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(54) Title: WEIGHT EXERCISE MACHINE

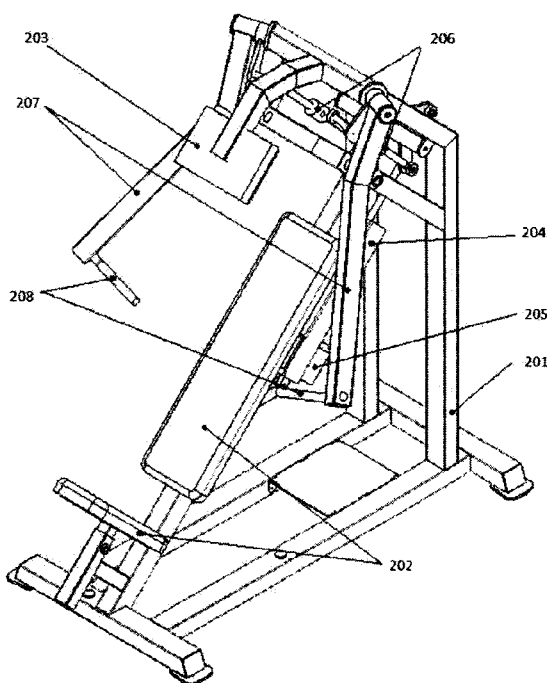


Fig. 2

(57) Abstract: The present invention relates to a weight exercise machine and training methods for development and strengthening of muscles and joints with exercises aimed for overcoming a counteracting force with or without measuring equipment, more specifically, to training devices and training methods with the eccentric phase of the training. The weight exercise machine comprises a frame bearing a seat for an exerciser, the seat fastened to the frame; a touch screen connected with a control unit for controlling training modes and monitoring training parameters; an actuator controlled by the control unit; and an interface interacting with the exerciser. Thus, efficiency of weight training can be improved.



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WEIGHT EXERCISE MACHINE

5 Field of the invention

The present invention relates to training devices and training methods for development and strengthening of muscles and joints with exercises aimed for overcoming a counteracting force with or without measuring
10 equipment, more specifically, to training devices and training methods with the eccentric phase of the training.

Background of the invention

15 An eccentric phase of training is the phase when a tight muscle is stretched under load. By eccentric contraction the muscle-tendon complex stretches and absorbs the mechanical energy. An extensive eccentric training causes a number of muscle adaptations that are advantageous for after-workout recovery and sports events. Muscles can generate a
20 significantly greater eccentric force in comparison with a concentric force. In the eccentric phase, the force is generated by both contractile elements of muscle fibers and by viscoelastic components of connective tissue. At the same time, by concentric contractions the force is generated only by contractile elements.

25 While performing high intensity eccentric exercises, the muscle mass is increased due to the growth of fiber width and the quantity of sarcomeres, mainly, fibers of the II type. In contrast to the traditional concentric training with weights, hypertrophy happens earlier at the eccentric training.
30 Researchers have found that the muscle stretching in the eccentric phase stimulates muscle protein synthesis better than the concentric contraction does.

High intensity eccentric exercises provide a significant increase in strength that is higher than by concentric exercises. Current scientific data for trained sportsmen show that the eccentric exercises effectively increase the strength. Further, an explosive strength can be increased. Taking into account that the muscular fatigue can be incomplete in the concentric exercises, the usage of eccentric phase can lead to higher fatigue of motor units in the body and thus create an additional stimulus to hypertrophy.

Regular eccentric exercises can increase contractile part of a muscle without visual length increase. As a result, two important changes of a muscle function happen: the speed of contraction increases; the force peak is developed earlier. This enables better protection of joints by muscles against damages which can be caused by quick movements because muscles begin to contract earlier, thus increasing the control over a movement. It is one of the reasons to recommend eccentric exercises for prevention of injuries and for rehabilitation.

