projecting rearwardly therefrom is provided with a transverse horizontally extending bore for receiving a pin **213** which defines the axis about which the rockers pivot.

The rockers **205** are disposed on opposite sides of the mounting unit **207** and each is in the form of an elongated generally vertically disposed bar having a central hole to receive the pin **213**. Each of the rockers is bifurcated at each of its ends to provide slots **215** which receive the lugs **177** of the tubes **167** and **169**. Accordingly, the rockers pivot about the axis of the pin **213** and, when one of their ends is moved incident to a force applied to one of the assemblies **143** or **145**, the opposite end will be moved also and thereby transmit the applied force to the opposite assembly.

It will be appreciated that unless the rockers are pivoted exactly centrally of the tubes **167** and **169**, there will be a mechanical advantage in favor of one of the assemblies and a factor of error, however small, will be introduced into the system. Accordingly, and in order to facilitate accurate centering of the pin **213**, the mounting **207** is adjustably secured to the strip **155**. In this regard, the plate **209** is provided with a vertically elongated slot **217** above and below the block **211**, each slot being adapted to receive a bolt **219** threaded into a tapped hole in the strip **155**. The plate **207** is therefore vertically adjustable when the bolts **219** are loosened. In addition, a boss **221** is secured to the strip **155** above and below the plate **209** and is provided with a vertically disposed tapped hole adapted to receive an elongated adjusting bolt **223** which engages the adjacent edge of the plate **209**. By loosening one of the bolts **223** and tightening the other with the bolts **219** loosened, the position of the plate **209** and, hence, of the pin **213**, can be adjusted within very close tolerances.

Accordingly, a force applied to one of the assemblies **143** or **145** is transmitted to the other assembly through the rockers **205**. More importantly, a force is exerted on the foot plate assembly **145** regardless of whether the user applies a force to the hand grip assembly **143** or directly to the foot plate assembly. The gauging unit **18** is connected to the foot plate assembly but, because of the above referred to interconnection, is responsive to forces exerted on the hand grip assembly as well. Actually, the transmission of the forces through the rockers **205** results in a change in direction of the forces, i.e., a forwardly directed force on one of the assemblies will be transmitted to the opposite assembly as a rearwardly directed force. However, this does not affect the gauging unit **18**, which is equally responsive to forces in either of two directions.

Referring now to the gauging or indicating unit **18**, there is provided a transducer **225** mounted at the forward end of the tube **169** of the foot plate assembly **145**, the transducer being effective to translate longitudinally directed forces applied to the tube **169** into fluid pressure, whether these forces be applied directly through the foot plate **201** and tube **195**, or indirectly through the tube **167** and linkage **203**. The fluid pressure within the transducer **225** is transmitted through a conduit **227** to a gauge **229** which provides a reading, preferably in units of force. The gauging unit **18** is responsive to both push and pull forces, thus rendering it effective to indicate push and pull forces applied to the carriage incident to both eccentric and concentric isotonic contractions.

More specifically, the transducer **225** comprises a generally cylindrical body **231** which includes a cup section **233** and a cap section **235** threadedly interconnected to define an internal cavity **237**. The cup section **233** includes a generally circular end wall **239** and a generally cylindrical side wall **241**. The end wall is provided with abutments **243** and **245** on each of its outer and inner faces respectively, and a hole **246** extends centrally through the abutments and receives an elbow-shaped fitting **247** which provides a connection between the transducer and the conduit **227**. The outer edge portion of the cylindrical side wall **241** is machined to provide a somewhat greater internal diameter terminating in a shoulder **249**, and is threaded to receive the cap **235**.

The cap **235** comprises a generally cylindrical threaded plug **251** flanged adjacent its outer end and adapted to be inserted into the cup until the peripheral portion of its inner end is disposed immediately adjacent the shoulder **249** of the cup. A hole extends centrally through the cap and receives the threaded neck of a relatively short square shaft or bar **253** having a configuration similar to, but

dimensions less than, the interior of the tube **169**. The shaft extends outwardly of the cap and is fixedly secured thereto.

