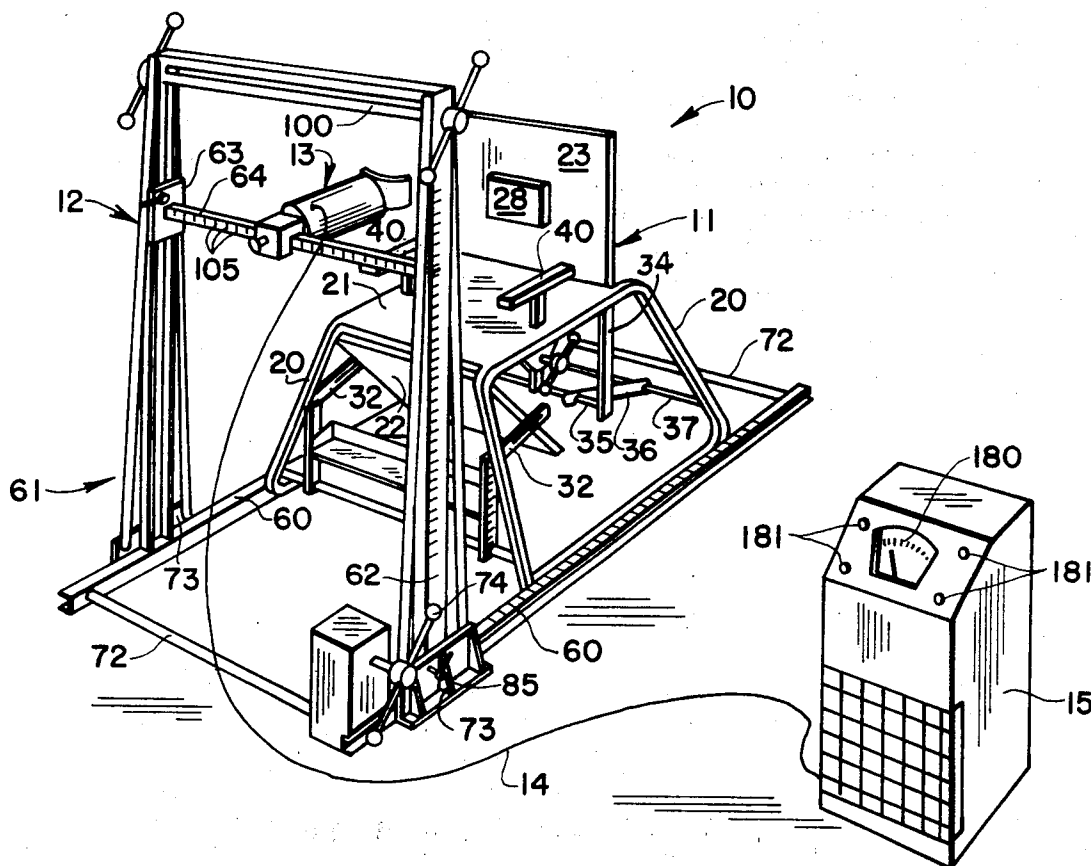


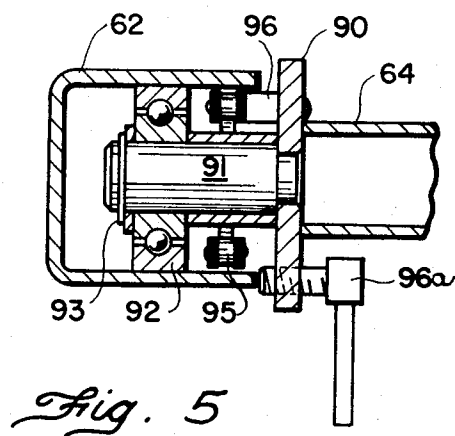
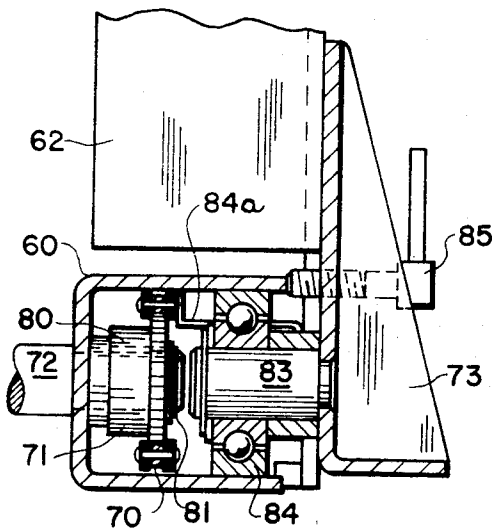
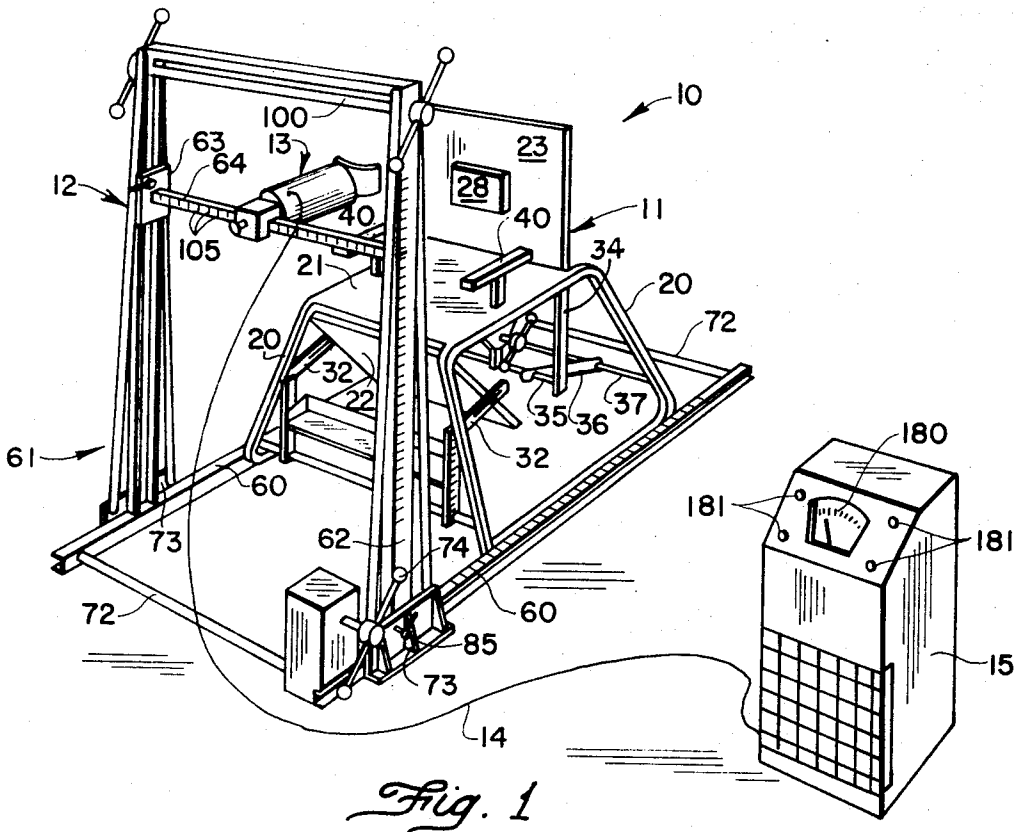
[54] **MUSCULAR EVALUATION METHOD AND TESTING APPARATUS**[76] Inventor: **Keith E. Weigle, Jr.**, Chagrin River Rd., Gates Mills, Ohio 44040[22] Filed: **July 23, 1971**[21] Appl. No.: **165,683**[52] U.S. Cl. **128/2 S**[51] Int. Cl. **A61b 5/00**[58] Field of Search. **128/2 R, 2 S; 73/379; 272/73, 57 R**[56] **References Cited****UNITED STATES PATENTS**

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Primary Examiner—Lawrence W. Trapp
Attorney—Donald M. Wright et al.[57] **ABSTRACT**

An adjustable apparatus and method for positioning a force sensor adjacent various portions of the patient's body and for measuring and recording forces exerted by the voluntary muscles of the patient. The apparatus is calibrated such that the adjustment of the apparatus for positioning the patient and the force sensor may be recorded and later exactly reproduced. An adjustable calibrated platform positions the patient while an adjustable calibrated frame positions the force sensor. The frame and the patient support platform are relatively movable such that the force sensor may be positioned adjacent substantially any portion of the patient's body. The adjustments of the apparatus are recorded such that the position of the patient and the force sensor may later be duplicated to compare the patient's muscular condition at spaced time intervals.