Eccentric exercises also require much lower level of oxygen consumption and stress on the cardiovascular system as well as lower level of perceived load for any level of the complexity of exercises. Therefore, it was proved that eccentric exercises were the perfect choice for elderly people and people suffering from cardiovascular collapse as the eccentric exercises help to build up muscles quickly and safely, and significantly decrease injury risks without overloading the cardiovascular system.

Some well-known devices for development of strength are already adapted to eccentric exercises.

EP2263759 discloses a device for affecting a muscle or a group of muscles of the exerciser in an eccentric or a concentric mode. Thus, at least one pneumatic cylinder allows, while exercising, limiting the load in the concentric phase of the training in comparison with the eccentric one.

US4865315 discloses a programmable device designed for power control and power management in both the concentric and eccentric phase of physical exercises and the values of applied force are displayed and recorded in a real-time mode and can be sent to external computer systems.

5 Possibility of individual load selection for each exerciser is implemented in this device.

US5254066 discloses a device for applying physical force to the finger, wrist, hand and arm of the exerciser that allows affecting the said body parts
10 of the exerciser concentrically or eccentrically. The device is designed for the physical therapy, rehabilitation and training of the said body parts.

US20150148203 discloses a counter-force system for eccentric exercises wherein the initial movement of the pedal or hand bar is
15 performed without applying any force by the exerciser and upon reaching a specific position of the travel, the system automatically exerts force in the opposite direction in order to return the pedal or hand bar to the initial position.

20 In the examined documents the construction of each device supposes the usage of a weight or a mass that imposes load on exerciser's muscles. Along with this, the limitation of this load is possible by shifting a part of the load to another mechanism (hydraulic cylinder, electric drive). In case of the usage of heavy load, a part of the load also can be shifted and the
25 proportion of this shifted load is limited by the power of drives and the loading capacity of the used mechanisms.

US6716144 discloses a device that allows performing exercises for strengthening abdominal muscles using resilient means in order to provide
30 resistance in the eccentric phase of the exercise and to assist in the concentric phase of the exercise. The flaw of this invention is the usage of a

resilient, uncontrollable element (spring). Such element cannot provide a precise control over the applied load.

The closest prior art to the claimed invention is described in
5 US5476428 disclosing an attachment for weight stack type exercise machines, the attachment comprising weight, an interface interacting with the weight, such as a lifting mechanism, an electric motor, a control unit with keypad, a display and a microcontroller that allow to compensate part of the weight by performing an exercise, as well as to control weight in
10 concentric and eccentric phases. The attachment for weight stack type exercise machines, known from US5476428, provides the diversity of exercises and while adapting them for exerciser's individual requirements due to possibility of controlling the weight along the entire stroke path of the moving part of the attachment.

15 However, considering the abovementioned information, the concentric phase of the exercise loads muscles is less effectively than the eccentric phase of the exercise, and the usage of the concentric phase in the exercise limits the effectiveness of the exercise in whole. This limitation pertains to all
20 known exercise machines, including the closest prior art.

Therefore, there is yet unsatisfied need for improving efficiency of weight training and for providing an exercise machine therefor.

25 **Summary of the invention**

It is an object of the present invention to improve efficiency of weight training.

30 The object is achieved by creating a weight exercise machine comprising:

a frame carrying:

- an actuator having a movable part coupled to an interface interacting with an exerciser to receive a force from the actuator,

wherein the interface is movable along a first stroke path assigned to stretching a target muscle or a group of muscles of the exerciser, and a
5 second stroke path assigned to contracting the target muscle or the group of muscles of the exerciser; and

- a control unit for controlling the actuator such that,
when moving along the first stroke path, the interface opposes the force applied by the exerciser while,

10 when moving along the second stroke path, the interface aids the exerciser by creating a force sufficient for allowing the interface to move, at least partially, along the second stroke path without applying a muscle force of the exerciser to the interface.