The cavity **237** of the body **231** is divided into a forward and rearward chamber by means of a generally circular diaphragm **255** clamped between the forward peripheral portion of the cap **235** and the shoulder **249**. The forward chamber (to the left in FIG. 7) is filled with an oil or similar fluid which also occupies the conduit **227** and a portion of the gauge **229**. A piston **257** occupies a portion of the rearward chamber and comprises a flat circular disk **259** and a piston rod **261**. The disk **259** is disposed in face to face contact with the rearward surface of the diaphragm **255**, and the rod **261** extends outwardly from the disk through a bore **262** provided in the square shaft **253**, previously referred to.

It will be seen, therefore, that when the piston **257** is moved forwardly (to the left, FIG. 8), the fluid within the transducer is placed under pressure and a reading is provided on the gauge **229**. Likewise, if the piston is maintained in a stationary position but the transducer body **231** is moved rearwardly (to the right, FIG. 8), the fluid will again be placed under pressure and a reading again provided. Relative movement between the transducer body and the piston is effected whenever a force is applied to the foot plate assembly by virtue of a unique connection between the transducer and the tube **169**, as hereinafter described.

More specifically, the square shaft **253**, which is rigidly connected to the transducer body **231** and which is provided with a bore **262** to receive the rod **261** of the piston **257**, is also provided with a transverse slot **263** adjacent the inner end of the bore **262** and with a transverse circular hole **265** spaced rearwardly from the slot **263**. Each the slot **263** and hole **265** receive pins **267** and **269** respectively. However, the slot **263** is so disposed relative to the bore **262** that, when the pin **267** is positioned in the slot, the rearward end of the piston rod **261** abuts the side wall of the pin. Moreover, the slot **263** is elongated in the direction of the length of the shaft, thereby permitting the pin **267** to be moved forwardly in the slot relative to the shaft **253** and, in so moving, to also urge the piston rod **261** forwardly relative to the shaft **253**. Since the shaft **253** is affixed to the transducer body **231**, movement of the piston relative to the shaft results in movement of the piston relative to the transducer body as well.

The body of the shaft **253** is carried within the forward end of the tube **169** and is maintained therein by the pins **267** and **269** which project through horizontally spaced slots **271** and **273** respectively located in opposite side walls of the tube **169**. The slots **271** and **273**, like the slot **263**, are elongated in the direction of the length of the tube and, from FIGURE 9 it will be noted that the distance between the rearward edge **275** of a slot **271** and the forward edge **277** of a slot **273** is equal to the distance between the rearward wall of the slot **263** and the forward wall of the hole **265**. Also, when the apparatus is not being operated, the pin **267** is disposed in abutting relation to the rearward wall of the slot **263**.

It should now be understood that since the pin **267** is in engagement with the piston rod **261**, and since the shaft **253** is affixed to the transducer body **231**, movement of the pin forwardly relative to the shaft **253** will cause relative movement between the piston and transducer body so as to create a fluid pressure within the transducer. This relative movement may be accomplished by maintaining the pin **269** stationary (there is no relative movement between the pin **269** and the shaft **253**) and moving the pin **267** forwardly, or may be accomplished by holding the pin **267** stationary and moving the pin **269**, and with it the shaft **253**, rearwardly. The pins **267** and **269** are alternately moved by forward or rearward movement of the tube **169**, as when a force is applied thereto, and are alternately maintained in a stationary position by engagement thereof with the carriage **15**, as hereinafter described.

More particularly, the tube **169**, within which the shaft **253** is carried, is disposed, as has already been mentioned, within the lower channel **163**. The channel **163** is defined on opposite sides by the plates **125** and **165** of the carriage, which plates are stationary insofar as the carriage is concerned, and these plates are provided with slots **279** and **281** elongated in a horizontal direction and spaced horizontally from one another such that the distance between the rearward edge **283** of a slot **279** and the forward edge **285** of a slot **281** is equal to the distance between the rearward edge **275** of a slot **271** and the forward edge **277** of a slot **273** of the tube **169**. The ends of the pins **267** and **269** protrude through the slots **279** and **281**, and these pins may be capped at their outer ends to prevent them from being inadvertently withdrawn.

In the operation of the gauging unit **18**, when a force directed toward the left (FIG. 9) is applied to tube **169**, either through the tube **195** or as transmitted from the tube **167** through the linkage **203**, the tube, pins, shaft **253** and transducer **225** are moved until the pin **269** abuts the forward edges **285** of slots **281** in plates **125** and **165**, thus limiting forward movement of the pin **269** and, hence, of the shaft **253** which is affixed to the transducer body. Further forward movement of the tube **169** causes forward movement of the pin **267** by virtue of the engagement of the rearward edges **275** of the slots **271** of the tube with the pin, and this forward movement of the pin **267** causes forward movement of the piston rod **261** which is in abutting relation thereto. Accordingly, the piston is moved while the shaft **253** and transducer body **231** are stationary, thus placing the fluid within the transducer under pressure.