31 Claims, 19 Drawing Figures



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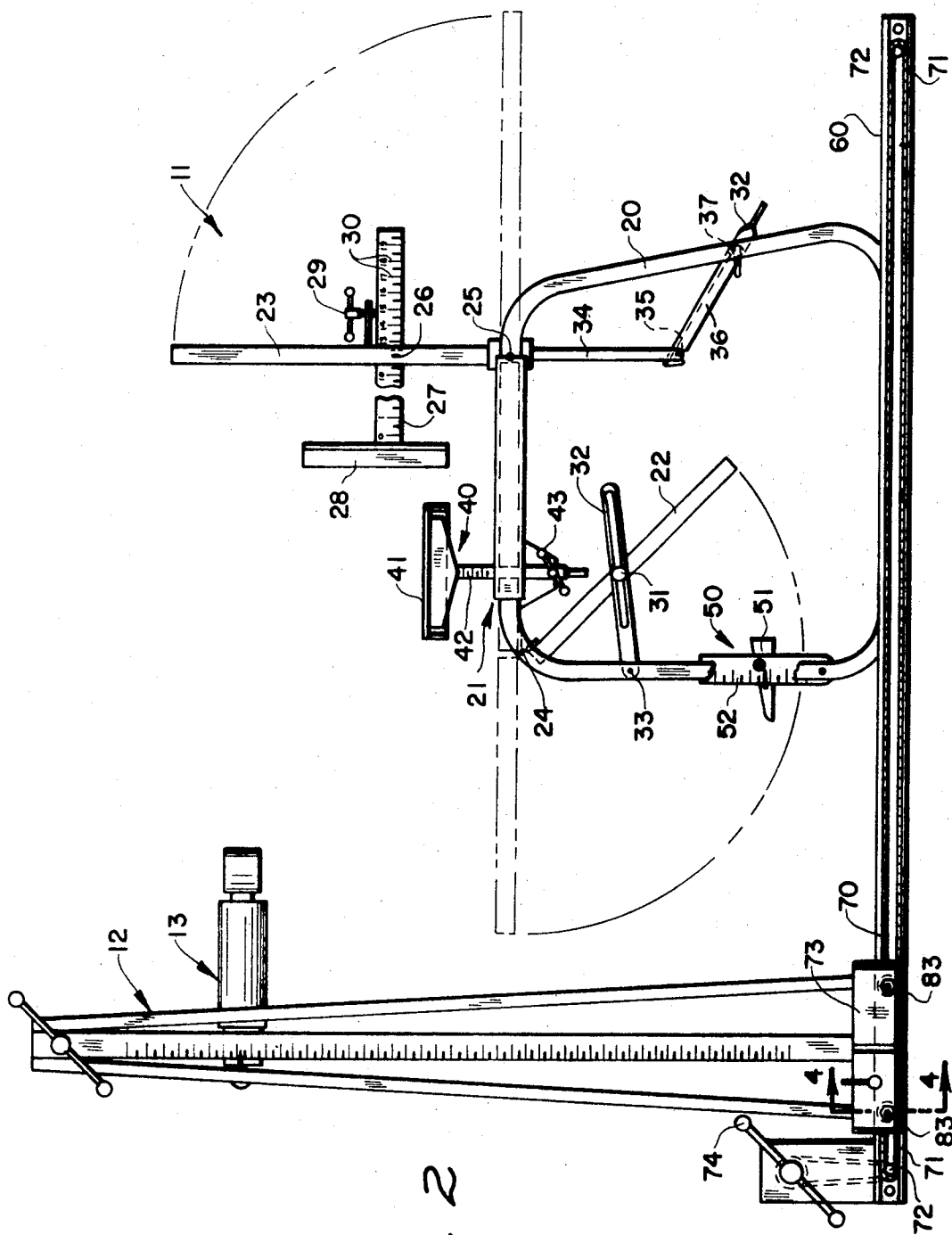


Fig. 2

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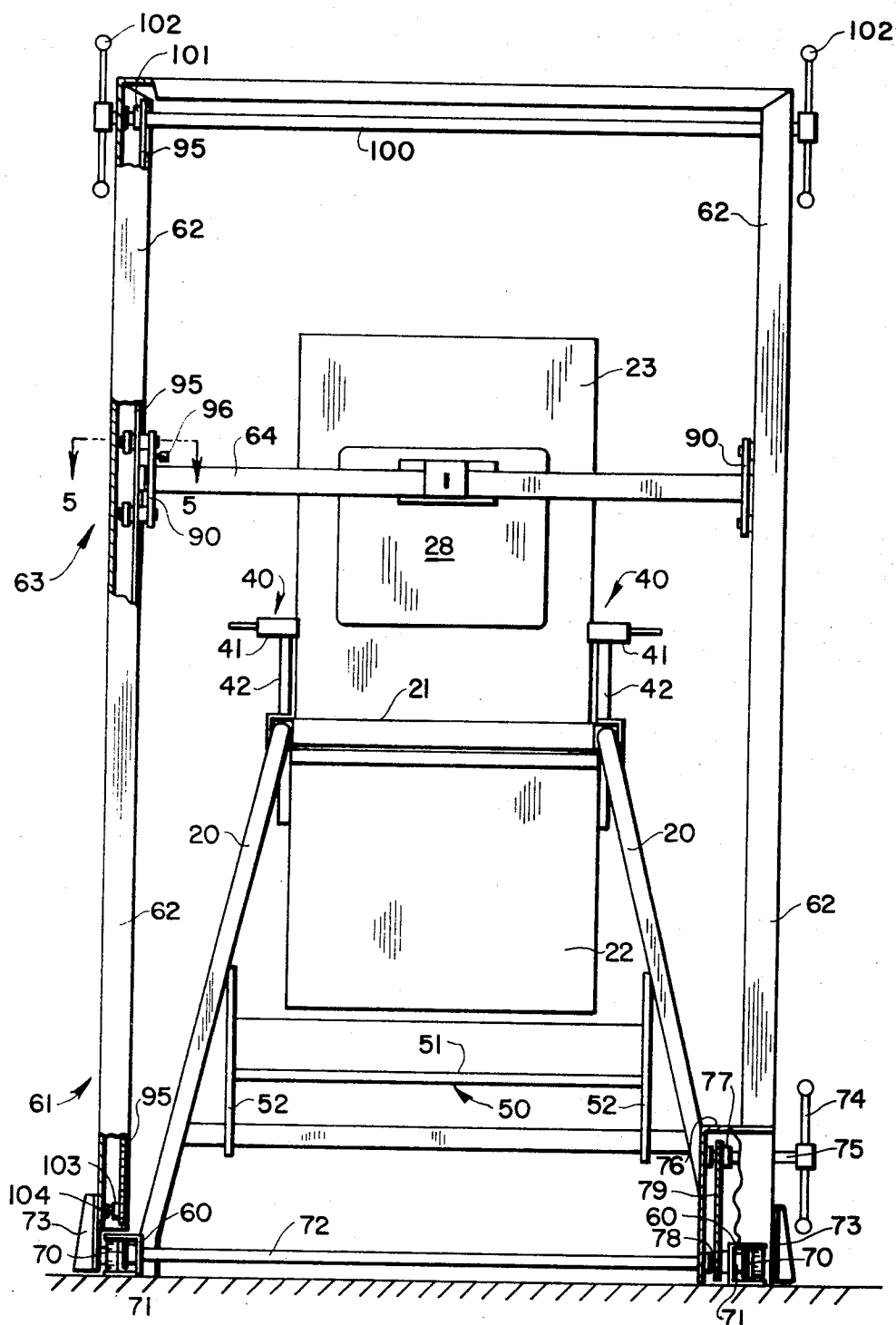