15 In one of the embodiments,
the control unit controls an acceleration of the interface when moving, at least partially, along the stroke path; and/or
the control unit controls a length of the stroke path of the interface.

The control over said acceleration on at least on the part of the stroke
20 and the length of the stroke provides the possibility of setting such stroke of interface that it allows to affect a specific (target) muscle or a group of muscles that improves the efficiency of the exercise and makes possible the usage of such exercise machine for the rehabilitation and recovery of muscles after injuries.

25 In one of the embodiments, the interface is provided with a strain gage transducer to transmit a signal to the control unit. The usage of the strain gage transducers configured to transmitting the signal to the control unit allows to record and use for calculations the values of the force applied
30 by the exerciser.

In one of the embodiments, the control unit controls the interface based on the signal from the strain gage transducer .

5 In one of the embodiments, when moving along the second stroke path, the interface aids the exerciser by that the control unit uses a weight of a body part of the exerciser and/or a gravity force affecting the body part. This can improve efficiency of training.

10 In one of the embodiments the control unit measures the weight of the body part of the exerciser and/or the gravity force affecting the body part, based on the signal from the strain gage transducer, when the exerciser, while using the weight exercise machine and interacting with the interface, does not apply his/her muscle force developed by the body part to the interface; and

15 the control unit measures the force created to aid the exerciser, when moving along the second stroke path, based on the measured weight and/or the gravity force. This can improve efficiency of training.

20 In one of the embodiments, the control unit measures the force created to aid the exerciser, when moving along the second stroke path, further based on the phase of the stroke and/or direction of the stroke of the interface. This can improve efficiency of training.

25 In one of the embodiments, the interface comprises two interface elements for interaction with limbs of the exerciser, each limb bearing one strain gage transducer to transmit a signal to the control unit.

30 In one of the embodiments, the two interface elements are driven by two independent rods. Such solution allows measuring the resistance force of each exerciser's limb and, based on these results, providing simultaneous travel of the interface with exerciser's limbs.

In one of the embodiments, the opposing action is defined by the weight of the body part and/or the gravity force affecting the body part. This can improve efficiency of training.

5 The object is also achieved by a weight training method, the method comprising:

 providing a weight exercise machine as disclosed above;

 by using the interface, opposing the force applied by the exerciser, when moving along the first stroke path assigned for stretching the target
10 muscle or the group of muscles of the exerciser, and

 by using the interface, aiding the exerciser by creating a force sufficient for allowing the interface to move, at least partially, along the second stroke path without applying the muscle force of the exerciser to the interface, when moving along the second stroke path.

15 **Brief description of drawings**

 Fig. 1 shows a weight exercise machine for training anterior and posterior surfaces of the thigh.

20 Fig. 2 shows an isometric view of a weight exercise machine for training chest muscles.

 Fig. 3 shows an isometric view of a weight exercise machine for training back muscles.

25 **Detailed description**

 According to one embodiment shown on the Fig. 1, the weight exercise machine for the training of anterior and posterior surfaces of the thigh comprises a frame hidden with a set of plastic housings. The base of the
30 weight exercise machine is made in the form of H-shaped platform 107 that is a part of the frame and on one side of which a seat 104 for the exerciser is mounted, which is made in such a way that the exerciser can adjust its