Movement of the tube **169** in the rearward direction (to the right in FIGS. 7 and 9) causes the pin **267**, the shaft **253** and transducer **225** to be moved rearwardly until the pin **267** engages the rearward edges **283** of slots **279** in plates **125** and **165**, thus limiting further rearward movement of the pin **267**. Since the piston rod **261** abuts the pin **267**, such contact maintains the piston in a stationary position as well. Further rearward movement of the tube **169** causes the pin **269** to move rearwardly by virtue of the engagement of the edges **277** of slots **273** with the pin, and this movement of the pin **269** carries with it the shaft **253** and, hence, the body **231** of the transducer **225**. Accordingly, the transducer is moved relative to the piston and a fluid pressure is again created within the transducer.

It will be appreciated that the movement of the above described elements is very slight, e.g., ⅛ inch. This slight movement is negligible and does not affect the accuracy of the evaluation where it is desired to maintain at a constant value the distance through which the body moves.

The gauging means **18** enables a user to obtain an indication of the magnitude of the force applied to the carriage when the carriage is moving and the force is exerted by muscles in isotonic contraction, or when the carriage is at rest, in which case the force is exerted by muscles in isometric contraction. It should be realized that the force exerted on the carriage will vary with the distance of the carriage from the body support **11**, with the particular muscles which exert the force, and, when the carriage is moving, with the speed at which it is traveling. The gauging means **18** can be utilized to accurately determine the strength of various muscles, to determine a weakness in a muscle as in a portion of its range of motion, and to determine the degree to which the muscle responds to therapy.

Referring now to the power means **17**, there is providing generally a constant speed electric motor **287**, a drive shaft **289** coupled to the carriage **15**, and a pulley **291** carrying belts connecting the motor and drive shaft, the pulley being adjustable to permit the speed of the

drive shaft to be varied while the speed of the motor remains constant. The power means 17 also includes a mechanism 293 for reversing the direction of rotation of the motor substantially instantaneously so as to effect a corresponding reversal in the direction of movement of the carriage.

More particularly, the electric motor 287 is preferably capable of rapidly achieving and then maintaining a constant speed, and of rapidly reversing the direction of rotation of its armature by a sudden change in the electrical power supplied to the motor. For example, the motor may be operated on direct current, in which case a reversal in the direction of flow of current will effect a reversal in the direction of rotation of the armature. Alternatively. the motor may be a single-phase A.C. motor with the switch means 295 being effective to cause a change in the direction of a rotating magnetic field. Either form of motor would be suitable. The shaft of the motor has affixed thereto a pulley 299 to receive a belt 301 by means of which the mechanical power of the motor is transmitted to the drive shaft 289.

Also, the size and torque characteristics of the motor 287 are preferably such that it is capable of causing traveling movement of the carriage at a constant speed whether or not a load is applied to the carriage and despite the magnitude of the load. In effect, therefore, the motor-driven carriage provides a supra-maximal resistance to isotonic contractions. Accordingly, even though the user exerts a maximal rather than a supra-maximal force, he is always assured of at least a maximal resistance. The user may, of course, exert less than a maximal force, in which case the carriage will offer a sub-maximal resistance.

The motor 287 is affixed to a plate 303 pivotally mounted adjacent its upper end to the upper portion of the frame 27 of the rectangular metal box of the body support 11. Accordingly, the plate 303 is swingable within the box about its pivotal axis and is therefore capable of shifting the position of the motor slightly to compensate for changes in the position of the pulley 291, hereinafter described. The plate is guided in its swinging movement by a bolt 305 secured adjacent the lower end of the frame 27 and extending inwardly of the box and through a suitable hole in the plate. An enlarged head 307 is provided at the inner end of the bolt and a compression spring 309 encircles the bolt and serves to urge the plate 303 in a direction which will maintain the belt 301 of the motor pulley 299 in a taut condition.