Fig. 3

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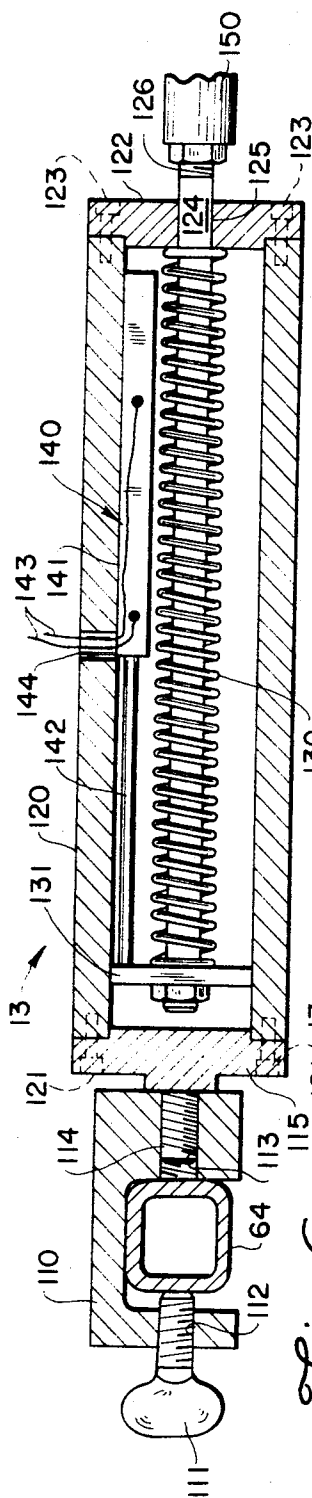


Fig. 6

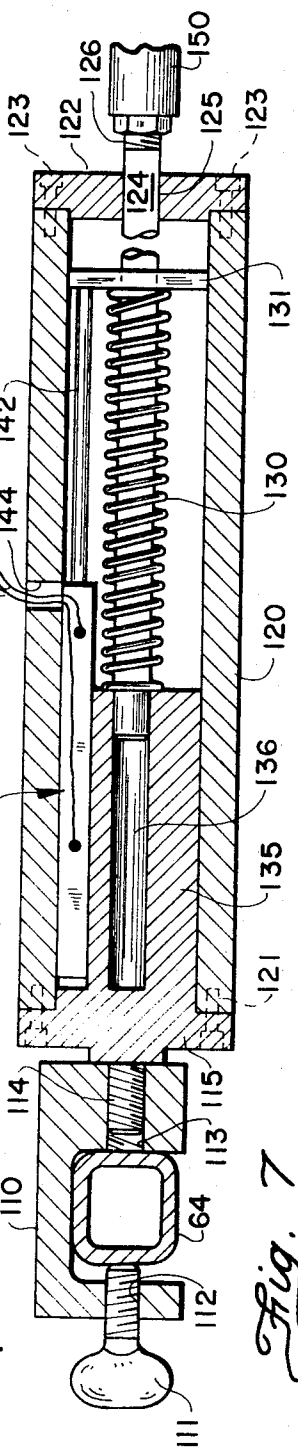


Fig. 7

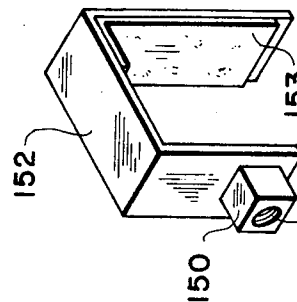


Fig. 8

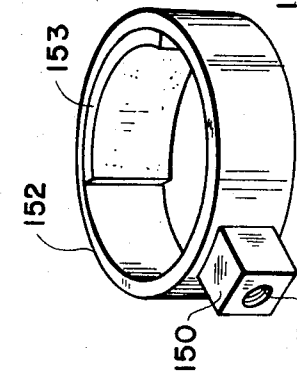


Fig. 9

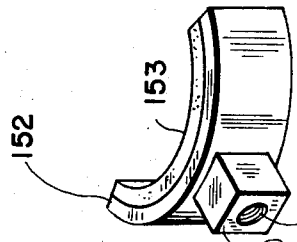


Fig. 10

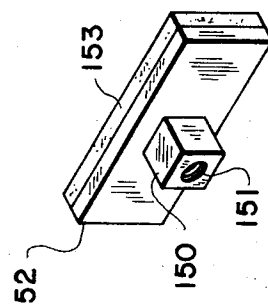
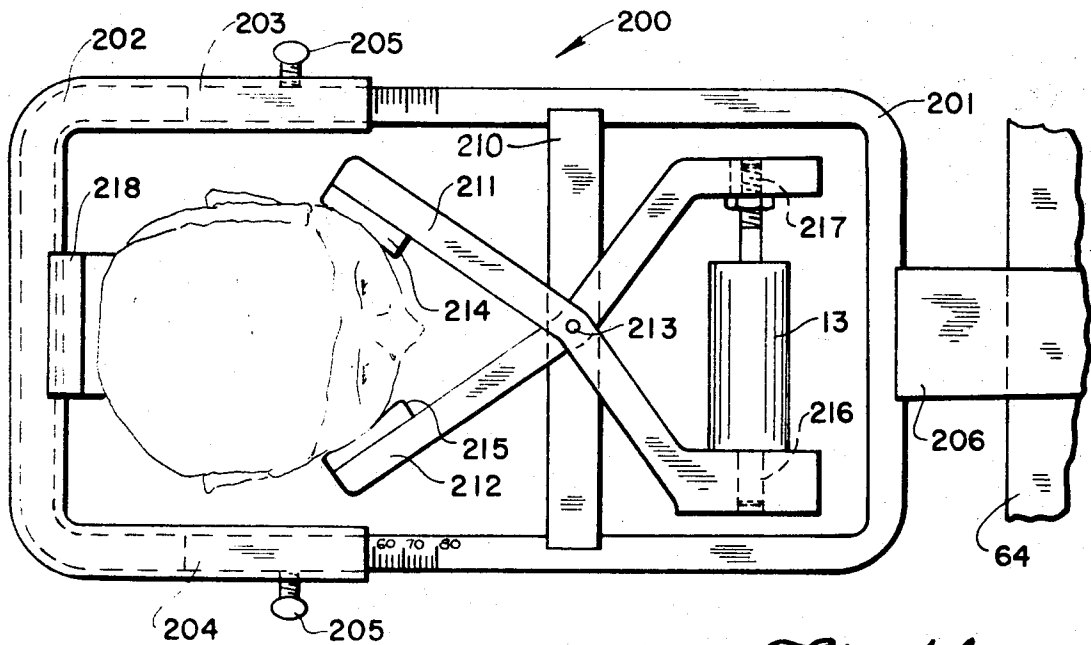


Fig. 11

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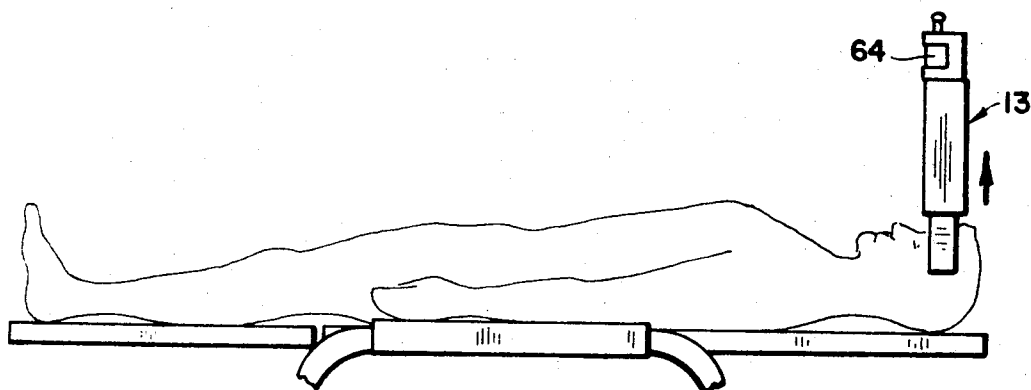