height and incline against the platform 107 with help of control drives located under a housing 106. There are two arched handles 105 for each arm of the exerciser by a seat base made from metal tubes in the middle part of which there is a soft nonskid pad. The seat 104 is covered with a layer of rubber water-repellent material and has a back 108 covered with the same material. On the other side of the platform there is an inverted U-shaped part 102 of the frame that is hidden with a plastic housing under which the control unit and the actuator are located. The actuator transmits the force to an interface 103 interacting with the exerciser via a crank mechanism. The actuator is a Festo electric cylinder ESBF whose piston transmits the force to the crank mechanism that has the interface 103 mounted on its axis of rotation. The interface 103 is an eccentric member, one of the ends of which is fastened on the axis of the crank mechanism and on the other end of which two rollers are fastened. The rollers are placed with a gap in horizontal and vertical directions relative to each other and their length and distance between them allow keeping in place both exerciser's legs between them. The rollers are located on the axis that is parallel to the axis of rotation of the crank mechanism. The distance between the axis of the crank mechanism and the rollers location axis that corresponds to the exerciser's shin length, can be adjusted in a known way. On the axis between the piston of the electric cylinder and the arm of the crank mechanism a strain gage transducer defining the force applied by the exerciser to the eccentric member is fastened. The force is composed of the muscles force and the force defined by an exerciser's body part that interacts with the interface 103, for example, via a leg weight. The strain gage transducer is connected with the control unit transmit the signal that corresponds to the amount of the force applied by the exerciser to the eccentric member. The signal from the strain gage transducer can be recorded by the control unit in order to monitor forces applied by the exerciser to the eccentric member. The control unit is a computing system to control drives and the actuator and to indicate the information on a touch

screen 101 located on top of the inverted-U-shaped part of the frame over a plastic housing 102.

In one of the embodiments the exerciser takes the seat 104, fixes legs
5 between rollers located on the interface 103 in the form of the eccentric member, and adjusts the parameters of the weight machine for his needs, using the touch screen 101. These parameters can include: incline of the seat, height of the seat, incline of the backrest, shin length and so on. One of these parameters is the weight of exerciser's legs measured with help of
10 the strain gage transducer in a position when, using the exercise machine, the exerciser does not affect interface 103 with the muscles force, and the effect applied to the interface equals to the attractive force of legs to the Earth (the gravity force affecting legs). At that, the exerciser additionally exerts on the means 103 force that is defined by the weight of a
15 corresponding body part. Also it should be noted that the amount of such effect can vary from the amount of the gravity force applied to a corresponding body part and defined by an indicated weight, to the fraction of the amount of this the gravity force less than unity, depending on the phase of the stroke of the mean 103 of interaction with the exerciser and
20 the type of the exercise machine. Depending on the type of the exercise machine, the weight of different exerciser's body parts can change. In some embodiments, together with the weight of a body part or in addition to it, the gravity force applied to this body part can be measured. The parameters can be recorded in a memory storage of the control unit for further trainings
25 in the form of, for example, a profile of a specific exerciser, in order to have the possibility for the exerciser to select a necessary set of individual parameters recorded in the memory storage. After identification of the exerciser with loading of a stored profile or adjusting the parameters, the exerciser can select a training plan depending on one of the goals:
30 increasing of muscle strength in the concentric phase, increasing of muscle strength in the eccentric phase, increasing of muscle strength in the mixed phase, knock-up and so on. Also, it is provided the possibility of independent

adjustment of concentric and eccentric phases; in particular acceleration on the whole length of the stroke of the interface 103 or their part can be adjusted by the exerciser or preset in accordance with selected training plan. The adjustment includes in particular cutoff of the load applied to the exerciser in any phase and also in any part of the stroke of the interface 103. All said actions can be made with help of a touch screen 101. After selecting training modes and adjusting exercises for the training of the anterior surface of the thigh in the eccentric phase, the exerciser will be warned about moving of the interface 103 in the initial state – legs are straightened in knees. When the interface 103 are moved in the initial state, the execution of exercises begins. In this training mode the exerciser feels pressure in the fore part of a shin of a straightened leg. The exerciser's task is to resist to this pressure on along the entire section of the stroke of the interface 103 from the position when legs are fully straightened to the position when legs are bent in knees. After passing this section, the exercise machine will return exerciser's legs in the initial position without exerciser's help. If the system detects resistance from the exerciser, the screen will show a notification that physical activity shall be stopped. The detection of opposing resistance from the exerciser in such embodiment of the exercise machine is realized by analysis of the control unit of the signal from the strain gage transducer considering measured weight of exerciser's legs. For example, when moving the interface 103 from the position where legs are bent in knees, the influence of legs weight increases with the increase of the rotation angle of the eccentric member towards the direction where legs are straightened in knees. Thus, the control unit calculates the value of influence of the weight of legs depending on a known rotation angle of the eccentric member and takes this value into account by measuring resistance from the exerciser.