Electrical connection to the motor 287 is made through the switch 295 which controls the nature of the power supply to the motor. The switch has two operative conditions which are determined by the alternate positions of a toggle 311. When the toggle is in a first position, the motor shaft 297 is caused to rotate in one direction, and when the toggle is in a second position, the motor shaft 297 is caused to rotate in the opposite direction. An on-off switch (not shown) is preferably also provided to permit interruption of the electrical connection to the motor. Accordingly, movement of the carriage can be halted at any point in its travel to permit isometric exercise and evaluation.

The toggle 311 is pivoted between its first and second positions by a sliding bar 313 which is moved by the carriage when the latter has reached a predetermined limit position. More specifically, the bar is in the form of a thin tube of square cross sectional configuration supported adjacent one end within a square hole provided in the upper arm 117 of the I-support 115 and passing through a similar square hole provided in the forward wall 23 of the body support 11 into engagement with a second support adjacent its opposite end. The rod is therefore slidable longitudinally in either direction within the holes, and is preferably capped at opposite ends to prevent its being inadvertently moved out of the holes.

The portion of the bar disposed within the body support 11 has affixed thereto a collar 315 which is adapted to engage the toggle 311 of the switch 295 and cause the toggle to pivot as the bar moves longitudinally. The postions of the toggle are preferably coordinated with the directions of rotation of the shaft of the motor and, hence, with the directions of rotation of the drive shaft 289 such that movement of the bar rearwardly causes the toggle to be pivoted to a position causing the motor 287 to rotate the drive shaft in a direction which will move the carriage forwardly, and such that movement of the bar forwardly causes the toggle to be pivoted to a position causing the motor to rotate the drive shaft in a direction which will move the carriage rearwardly. As will soon become apparent, movement of the carriage rearwardly past a predetermined position causes the bar to move rearwardly and reverses the direction of rotation of the motor so as to cause the carriage to commence forward movement. Conversely, movement of the carriage forwardly past a predetermined position causes the bar to shift forwardly so as to reverse the direction of rotation of the motor and cause the carriage to commence rearward movement.

Sliding movement is imparted to the bar 313 incident to movement of the carriage by means of a bracket 317 extending laterally from the carriage and including a hole 319 through which the bar extends. A pair of stops 321 are carried by the bar in spaced relation to one another on opposite sides of the bracket 317 and are positionable in any of a plurality of positions along the bar. Accordingly, movement of the carriage in either direction eventually brings the bracket 317 into contact with one of the stops 321, thus causing the bar to be shifted in the direction of movement of the carriage and causing a reversal in the direction of movement. Each stop comprises (FIG. 6) a frame 323 which carries a pin 325 biased downwardly by a spring 327 into engagement with any one of a plurality of holes 329 in the upper wall of the bar. Preferably, a compression spring encircles the bar 313 adjacent each of the stops to absorb the shock of the bracket striking the stop.

The stops 321 can be positioned in any of several locations along the bar 313 and can be utilized to selectively control the distance through which the carriage travels in either direction. Since the extent of movement of the carriage is directly related to the range of motion of the body during the exercise, this range of motion can thus be selectively controlled by merely moving the stops 321. Thus, if the muscles of a particular portion of the body are found to be especially weak in a small segment of the range of motion of this portion of the body, the exercise can be concentrated in this segment. If, on the other hand, a stretching of the muscles is desired, a traveling movement of much greater length can be provided.

The drive shaft 289 of the apparatus (FIG. 7) comprises a hollow tube 331 extending outwardly from the interior of the rectangular box in adjacent relation to the rail 13 and journalled for rotation in bearings 332 affixed to the frame 27 and to the rail 13. A large pulley 333 is keyed to the rearward or inwardly disposed end of the tube 331 to receive a belt 334, and a nut 335 and is secured within the tube adjacent its forward end to receive a threaded shaft 337, hereinafter described.

The threaded shaft 337 is affixed to the plate 125 of the carriage by means of a block 338 through which it passes and to which it is keyed by a pin 339. The shaft extends rearwardly from the block 338 into threaded engagement with the nut 335 of the tube 331 such that the tube and shaft are concentrically disposed. When the tube rotates, the shaft 337 is moved either inwardly or outwardly thereof so as to move the carriage toward or away from the body support 11.

The pulley 229 of the motor 287 and the pulley 333 of the drive shaft 289 are interconnected by means of the belts 301 and 334, each of which extends to, and encircles, the intermediate speed control pulley 291 rotatably mounted on a shaft 340. The pulley 291 comprises a pair

of plates **341** and **342** disposed in a fixed spaced relation to one another on the shaft **339** and provided with conical surfaces on their opposing faces. A shiftable plate **343** having conical surfaces on each of two oppositely directed faces is disposed intermediate the plates **341** and **342**.