Fig. 16

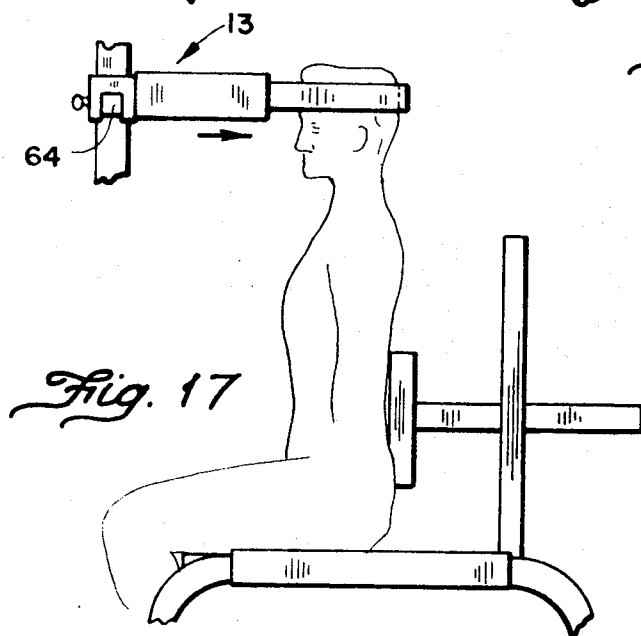


Fig. 17

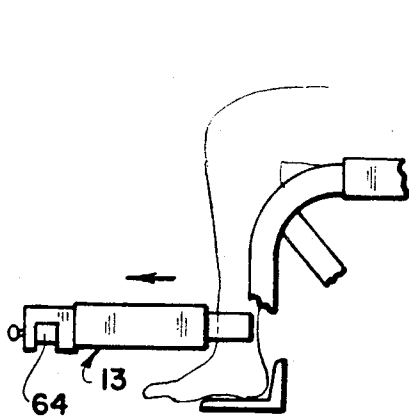


Fig. 18

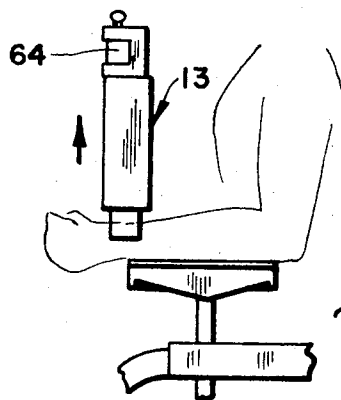


Fig. 19

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MUSCULAR EVALUATION METHOD AND TESTING APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to the science of muscular evaluation and more particularly to improved and novel methods and apparatus for muscular evaluation.

2. Prior Art

A variety of muscle testing devices have been proposed by the prior art. However, no acceptable medical diagnostic apparatus has previously been developed which is suitable for use by members of the medical profession for properly evaluating the condition and progress of a patient suffering from a muscle disorder. Since suitable diagnostic apparatus has not been available, the diagnosis of persons with many types of muscular disorders has been relatively primitive. Even in the best of clinics known for their skilled physicians and elaborate equipment, the accepted and most exclusively used procedure for evaluating the muscular improvement or deterioration of a patient comprises having the patient push, pull, or exert some other force on the examining physician. The physician then endeavors to recall his impression of the force which the patient was able to exert during a previous visit, and compares these two events in his mind to reach a conclusion regarding the patient's condition.

The reliability of such an impression, recall, and evaluation procedure is questionable, particularly where the physician sees hundreds of patients between visits with any particular one patient. His ability to recall exactly what force a patient could exert during a prior visit is likely to be subject to error.

Hence, while a variety of muscular evaluation devices have been proposed, the fact remains that they have not been found to be practical or widely acceptable for use in medical diagnosis.

One significant problem common to most known muscular evaluation devices is that they are not adapted for use in testing muscles or muscle groups at substantially any selected position over the patient's body. Rather they comprise specialized devices adapted for use in testing only limited muscle groups, such as those associated with the hand, or the arm, etc.

Most known muscular evaluation devices are not designed to permit later duplication of the testing environment. This drawback is two-pronged in nature. First, most known muscular evaluation devices fail to provide adequate reference surfaces or positioning means whereby the relative position of the patient and the apparatus is exactly controlled. Second, most known devices are not adequately calibrated such that their position relative to the patient can be recorded and later reproduced. Together these drawbacks render it impossible to assure that at each subsequent testing, the apparatus is positioned in the same relative location to the muscles being evaluated. Accordingly, a variation in the lever-arm through which forces are applied frequently results in false data which does not correspond to prior examinations.

It should be realized that a very significant need which has in no way been solved by prior art devices in the provision of an apparatus which can be universally used to provide significant muscular evaluation data on large numbers of patients. No acceptable apparatus has

previously been developed whereby, for instance, data can be compiled to indicate normal ranges of muscle strengths for persons according to sex and body build. No universally acceptable apparatus or method for muscular evaluation has previously been provided, the data from which can be meaningfully interpreted and understood by doctors, athletic directors, and the multitude of others who must evaluate and classify persons according to physical fitness.

SUMMARY OF THE INVENTION

The present invention provides a significant step forward in the science of muscular evaluation, and provides novel and vastly improved methods and apparatus for muscular testing and evaluation.

In accordance with one important aspect of the present invention, an adjustable apparatus is provided for receiving and supporting patients of a wide range of body builds. By the term "patient", it is intended to include all such persons as may be tested by the methods and apparatus of the invention, and accordingly it is to be understood that persons who are not under the direct care of a doctor are not to be excluded from the intended scope of this term.

An adjustably positioned force sensor is provided which can be positioned adjacent substantially any portion of a patient's body whereby forces exerted by various muscles and muscle groups can be sensed and recorded. The apparatus has calibrations associated with each of its adjustments whereby both the position of the patient and the position of the force sensor may be recorded and later be duplicated.

One advantage of the apparatus of the present invention is that testing conditions for a particular patient may be exactly duplicated at spaced time intervals. Accordingly the muscular condition of a patient can be accurately ascertained, and his muscular improvement or deterioration can be accurately measured. Another significant advantage is that patients of similar body build may be tested under identical conditions to improve data indicative of the normal range of muscular characteristics for patients of that particular body make-up.

Still another extremely significant advantage of the present invention is the provision of an apparatus whereby many muscular characteristics of patients of a wide variety of physical builds can be measured and correlated. The data so correlated may then be used to establish standards for muscular condition and normality ranges enabling the muscular condition of a particular patient to be meaningfully compared to that of many other persons.

In accordance with one method of muscular evaluation of the present invention, a patient is positioned in an adjustable calibrated supporting apparatus. The apparatus is then adjusted to accommodate the physical build of the patient. The apparatus is further adjusted to position a force sensor adjacent a portion of the patient which is movable in response to movement of such muscles as are to be evaluated. The settings of the apparatus when so adjusted are recorded such that the patient may later be repositioned in the apparatus in exactly the same manner with the sensor adjacent the same portion of the patient. The force applied to the sensor by movement of the muscles under evaluation is then measured and recorded. By this arrangement, data obtained from repeated tests of the patient over spaced

intervals of time may be used to evaluate the patient's muscular improvement or deterioration.

In accordance with another method of the present invention, a large number of patients are tested in an adjustable calibrated apparatus including patient support means and force sensor means which may be adjustably positioned to receive patients of a wide range of physical builds. Each of the patients is tested in accordance with the following steps:

1. the patient is positioned in the apparatus;
2. the apparatus is adjusted to accommodate the physical build of the patient;
3. the apparatus is further adjusted to position the force sensor adjacent a portion of the patient which is movable in response to movement of such muscles as are to be evaluated;
4. the settings of the apparatus so positioned are recorded in order that other patients of similar physical build may be positioned in exactly the same manner in the apparatus for testing; and,
5. the forces applied to the sensor by the patient upon moving the muscles under evaluation are measured and recorded.