In one of the embodiments, the control unit deducts the value of force defined by measured weight of exerciser's legs, with a correction for the eccentric rotation angle, from a defined value of exerciser's force by

affecting the interface 103 in a corresponding phase of the stroke of the interface. If the obtained value exceeds a predetermined limit, the control unit identifies exerciser's resistance and shows a corresponding notification on the touch screen. The limit can be set in the proportion of the gravity force affecting legs, for example, 0.05 of the gravity force. Any suitable limit value can be used. In one of the variants of realization, the limit can be set to zero.

In another embodiment, the control unit can define the ratio of defined value of exerciser's force on the interface 103 in a corresponding phase of the stroke of the interface to the force defined by measured weight of exerciser's legs with a correction for an eccentric rotation angle. If the obtained value is more than a predetermined limit, the control unit identifies exerciser's resistance and shows a corresponding notification on the touch screen. The limit can be set as a numerical value, for example, 1.05. Any suitable limit value can be used. In one of the embodiments, the limit can be set to 1.

In another embodiment the actuator can be represented in the form of a gear motor made configured to transmit the force to the interface with the exerciser with help of a belt drive. Also in this embodiment the gear motor can have an output axis angle transducer.

In some embodiments the gravity force is measured instead of weight. Consequently, the control unit defines the force value defined by measured gravity force, effecting exerciser's legs, with the correction for an eccentric rotation angle, instead of defining the effect value defined by measured weight of exerciser's legs with the correction for an eccentric rotation angle. The further actions are performed similar to abovementioned embodiments.

The control over the strain gage transducer signal allows to define force applied by the exerciser on the part of the stroke of the interface 103

where the force from the exerciser shall be applied, and to record in the control unit values of these forces in order to monitor forces applied by the exerciser.

5 According to another embodiment presented on the Fig. 2, the weight exercise machine for the chest training comprises a frame 201 on which a seat 202 for the exerciser is fastened, a touch screen 203 connected with a control unit 205 designed for the control over training modes and the monitor of training parameters, an actuator 204 controlled by the control
10 unit 205, interface with the exerciser that include two elements for interaction with the exerciser in the form of arched levers 207 with fixed handles 208 on them for the exerciser and strain gage transducers 206. In this embodiment each lever 207 has one strain gage transducer 206 on it. Each strain gage transducer independently defines the force applied by the
15 exerciser to a corresponding lever, and transmits the signal to the control unit. For example, the control unit receives information about release of the force applied by the exerciser to one of the levers, and generates the signal for the exerciser, that is shown on the touch screen 203, about insufficiency of the force applied by the exerciser. In another embodiment, the control
20 unit receives information about redundancy of the force applied by the exerciser to one of the levers. Separate measuring of forces applied to each lever by the exerciser increases accuracy of the reaction of the weight exercise machine to exerciser's actions and therefore the effectiveness and safety of interaction of the exerciser with the weight exercise machine. It
25 should be mentioned that depending on appliance, the direction of change of counteracting force (intensification or relaxation) depending on the change of the force applied by the exerciser (intensification or relaxation), can be different and is realized similar to the abovementioned example. Moreover, the control over change of assisting effect, depending on the measured force
30 applied by the exerciser, can be realized.

Also signals from strain gage transducers can be recorded by the control unit to monitor the force applied by the exerciser.