Accordingly, it will be seen that, in effect, two pulleys are provided on a common shaft, one pulley being defined by the plate **341** and the adjacent side of the plate **343** and receiving the belt **334**; the other pulley being defined by the plate **342** and the adjacent side of the plate **343** and receiving the belt **301**. As the shaft **339** on which the pulley **291** is mounted is moved toward the pulley **333** of the drive shaft, the tension on the belt **301** will cause the plate **343** to shift toward the plate **341**, thus providing the belt **301** with a lesser pulley diameter at the shaft **339** and increasing the speed of rotation of the shaft **339** and, hence, of the drive shaft pulley **333**. This shifting of the plate **343** also increases the pulley diameter of the belt **334** at the shaft **339** and therefore further increases the pulley diameter of the belt **334** at the shaft **339** and, consequently, further increases the speed of rotation of the pulley **333**.

Shifting movement of the pulley shaft **339** to effect a change in speed of the drive shaft **289** is accomplished by the mounting of the pulley shaft on the lower end of an arm **345** pivotally attached at its upper end to the frame **27** of the body support **11**. Swinging movement of the arm **345** effective to shift the position of the shaft **339** is accomplished by means of a lever **347** secured at one of its ends to the arm in spaced relation to the upper end thereof, and having at its opposite end a circular plate **349** eccentrically keyed to a shaft **351** such that rotation of the shaft will cause generally lateral movement of the arm lever **347** and, hence, pivotal movement of the arm **345**. Rotation of the shaft **351** is accomplished by a crank **353** affixed to the shaft and disposed adjacent the forward wall **23** of the body support **11**.

By virtue of the above-described pulley arrangement, it is possible to selectively vary the speed at which the carriage moves on the rail **15**. By varying the speed, the rate at which the muscle fibers change length, either by shortening, as in concentric contractions, or lengthening, as in eccentric contractions, can also be varied.

In the above description of the apparatus, it has been assumed that the user engages the hand or foot assemblies of the carriage directly, i.e., that either the hands or feet of the user are brought into direct engagement with one of the assemblies. In FIGURES 11 through 13, however, a manner of using the apparatus in which there is no direct contact but rather, one or more cables **355** interconnect the body of the user with the foot plate assembly. The cables are guided by a pair of horizontally disposed pulleys **357** mounted on the rail **13** adjacent the body support **11** and by a vertically disposed pulley **359** mounted on the forward wall of the body support. The pulleys determine the direction of the force applied to the body of the user through the cables **355**. For example, longitudinal forces are applied with the vertically disposed pulley **359** and transverse or lateral forces are applied by the horizontally disposed pulleys **357**.

As can be seen from the drawings, the use of the cables is capable of providing the desired exercise involving both isotonic and isometric contractions at selectively variable speeds and over a selected segment of a range of motion of the body. The use of the cables permits exercise and evaluation of substantially all of the major muscles of the body.

Accordingly, it will be seen that an apparatus has been provided which is adapted to both increase and evaluate the strength of the muscles of a user throughout the range of motion of portions of the body associated with these muscles. The evaluation of the strength of the muscle provides an accurate indication of the forces exerted thereby by maintaining constant both the speed of movement of the bodily parts and the distance through which the parts move.

While the present invention has been shown and described with respect to one specific embodiment, it should be apparent that various structural modifications may be made therein without departing from the scope of the invention.

What is claimed is:

1. An exercising apparatus having a platform for supporting the body of a user, which apparatus comprises a carriage, means guiding said carriage for movement along a predetermined path, power means for effecting movement of said carriage along said path, means on said carriage for assisting a user in exerting a force on the carriage in a direction parallel to the direction of movement thereof, said latter-mentioned means including a first member engageable by the hands of the user and a second member engageable by the feet of the user, said members being interconnected through a pivot point located intermediate said members so that a force exerted on one of the members is transmitted without change in magnitude to the other of the members, and means connected to the other of the members for indicating the magnitude of the force exerted by the user.