The test information so obtained is then compiled into table corresponding to the physical make-up of the person so tested such that a range of performance characteristics is established for patients of various physical make-ups.

The present invention has a wide range of application. The apparatus is a highly versatile diagnostic tool for use by the medical profession. It is also useful in quantitatively evaluating the effect of drugs on the body.

In physiotherapy, the methods and apparatus of the invention permit the therapist to quantitatively evaluate the progress of a patient. Persons recovering from strokes have been found to improve to a point at which their improvement tends to plateau. The present invention enables the therapist to know when this plateau is reached, beyond which point most therapy is a waste of time.

The present invention is a valuable tool in programming the exercise of an athlete. Athletes tend to loose fitness or decay during the off-seasons of their particular sports. When they begin training again at the opening of a new season, different parts of their bodies regain fitness more quickly than others. The present invention permits quantitative evaluation of the progress of an athlete's training whereby the athlete's muscle groups which are slow in responding to training can be detected. Where athletes are tested at the height of their fitness during a previous season, these test results may be compared with tests during a subsequent training prior to quantitatively evaluate the athlete's fitness.

Still other applications for the present invention will be apparent to those skilled in the art. As an employee screening device for industry, the present invention is effective to detect back injuries and other potential health problems. Accident victims complaining of a wide range of injuries can also be tested by the methods and apparatus of the present invention. By measuring the amount of force such persons are able to exert and the length of time over which they are able to continuously or repetitiously exert such force, the presence or absence of an injury and its extent are often quantitatively determinable.

Accordingly, it is the principal object of the present invention to provide improved methods and testing apparatus for muscular evaluation.

Other objects and a fuller understanding of the invention may be had by referring to the following description and claims taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of one embodiment of the muscular evaluation apparatus of the present invention;

FIG. 2 is a side elevational view of the apparatus of FIG. 1, illustrating in phantom various movements of the patient positioning apparatus;

FIG. 3 is an end elevational view of the apparatus of FIG. 2 with portions broken away to illustrate detail;

FIG. 4 is a sectional view as seen from the plane indicated by the line 4—4 in FIG. 2;

FIG. 5 is a sectional view as seen from the plane indicated by the line 5—5 in FIG. 3;

FIG. 6 is a sectional view illustrating a tension force sensor which may be used in conjunction with the apparatus of FIG. 1;

FIG. 7 is a sectional view illustrating a compression force sensor;

FIGS. 8—11 are perspective views illustrating various padded muscle engaging devices for use in conjunction with the force sensors of FIGS. 6 and 7;

FIG. 12 is a perspective view illustrating a variable angle mounting device for the force sensors of FIGS. 6 and 7;

FIG. 13 is an elevational view of a force sensor support for testing the bite of a patient;

FIG. 14 is a plan view of a force sensor support for testing the facial muscles of a patient;

FIG. 15 is a perspective view of an alternate embodiment of the apparatus of the present invention; and,

FIGS. 16—19 are schematic illustrations showing an exemplary few of the muscle testing arrangements which may be provided by the apparatus of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1, a muscular evaluation apparatus is shown generally at 10. The apparatus 10 generally comprises a patient support device 11 and a force sensor support frame 12. A force sensor, indicated generally by the numeral 13, is carried by the frame 12. As will be explained in greater detail, the force sensor 13 includes an electrical signal generating means which is coupled by an electrical cable 14 to an electrical display and recording instrument 15.

Referring to FIGS. 2 and 3, the patient support device 11 comprises a pair of generally trapezoidal-shaped upright frame members 20. The members 20 rigidly support a horizontally disposed platform 21.

A pair of support panels 22, 23 are provided forwardly and rearwardly of the platform 21. Each of the panels 22, 23 is pivotally mounted for movement relative to the platform 21. The panel 22 is hinged about an axis 24 so as to be pivotal from a position beneath the platform 21 to a substantially horizontal position. The panel 23 is hinged about an axis 25 so as to be pivotal from the vertical position shown in FIG. 2 to a substantially horizontal position. When the panels 22, 23

are in their horizontal position, they serve as extensions for the platform 21.

The panel 23 is provided with a centrally disposed through aperture 26. A support bracket 27 extends through the aperture 26 so as to be movably carried by the panel 23. A suitably padded backrest member 28 is carried by the bracket 27. A locking device 29 is provided for locking the bracket 27 in place relative to the panel 23. A series of calibration marks 30 are provided along the bracket 27. By this arrangement, the backrest 28 may be suitably positioned in contact with a patient and locked in place. The position of the backrest may then be ascertained from the calibration marks 30 and recorded. The backrest 28 and the support bracket 27 may be removed when the panel 23 is positioned horizontally to serve as an extension for the platform 21.

A pair of threaded clamping bolts 31 are carried by opposite sides of the panel 22. A pair of slotted latch arms 32 are slidably positioned on the bolts 31 such that the bolts 31 may be tightened to clamp the arms 32 against the sides of the panel 22. The arms 32 are mounted about an axis 33 for pivotal movement relative to the frame members 20. By this arrangement, the bolts 31 serve to clamp or lock the panel 22 in position.

A pair of arms 34 extend from the panel 23 into the region below the platform 21. The arms 34 journal the ends of a rod 35 which extends between the lower ends of the arms 34. A notched latching arm 36 is pivotally mounted on a rod 37. The rod 37 extends between the frame members 20 and has its ends journaled by the frame members. The notched latching arm 36 is engageable with the rod 35 to lock the panel 23 in its vertical position. Alternately the rod 35 is engageable with the underside of the platform 21 to hold the panel 23 in its horizontal position.

A pair of arm supports 40 are adjustably carried by the frame members 20. The arm support 40 are constructed in a manner similar to the backrest 28, and include suitably padded support portions 41 carried on calibrated brackets 42. The brackets 42 are extensible in vertical directions relative to the frame members 20. Locking devices 43 are provided to lock the brackets 42 in place relative to the frame members 20.

An adjustable foot support member 50 is provided between the frame members 20. The foot support includes a movable platform 51 carried between a pair of uprights 52. The uprights 52 are calibrated along their lengths to indicate the position of the platform.

The force sensor frame 12 includes a pair of horizontally extending track members 60. A first carriage structure 61 is slidably mounted on the horizontal track members 60. The first carriage 61 includes a pair of vertically extending track members 62. A second carriage structure 63 is slidably mounted on the vertical track members 62. The second carriage 63 includes a horizontally extending mounting bar 64. The force sensor 13 is removably secured to the bar 64, as will be described in greater detail.

A chain drive system is provided for moving the first carriage structure 61 along the horizontal track member 60. As is best seen in FIGS. 2 and 3, each of the track members 60 comprises an outwardly facing U-shaped channel having a roller chain positioned therein. The chains 70 are reeved around sprockets 71 carried on shafts 72 journaled by the track members 60. The chains 70 are endless and connect with carriage base members 73.

A rotatable crank 74 is provided for moving the chains 70 and hence the carriage 61 along the tracks 60. The crank 74 is mounted on a shaft 75. The shaft 75 is rotatably supported by a bracket 76. A sprocket 77 is carried on the shaft 75. An aligned sprocket 78 is carried on the shaft 72. An endless chain 79 is reeved around the sprockets 77, 78. By this arrangement, rotation of the crank 74 will cause rotation of the shafts 75, 72 and, consequently, movement of the chains 70 and the carriage 61.

Referring to FIG. 4, the arrangement of parts within one of the U-shaped channels 60 is shown in greater detail. Each of the sprockets 71 is keyed to an end of one of the shafts 72 by a key 80. A snap ring 81 carried in an annular groove in the shaft 72 holds the gear 71 in place on the shaft.

The carriage base members 73 mount stub shafts 83. Ball bearings 84 carried on the stub shafts 83 support the carriage 61 for movement relative to the tracks 60. Brackets 84a are connected to the base members 73. The brackets 84a connect with the endless chains 70 to cause the carriage 61 to move in response to movement of the chains. The shafts 72 and sprockets 71 assure that the chains 70 will move in unison to move the carriage 61.