According to another embodiment, presented on the Fig. 2, the weight training machine for back training comprises a frame 301, on which a seat 302 for the exerciser is fastened, a touch screen 303 connected with a control unit 305, designed for controlling over training modes and monitoring training parameters, an actuator 304 controlled by the control unit 305, an interface interacting with the exerciser that include two elements for interaction with the exerciser in the form of arched levers 307 with fixed handles 308 on them for the exerciser and strain gage transducers 306 and rollers 309.

In one embodiment the exerciser using the weight exercise machine can adjust the actuator control unit in such a way that some exercise partials can be repeated, in other words, the interface can pass not the full stroke. Such repetitions can be added in the end of a training realizing so called forced repetitions. Another variant of usage of an incomplete stroke of the interface is the possibility of affecting specific muscles or part of exerciser's muscles. For example, while executing the exercise in 10-12 cm of the stroke of the interface on the weight exercise machine, it is possible to affect only tendons of the anterior surface of the thigh. Thus, the weight exercise machine can be adjusted for work with a specific muscle or a group of muscles for working on a damaged limb.

25

In one embodiment the exerciser can set acceleration of interface with the exerciser in different ways depending on a section of the stroke of the interface. For example, to set 10% of maximal acceleration on the first part that is equal to 1/5, 30% on the last 1/5 of the stroke and 100% in the middle of the stroke of the interface. So the exerciser can reduce the load on tendons in the beginning and in the end of the exercise.

30

Although the present description contains some preferable embodiments, they are not limiting and are given as an example. The scope of the invention is not limited by the given examples; rather it is defined only by the below claims.

5

Claims

A weight exercise machine comprising:

a frame carrying:

- an actuator having a movable part coupled to an interface interacting with an exerciser to receive a force from the actuator,

wherein the interface is movable along a first stroke path assigned to stretching a target muscle or a group of muscles of the exerciser, and a second stroke path assigned to contracting the target muscle or the group of muscles of the exerciser; and

- a control unit for controlling the actuator such that,

when moving along the first stroke path, the interface opposes the force applied by the exerciser while,

when moving along the second stroke path, the interface aids the exerciser by creating a force sufficient for allowing the interface to move, at least partially, along the second stroke path without applying a muscle force of the exerciser to the interface.

2. The weight exercise machine of claim 1, wherein
the control unit controls an acceleration of the interface when moving, at least partially, along the stroke path; and/or
the control unit controls a length of the stroke path of the interface.

3. The weight exercise machine of claim 1, wherein
the interface is provided with a strain gage transducer to transmit a signal to the control unit.

4. The weight exercise machine of claim 3, wherein
the control unit controls the interface based on the signal from the strain gage transducer.

5. The weight exercise machine of claim 3 or 4, wherein,

when moving along the second stroke path, the interface aids the exerciser by that the control unit uses a weight of a body part of the exerciser and/or a gravity force affecting the body part.

6. The weight exercise machine of claim 5, wherein

the control unit measures the weight of the body part of the exerciser and/or the gravity force affecting the body part, based on the signal from the strain gage transducer, when the exerciser, while using the weight exercise machine and interacting with the interface, does not apply his/her muscle force developed by the body part to the interface; and

the control unit measures the force created to aid the exerciser, when moving along the second stroke path, based on the measured weight and/or the gravity force.

7. The weight exercise machine of claim 6, wherein

the control unit measures the force created to aid the exerciser, when moving along the second stroke path, further based on the phase of the stroke and/or direction of the stroke of the interface.

8. The weight exercise machine of claim 1, wherein

the interface comprises two interface elements for interaction with limbs of the exerciser, each limb bearing one strain gage transducer to transmit a signal to the control unit.

9. The weight exercise machine of claim 8, wherein

the two interface elements are driven by two independent rods.

10. The weight exercise machine of claim 6, wherein

the opposing action is defined by the weight of the body part and/or the gravity force affecting the body part.