2. An exercising apparatus comprising means defining a surface for supporting the body of a user, an elongated track extending from said surface, a carriage movable along said track and adapted to receive a force exerted thereon by the user, power means for moving said carriage along said track toward and away from said body-supporting surface, a cable attachable at one of its ends to said carriage and adapted to be engaged by the user at the other of its ends, pulley means intermediate the carriage and the body-supporting surface for guiding said cable, and means for effecting movement of said carriage along said path.

3. An exercising apparatus having a platform for supporting the body of a user, which apparatus comprises a member adapted to receive forces exerted thereon by the user in directions toward and away from the user, means for guiding said member for movement along a predetermined path, power means for effecting movement of said member along said path, and means for evaluating the magnitude of the said forces exerted on the member by the user, said evaluating means comprising a transducer including a hollow body defining a reservoir containing a quantity of liquid, a rod disposed adjacent said reservoir and movable relative thereto incident to a force applied to the rod, movement of said rod in a given direction relative to said reservoir being effective to place said liquid under a pressure proportionate to the force applied to said rod, said transducer being mounted on said carriage such that a force applied to said carriage in a given manner causes relative movement of said rod in said given direction, and gauge means connected to said transducer and adapted to indicate the force required to create the said fluid pressure.

4. An apparatus for providing resistance to push and pull forces exerted by a muscle incident to isotonic contractions of the muscle, which apparatus comprises a platform for supporting the body of a user, a track extending from said platform, a carriage moving along said track and adapted to receive a force applied thereto by a user, power means for moving said carriage along said track, a transducer mounted on said cariage and including a hollow body defining a reservoir containing a quantity of liquid, a rod extending inwardly of said transducer body into adjacent relation to said reservoir and movable inwardly of said transducer body incident to a force applied to said rod in a given direction, movement of said rod inwardly of said transducer body being effective to place said liquid under a pressure proportionate to the force causing said movement, means limiting relative movement between said carriage and said transducer body in one direction, means limiting relative movement between said rod and said carriage in the opposite direction, a member slidable relative to said carriage and connected to said

transducer body and said rod in such a manner that movement of said member relative to said carriage in said one direction is effective to move said rod in the direction of said transducer body, and in such a manner that movement of said member relative to said carriage in said other direction is effective to move said transducer body in the direction of said rod, thereby placing said fluid under a pressure, and gauge means connected to said transducer and adapted to indicate the force required to create the said fluid pressure.

5. An apparatus for providing resistance to push and pull forces exerted by a muscle incident to isotonic contractions of the muscle, which apparatus comprises a platform for supporting the body of a user, a track extending from said platform, a carriage movable along said track and adapted to receive a force applied thereto by a user, power means for moving said carriage along said track, a transducer mounted on said carriage and including a hollow body defining a reservoir containing a quantity of liquid, one end of said transducer body being provided with a hole, a rod extending inwardly of said transducer body through said hole and having an end disposed adjacent said reservoir, movement of said rod inwardly of said transducer body being effective to place said liquid under pressure, a bar secured to said one end of said transducer body in the vicinity of the said hole and having a longitudinally extending bore to receive the outwardly extending portion of the said rod, said rod being provided with a first transverse hole located adjacent the end of said bore and with a second transverse hole spaced from the first transverse hole in a direction away

from said transducer body, a first and a second pin disposed in said first and second transverse holes respectively, said first pin being engaged by the opposite end of said rod, a hollow member slidably mounted on said carriage and adapted to receive said bar, said member being provided with slots to receive the pins of the transverse holes of the bar, said member being disposed on said carriage such that when said member is moved in one direction relative to the said carriage, the said second transverse pin engages said carriage and is restrained from movement whereas the said first transverse pin moves in said one direction and moves said rod inwardly of said transducer body, and when said member is moved in the opposite direction the said first transverse pin engages said carriage and is restrained from movement whereas the second transverse pin moves in said opposite direction and causes movement of said rod inwardly of said transverse body, and gauge means connected to said transducer and adapted to indicate the force required to create the said fluid pressure.

References Cited

UNITED STATES PATENTS

528,779	11/1894	Kellogg	73—379
1,984,165	12/1934	Tolchin	272—79
2,714,507	8/1955	Goodrich	272—79 X
2,924,456	2/1960	Miller	272—79
3,045,667	7/1962	Sellner	128—25
3,103,357	9/1963	Berne	73—379 X
3,130,968	4/1964	Feen	272—79 X

RICHARD C. QUEISSER, *Primary Examiner.*