Threaded locking bolts 85 are carried by threaded apertures formed through the carriage base members 73. The locking bolts 85 are positioned to releasably engage the tracks 60 to clamp the first carriage 61 and the track 60 to prevent relative movement therebetween.

Referring to FIGS. 3 and 5, the second carriage 63 includes a pair of end plates 90. The end plates 90 mount stub shafts 91. Ball bearings 92 are mounted on the stub shafts 91 to guide the movement of the carriage 63 relative to the upright tracks 62. Snap rings 93 engage grooves in the stub shafts 91 and hold the bearings 92 in place.

Endless roller chains 95 are positioned in the upright tracks 62 in a manner similar to that of the chains 70. Brackets 96 are carried by the end plates 90 for connection with the chains 95.

Threaded locking bolts 96a are carried by threaded apertures formed through the end plates 90. The locking bolts 96a are positioned to releasably engage the tracks 62 to clamp the second carriage 63 and the tracks 62 to prevent relative movement therebetween.

A rotatably mounted control shaft 100 is journaled for support by the tracks 62 adjacent their upper ends. The shaft 100 carries sprockets 101. The roller chains 95 are reeved over the sprockets 101. Cranks 102 are provided to rotate the shaft 100 and to move the chains 95 in unison.

As is best seen in FIG. 3, a sprocket 103 is provided adjacent the lower end of each of the tracks 63. Stub shafts 104 rotatably mount the sprockets 103. The chains 95 are reeved around the sprockets 103.

The horizontal mounting bar 64 is provided with calibration marks 105 along its length. The calibration marks 105 serve to indicate the position of the force sensor 13 along the bar 64.

Referring to FIGS. 6 and 7, two embodiments of the force sensor 13 are shown in greater detail. Both embodiments have identical outer housing and support structures, which will now be described.

A C-shaped mounting bracket 110 is provided to support the force sensor 13 from the horizontally extend-

ing mounting bar 64. A threaded clamping member 111 extends through a threaded aperture 112 in the C-shaped bracket for releasably engaging the mounting bar 64. By this arrangement, the C-shaped bracket 110 may be positioned anywhere along the mounting bar 64 and clamped in position.

The C-shaped bracket has a second threaded aperture 113. The apertures 112, 113 are preferably axially aligned. A force sensor mounting stud 114 is threaded into the aperture 113. The stud 114 is formed integrally with a housing end plate 115. The housing end plates 115 differ in configuration in the embodiments of FIGS. 6 and 7, as will be explained in greater detail.

A hollow cylindrical housing 120 is secured to the end plate 115 by suitable fasteners 121. The end plate 115 serves to close one end of the housing member 120. The other end of the housing is closed by an apertured end plate 122. The end plate 122 is secured to the housing by suitable fasteners 123.

A rod member 124 is telescopically carried within the housing 120. The rod 124 extends through an aperture 125 in the end plate 122. The outer end 126 of the rod 124 is threaded to provide attachment means in order to mount various muscle engaging devices, as will be explained in greater detail.

The portion of the rod 124 which extends internally of the housing 120 carries a coil spring 130. The coil spring 130 is a compression coil spring adapted to exert a force opposing its compression in an axial direction. A plunger 131 secured to the rod 124 engages one end of the coil spring 130. In the embodiment of FIG. 6, the other end of the coil spring engages the end plate 122. In the embodiment of FIG. 7, the other end of the coil spring engages the end plate 115.

Referring to FIG. 6, the end plate 115 has a substantially planar configuration which serves simply to close one end of the housing 115. The plunger 131 is slip fitted within the housing and serves to support the rod 124.

Referring to FIG. 7, the end plate 115 has a substantially cylindrical portion 135 extending into the hollow housing 120. The portion 135 has a cylindrical guide hole 136 which carries one end of the rod 124.

In each of the force sensor embodiments a linear potentiometer 140 is provided to sense relative movement of the ends of the spring 130. The linear potentiometer 140 comprises a variable resistance device including a housing 141 which telescopically receives an axially translatable shaft 142. Linear potentiometers of this type are sold by Bourne Laboratories, Riverside, California.

In each of the embodiments of the force sensor, the transducer housing 141 is mounted on the housing 120, while the shaft 142 is secured to the plunger plate 131. By this arrangement, the shaft 142 will move with the rod 124 to vary the resistance of the transducer in accordance with the relative position of the rod 124 and the housing 120.

A pair of conductors 143 connect with the transducer 140 and extend through an aperture 144 in the wall of housing 120. The conductors 143 form part of the cable 14 which connects with the console 15. The cable 14 also includes a shielded jacket to shield the conductors 143 from spurious signals.

Referring to FIGS. 8-11, several embodiments of muscle engaging devices are illustrated. Each of the muscle engaging devices includes a square shoulder

150. A threaded aperture 151 is provided in the shoulder 150 to provide attachment means for threadably receiving the threaded end 126 of one of the force sensor rods 124. Additionally, each of the muscle engaging devices has a bracket structure 152 having portions 153 suitably padded. The bracket structure 152 is rigidly connected to the shoulder 150. By this arrangement, the muscle engaging devices may be threaded onto the force sensor rods 124 so as to be supported by the force sensor.

The bracket structures 152 may take on a variety of configurations, some of which are illustrated in FIGS. 8-11. It will be understood that the bracket structures are intended to provide a suitable configuration for engaging various regions of a patient's body. The devices of FIGS. 8 and 9 provide padded regions opposite the shoulder 150 and, as such, are primarily intended for use with the tension force sensor of FIG. 6. The devices of FIGS. 10 and 11 provide padded regions adjacent the shoulder 150 and, as such, are primarily intended for use with the compression force sensor of FIG. 7. As will be apparent, many other muscle engaging devices may be constructed with such contours and surfaces as are required to engage particular body surface portions.

Referring to FIG. 12, a variable angle mounting device 160 is shown for supporting the force sensors 13. The variable angle mount 160 is intended to replace the C-shaped mounting bracket 110 where the force sensor 13 needs to be tilted relative to the bar 64.

The variable angle mount 160 includes a C-shaped bracket 161 with a threaded locking bolt 162. A semi-circular support portion 163 connects with the bracket 161. The portion 163 defines a semi-circular chamber within which is positioned a circular disc 164. A shaft 165 has its ends journaled by the portion 163. The shaft 165 extends through the disc 164 and rotatably mounts the disc 164 with suitable bearings, not shown.

A square shoulder 166 rigidly connects with the disc 164. The shoulder 166 is provided with a threaded aperture 167. The threaded aperture 167 is adapted to receive the threaded stud 114 which mounts the force sensor 13.

The semi-circular portion 163 is provided with a semicircular slot 168. Calibration marks 169 are formed on the disc 164. The calibration marks 169 may be read in conjunction with one or more reference marks 170 to indicate the angular position of the disc 164 relative to the bracket 161.

A clamping screw 171 is threaded through an aperture in the portion 163 for releasably engaging the disc 164. By this arrangement, the disc can be clamped in a preselected position to hold one of the force sensors.

Referring to FIG. 13, a special purpose force sensor support 180 is illustrated. The support 180 is designed to facilitate measuring the bite force of a patient. The support 180 comprises first and second arms 181, 182 which are pivotally connected at 183. One end of each of the arms 181, 182 is provided with a throw-away plastic insert 184. The inserts 184 are removably interference fitted over the end portions of the arms 181, 182 and may be replaced following each use so as to provide a sanitary means of engaging a patient's teeth.

The inserts 184 are provided with end portions 185 of reduced cross-section. Shoulders 186 mark the transition between the main body of the inserts 184 and their reduced cross-sectional end portions. The shoulder

ders 186 are intended to be positioned in abutting contact with a patient's front teeth. By this arrangement, the patient's biting force is applied to the support 180 along a lever arm of controlled length, and the test environment may be easily duplicated at a later date.

A mounting block 188 forms the other end of the arm 181. The mounting block 188 includes a C-shaped bracket 189 with a threaded locking bolt 190 for securing the support 180 to the bar 64.