11. A method of weight training, the method comprising:

providing a weight exercise machine of any of claims 1-6;
by using the interface, opposing the force applied by the exerciser, when moving along the first stroke path assigned for stretching the target muscle or the group of muscles of the exerciser, and
by using the interface, aiding the exerciser by creating a force sufficient for allowing the interface to move, at least partially, along the second stroke path without applying the muscle force of the exerciser to the interface, when moving along the second stroke path.

12. The method of claim 11, comprising
measuring the force applied by the exerciser to the interface.

13. The method of claim 12, comprising
controlling the interface based on the measured force.

14. The method of claim 11, wherein
the exerciser is aided based on the weight of the body part of the exerciser and/or the gravity force affecting the body part.

15. The method of claim 11 or 12, comprising
measuring the weight of the body part of the exerciser and/or the gravity force affecting the body part when the exerciser, while using the weight exercise machine and interacting with the interface, does not apply his/her muscle force developed by the body part to the interface; and
measuring the force created to aid the exerciser based on the measured weight and/or the gravity force affecting said body part.

16. The method of claim 15, comprising
measuring the force created to aid the exerciser further based on the phase of the stroke and/or direction of the stroke of the interface.

17. The method of claim 11, comprising

controlling an acceleration of the interface when moving, at least partially, along the stroke of the interface; and/or
controlling a length of the stroke path of the interface.

18. The method of claim 12, wherein
opposing the force applied by the exerciser is controlled based on the measured force applied by the exerciser to the interface.

19. The method of claim 18, comprising
separate measuring the force applied by each limb of the exerciser to the interface.

20. The method of claim 18 or 19, wherein
opposing the force applied by the exerciser is controlled based on the weight of the body part of the exerciser and/or the gravity force affecting the body part.

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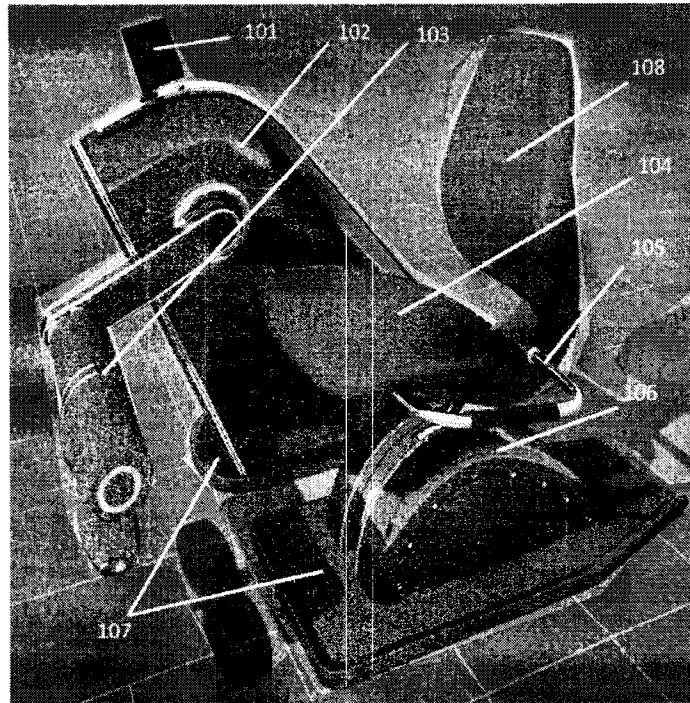