The mounting block 188 also includes a threaded aperture 191 for receiving the threaded stud 114 of the compression force sensor 13 as illustrated in FIG. 7. The arm 182 is provided with a threaded aperture 193 adapted to receive the threaded end 126 of the force sensor piston rod 124.

The support 180 operates in the manner of a pair of pliers to apply a compression force to the sensor 13 in response to the patient's exerting a biting force on the inserts 184. As will be apparent, the support 180 may be constructed with a variety of lever arm lengths, or with arms 181, 182 of adjustable calibrated length, so as to increase or decrease the sensitivity of the force sensor measurements in accordance with the biting capacity of a particular patient.

Referring to FIG. 14 a force sensor support 200 is illustrated. The support includes a pair of relatively movable U-shaped frame members 201, 202. The member 202 is substantially hollow along its length and telescopically receives the ends 203, 204 of the member 201. A pair of threaded lock members 205 are carried by the member 202 to releasably engage the ends 203, 204 and thereby clamp the members 201, 202 against relative movement.

The member 201 is provided with a C-shaped mounting bracket 206 of the same type employed in the aforescribed supports. The C-shaped bracket 206 mounts the support 200 on the bar 64.

A cross-member 210 extends between opposite legs of the U-shaped member 201. A pair of arms 211, 212 are pivotally mounted at 213 on the cross-member 210. The arms 211, 212 are provided with muscle engaging pads 214, 215 at one end, and with force sensor support apertures 216, 217 at the other end. In the manner of the support 180, a force sensor 13 is supported by the apertures 216, 217 so as to extend between the arms 211, 212.

The support 200 is adapted to be positioned over the head of a patient. A padded bracket 218 is carried by the frame member 202 for engaging the back of a patient's head. With the support positioned over a patient's head, the frame members 201, 202 are adjusted to bring the pads 214, 215 into engagement with the patient's cheek muscles. Such force as may then be exerted by the patient in holding his mouth closed and puffing his cheeks is then transmitted to the force sensor 13. In this embodiment, the sensor 13 is a tension sensor as shown in FIG. 6.

From the foregoing it will be apparent that a wide variety of force sensor supports and muscle engaging brackets may be used with the apparatus of the present invention. However, one significant feature of the wide variety of patient support and force sensor support devices that may be used with the apparatus of the present invention is that the apparatus is calibrated in conjunction with each adjustable member to enable the settings of the apparatus to be recorded and later exactly duplicated.

While the apparatus shown in FIGS. 1-3 provides an upstanding carriage 61 which is movable relative to the track members 60 and to the patient support device 11, the arrangement of these structures may be reversed while still rendering the carriage and the patient support relatively movable. Referring to FIG. 15, a second embodiment of the apparatus of the present invention is illustrated. In this embodiment, the patient support device 11' is mounted on rollers 230 which engage track members 60'. The upstanding members 62' are rigidly secured to the track members 60'. By this arrangement, instead of the members 62' forming a carriage which is movable relative to the patient support device 11', the patient support device is rendered movable relative to the members 62'. Calibrations are still provided along the track members 60' to ascertain the position of the patient support device.

The advantage of the arrangement of FIG. 15 is that the chain drive for the carriage 61 can be eliminated. The patient support device 11' is sufficiently rigid that it can simply be pushed into position along the tracks 60' and then locked in place. By eliminating the movement between the track members 60' and 62', these members may be rigidly connected to reduce play in the force sensor support apparatus. Except for these modifications, the apparatus of FIG. 15 is substantially identical to the apparatus of FIG. 1 and will not be described in further detail.

Referring to FIGS. 16-19 various applications of the described apparatus are illustrated schematically. In FIG. 16, the force sensor 13 is shown positioned in engagement with the forehead of a patient. By this arrangement, certain neck muscles of the patient may be exercised to exert a compressive force on the sensor 13 which may then be recorded. In FIG. 17, the force sensor 13 is positioned in engagement with the back of the head of a patient. By this arrangement, certain other neck muscles may be exercised to exert a tensile force on the sensor 13. In FIGS. 18 and 19, the force sensor 13 is positioned, respectively in engagement with the ankle and wrist of a patient. By this arrangement, certain muscles of the leg and arm may be exercised to exert a compressive force on the sensor 13.

Referring once again to FIG. 1, the display console 15 includes a galvanometer 180. Suitable controls 181 are provided for calibrating and changing the scale of the galvanometer. Appropriate electrical signal amplification circuitry, not shown, is provided to amplify the signal provided by the force sensor 13 and feed it to the galvanometer 180.

The console 15 may also include suitable recording apparatus for continuously graphically recording the signal from the sensor 13. Since such recording apparatus is well known and does not form a part of the present invention, it will not be described in detail.

In operation, a patient is positioned on the patient support device 11. The various movable portions of the support device 11 are then adjusted to accommodate the particular build of the patient. The settings of the patient support are then recorded so that the exact same testing environment may later be duplicated.

The carriages 61, 63 are then moved into position and locked. The force sensor 13 is then fitted with an appropriate muscle engaging device and locked in position. The positions of the carriages and the force sensor are then recorded.

With the force sensor in position, the patient exercises the muscles under observation so as to exert his maximum available force on the sensor 13. This force causes the spring 130 in the sensor 13 to compress. Simultaneously, the linear potentiometer 140 sends a signal which is representative of the magnitude of the exerted force. The console 15 visually presents the signal on the galvanometer 180 and suitably records the signal graphically if so desired.

The positions of the force sensor and the patient may be changed as desired during the examination to test other muscles and muscle groups. The data so obtained may then be compiled with data from other patients to establish normalcy ranges. By this arrangement, the muscular condition of the patient may be thoroughly and comprehensively evaluated.

Although the invention has been described in its preferred form with a certain degree of particularity, it is understood that the present disclosure of the preferred form has been made only by way of example and that numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and the scope of the invention as hereinafter claimed.

What is claimed is:

1. A method of evaluating muscular condition comprising the steps of:

- a. positioning a patient on an adjustable calibrated supporting apparatus;
- b. adjusting the apparatus to accommodate the physical make-up of the patient;
- c. further adjusting the apparatus to position a force sensor adjacent a portion of the patient which is movable in response to movement of such muscles as are to be evaluated;
- d. recording the settings of the apparatus when so adjusted such that the patient may later be repositioned on the apparatus in exactly the same manner with the sensor adjacent the same portion of the patient;
- e. measuring the force applied to the sensor by the patient upon moving the muscles under evaluation; and,
- f. recording the data so obtained whereby the patient may be repeatedly tested over a period of time to evaluate his muscular condition improvement or deterioration.

2. The method of claim 1 including the additional step of providing the sensor with a remotely positioned indicator means operably coupled thereto for remotely indicating the magnitude of the force sensed.

3. A method of establishing performance tables indicative of the relative muscular condition of a person as compared to other persons of similar physical make-up, comprising the steps of:

- a. providing an adjustable calibrated apparatus including patient support means and force sensor support means which may be adjustably positioned to receive patients of a wide range of physical builds and to position a force sensor means adjacent various portions of the patients positioned in the apparatus;
- b. testing a large number of patients each in accordance with the following steps:
 - i. positioning a patient in the apparatus;
 - ii. adjusting the apparatus to accommodate the physical make-up of the patient so positioned;

iii. further adjusting the apparatus to position the force sensor adjacent a portion of the patient which is movable in response to movement of such muscles as are to be evaluated;

iv. recording the settings of the apparatus so positioned in order that other patients of similar physical make-up may be positioned in exactly the same manner in the apparatus and so tested; and,

v. measuring and recording the force applied to the sensor by the patient upon moving the muscles under evaluation; and,

c. compiling the test information so obtained into tables corresponding to the physical make-up of the persons so tested such that a range of performance characteristics may be established for patients of various physical make-ups.