Fig. 1

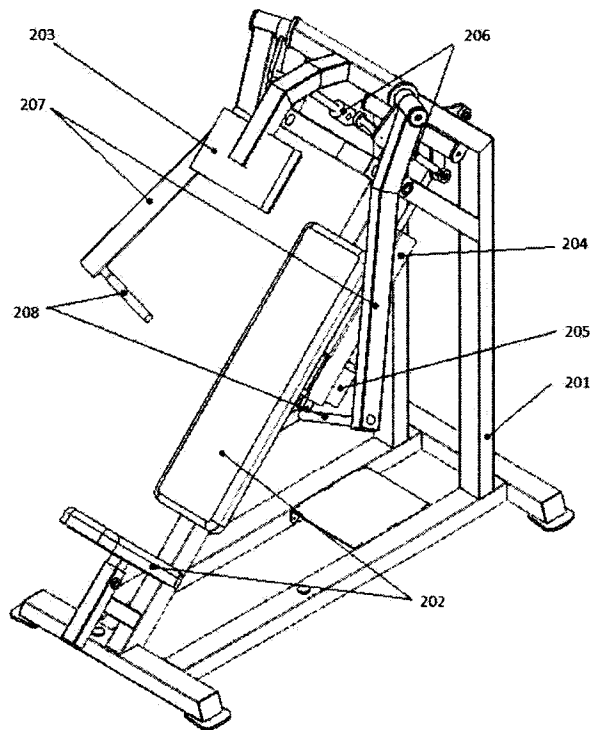


Fig. 2

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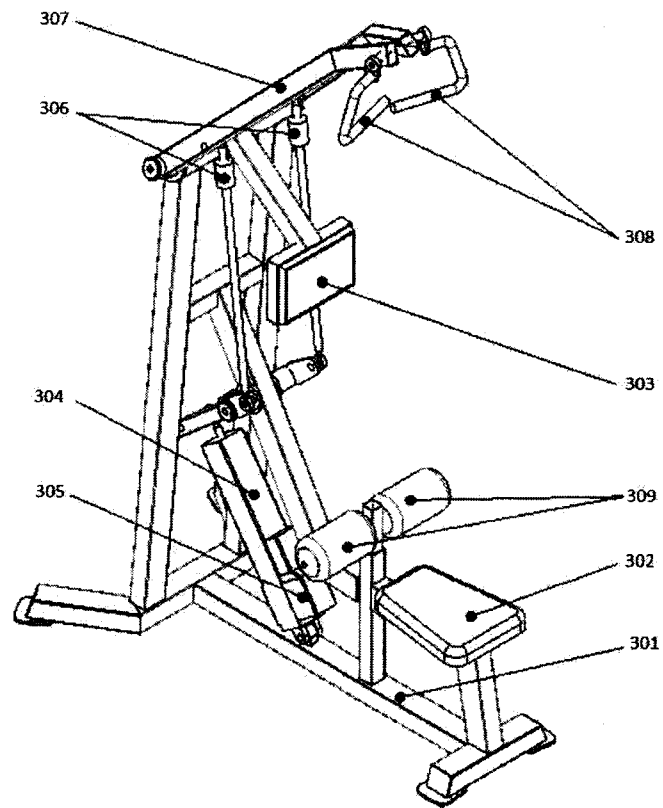


Fig. 3

INTERNATIONAL SEARCH REPORT

International application No.

PCT/RU 2017/000029

A. CLASSIFICATION OF SUBJECT MATTER <i>A63B 21/00 (2006.01)</i> <i>A63B 24/00 (2006.01)</i> According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) <i>A63B 21/00-21/28, 22/00-22/20, 23/00-23/20, 2/00, 24/00</i> Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) RUPAT, RUABU1, Esp@cenet, NCIP, Patentscope, DEPATISnet, CIPO, EAPATIS, USPTO, PatSearch (RUPTO internal)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
D, A	US 5476428 A (COMPUTER SPORTS MEDICINE, INC.) 19.12.1995	1-20
D, A	US 5254066 A (MOTIVATOR, INC.) 19.10.1993	1-20
A	RU 2516856 C2 (SAMKHANOV V.V.) 20.05.2014	1-20
☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
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Name and mailing address of the ISA/RU: Federal Institute of Industrial Property, Berezhkovskaya nab., 30-1, Moscow, G-59, GSP-3, Russia, 125993 Facsimile No: (8-495) 531-63-18, (8-499) 243-33-37	Authorized officer V. Glybin Telephone No. (495)531-64-81	