4. An apparatus for evaluating the muscular condition of muscles of a patient, comprising:

- a. an adjustable calibrated apparatus including patient support means and force sensor support means;
- b. force sensor means carried by said force sensor support means and adapted to engage a portion of a patient's body;
- c. said patient support means comprising relatively movable members which are adjustable to adapt said patient support means to receive and support patients of a wide range of physical make-ups, said patient support means being calibrated such that the adjustments made in the relative positions of said members to accommodate a patient of a particular physical make-up may be reproduced at a later time when working with the same patient or a patient of similar physical make-up;
- d. said force sensor support means and said patient support means being relatively movable to adjustably position said force sensor means adjacent a predetermined portion of a patient which is movable in response to movement of such muscles as are to be tested;
- e. said force sensor support means being calibrated such that the adjustments made in the apparatus to position said force sensor means adjacent said predetermined portion of said patient may be reproduced at a later time; and,
- f. indicator means connected to said force sensor means for providing an indication of the force applied to the force sensor by movement of the muscles under evaluation.

5. The apparatus of claim 4:

- a. including a frame which comprises horizontally extending track means engaging said force sensor support means and said patient support means; and wherein
- b. one of said support means is rigidly secured to said track means while the other support means is movable along said track means relative to said one support means.

6. The apparatus of claim 5 wherein:

- a. said patient support means comprises a platform which may be adjusted to receive and support a patient in sitting or lying positions; and,
- b. said platform is calibrated such that the adjustments made to position a particular patient may be recorded and reproduced at a later time.

7. The apparatus of claim 6 wherein:

- a. said force sensor support means comprises frame means having relatively movable components which may be adjusted to position said force sensor means adjacent a selected portion of the body of a patient; and,
- b. said frame means is calibrated such that the adjustments made to position said force sensor means may be recorded and reproduced at a later time.
8. The apparatus of claim 7 wherein said force sensor support means is rigidly secured to said track means and said patient support means is movable along said track means.
9. The apparatus of claim 7 wherein said patient support means is rigidly secured to said track means and said force sensor support means is movable along said track means.
10. The apparatus of claim 7 wherein said frame means includes carriage means movable relative to said patient support means.
11. The apparatus of claim 10 wherein said frame means additionally includes substantially vertically extending track means mounting said carriage means for movement relative to said patient support means, said vertically extending track means and said carriage means having calibration markings associated therewith such that the position of said carriage means relative to said patient support means can be recorded and later reproduced.
12. The apparatus of claim 11 wherein said carriage means includes a substantially horizontally extending force sensor mounting means adjustably secured thereto, and calibration markings are associated with said mounting means such that the position of said mounting means may be recorded and later reproduced.
13. The apparatus of claim 12 wherein said force sensor mounting means comprises an angularly adjustably mount for a force sensor, said mount having calibration markings associated therewith such that the angular position of a force sensor can be recorded and later reproduced.
14. An apparatus for evaluating the muscular condition of selected groups of muscles of a patient, comprising:
 - a. an adjustable calibrated apparatus including patient support means and force sensor support means;
 - b. force sensor means carried by said force sensor support means and adapted to engage a portion of a patient's body;
 - c. said patient support means and said force sensor support means having portions extending into engagement with each other to define a translational path of relative movement whereby said support means are movable relative to each other along said path;
 - d. said portions having calibration markings associated therewith such that the relative positions of said support means may be recorded and later reproduced;
 - e. said patient support means comprising relatively movable members which are adjustable to adapt said patient support means to receive and support patients of a wide range of physical make-ups, said patient support means being calibrated such that the adjustments made in the relative positions of said members to accommodate a patient of a par-

- ticular physical make-up may be reproduced at a later time when working with the same patient or a patient of similar physical make-up;
- f. said force sensor support means being adjustable to position said force sensor means adjacent a predetermined portion of a patient which is movable in response to movement of such muscles as are to be tested, said force sensor support means being calibrated such that the adjustments made in the apparatus to position said force sensor means adjacent said predetermined portion of said patient may be reproduced at a later time; and,
- g. indicator means associated with said force sensor means for providing an indication of the force applied to the force sensor by movement of the muscles under evaluation.
15. The apparatus of claim 14 wherein said force sensor means comprises a tension force responsive device including movable members, means biasing said members toward each other, and signal generating means coupled between said members for indicating the relative position of said members.
16. The apparatus of claim 14 wherein said force sensor means comprises a compression force responsive device including relatively movable members, means biasing said members apart, and signal generating means coupled between said members for indicating the relative position of said members.
17. The apparatus of claim 14 wherein said force sensor means includes first and second relatively movable members, biasing means engaging each of said members, signal generating means coupled between said members for indicating their relative position, said first member being adapted for mounting on said frame, and said second member being adapted to carry a muscle engaging device.
18. The apparatus of claim 17 wherein said first member comprises a housing telescopically receiving said second member, and said biasing means is disposed within said housing.
19. The apparatus of claim 17 wherein said force sensor means additionally includes a muscle engaging device carried by said second member, said muscle engaging device being lightly padded to comfortably engage a portion of the patient's body.
20. The apparatus of claim 17 wherein said force sensor comprises a tension force responsive device and said muscle engaging device includes portions engageable with certain portions of a patient's body for applying a tension force to said force sensor.
21. The apparatus of claim 17 wherein said force sensor comprises a compression force responsive device and said muscle engaging device includes portions engageable with certain portions of a patient's body for applying a compression force to said force sensor.
22. An apparatus for evaluating the muscular condition of muscles of a patient by positioning the patient in a predetermined attitude and measuring the static force which the patient is able to exert along a plurality of pre-selected axes comprising:
 - a. patient support means for receiving and supporting a patient, said patient support means comprising relatively movable members which are adjustable to adapt said patient support means to receive and support the particular body build of the patient under evaluation, said patient support means being calibrated such that adjustments made in the rela-

tive positions of said members to accommodate that patient may be reproduced later to facilitate positioning of that patient or another patient of similar body build in a desired testing attitude;

- b. force sensor means for selectively engaging predetermined portions of the patient's body and for generating a signal representative of the static force which the patient is able to exert on said force sensor means along an axis;
- c. force sensor support means coupled to said patient support means for supporting said force sensor means, said force sensor support means being adjustable and calibrated to facilitate the positioning of said force sensor means in contact with a selected portion of the patient so as to measure the force which he is able to exert along a corresponding one of a plurality of predetermined axes.

23. The apparatus of claim 22 additionally including indicator means operably coupled to said force sensor means for providing a visual indication of the force applied to said force sensor means.

24. The apparatus of claim 22 additionally including track means interposed between said patient support means and said force sensor means for facilitating the repositioning of said force sensor means relative to the patient.

25. The apparatus of claim 24 additionally including locking means associated with said track means for releasably locking said force sensor means in a desired position relative to the patient.

26. The apparatus of claim 24 wherein said force sensor support means includes carriage means movable along said track means for positioning said force sensor means in a desired position relative to the patient.

27. The apparatus of claim 22 wherein said force sensor means comprises first and second members, one received telescopically within the other, means axially bi-

asing said members toward a predetermined neutral position, and means for generating a signal representative of the force applied in moving said members axially relative to each other away from said neutral position.

28. The apparatus of claim 27 wherein said biasing means is pre-selected in accordance with the range of force which will be exerted to move said first and second members relative to each other, such that the biasing means exerts a biasing force of a magnitude which will limit the axial relative movement of the members to a range which is less than one inch in length, whereby the variation in positioning of the patient during testing is minimized.

29. Apparatus according to claim 4 in which said force sensor means comprises two assembled relatively movable members, one being carried by said force sensor support means and the other having first attachment means thereon for detachably mounting a muscle engaging device, said apparatus including a plurality of differently shaped muscle engaging devices respectively adapted for engagement with different parts of a patient's body and each having attachment means co-operable with said first attachment means.

30. Apparatus according to claim 4 in which said force sensor support means comprises a mounting bar and means rigidly supporting said bar at locations spaced longitudinally of the bar, said force sensor means being mounted on said bar.

31. Apparatus according to claim 30 in which said force sensor support means and said patient support means are relatively movable in one direction, and in which said mounting bar extends in a direction transverse to said one direction and said force sensor means is adjustably positionable along said mounting bar in said transverse direction.

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