Технічні науки

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FORMATION OF PROCESSES OF COMPLEX FUNCTIONAL AND PHYSIOLOGICAL REHABILITATION

Methods and devices for the formation of processes of complex functional and physiological rehabilitation using elements of artificial intelligence and artificial neural networks

Summary. *In a modern society, implementing and organizing various options for the comprehensive, multifaceted development of an innovative economy, especially in areas related to smart production and technology, stress loads of all kinds that arise in the most active organizers of project development processes and generators of new technical and commercial ideas aimed at optimizing and accelerating development processes require an adequate response and unobtrusive, but extremely reliable and natural technologies and special equipment for rehabilitation;*

The publication shows models of system control and regulatory complex model subsystems using contactless resonant sensors as dynamic links between a mobile controlled object and mobile communication facilities, operating on the principles of electromagnetic resonance spectroscopy and having different design versions.

Key words: *Rehabilitation processes, Complex functional rehabilitation processes, Complex physiological rehabilitation processes, Methods and devices for forming processes, Functional rehabilitation using elements of artificial intelligence*

and artificial neural networks, Physiological rehabilitation using elements of artificial intelligence and artificial neural networks.

In a modern society implementing and organizing various options for the comprehensive development of an innovative economy, especially in areas related to smart production and technology, stress loads of all kinds arising from the most active organizers of project development processes and generators of new technical and commercial ideas aimed at optimizing and accelerating development processes require an adequate response and unobtrusive, but extremely reliable and natural technologies and special equipment for rehabilitation.

Tabletop sports games are one of the most important and promising sources for comprehensive rehabilitation technologies.

Fig. 1. The figure shows a model of system control and regulatory complex model subsystems using contactless resonant sensors as dynamic links between a mobile controlled object and mobile communication facilities, operating on the principles of electromagnetic resonance spectroscopy and having different design versions

Fig. 2. The figure also shows a model of system control and regulatory complex model subsystems using as dynamic links between a mobile controlled object and mobile communication means made in the form of smart watches, contactless resonant sensors operating on the principles of electromagnetic resonance spectroscopy and having different design versions

For so-called smart watches, the sensor design is a flat coil, an electronic micro-board with an original flat solenoid topology

This sensor receives energy from the watch battery and is constantly in the mode of monitoring the parameters of the table tennis player's body.

In this case, real-time monitoring can measure several important parameters that can be affected by the excessively intense nature of the game - for example: blood sugar concentration, blood pressure, etc.

These application options are of particular importance in the case of integration of artificial intelligence elements and artificial neural networks into the software systems of the entire rehabilitation complex.

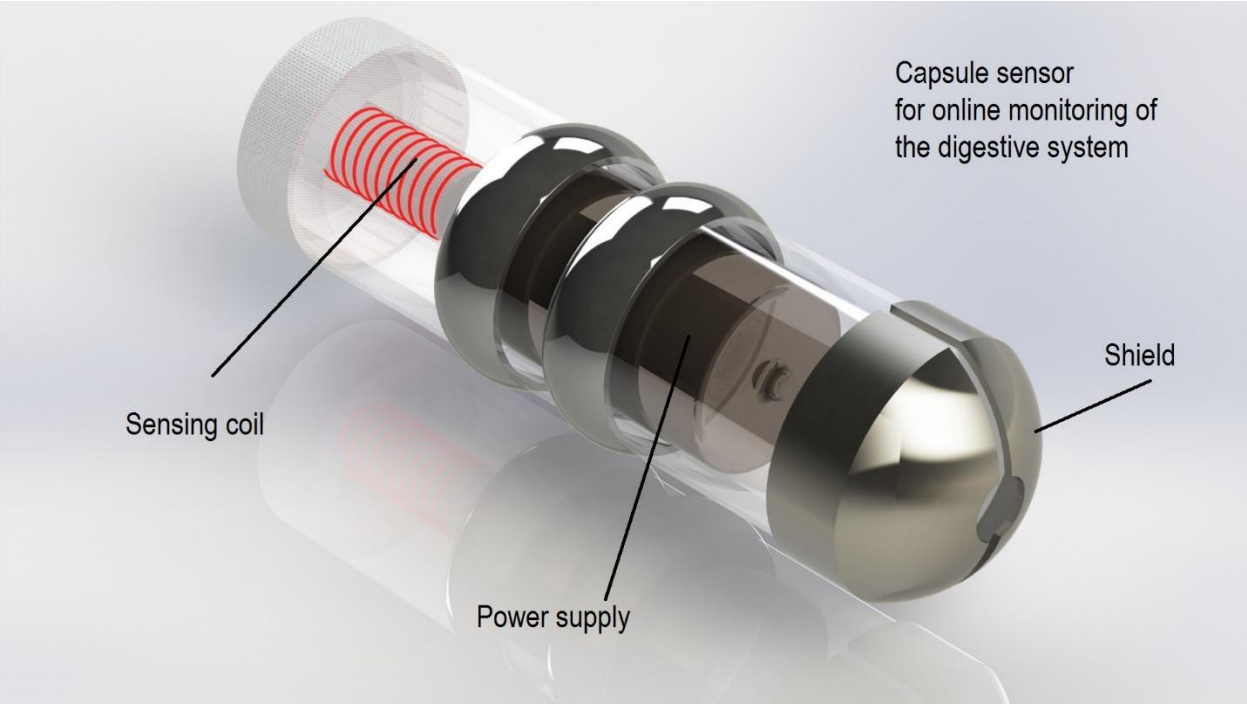

Fig. 3. The figure also shows a model of an integral sensor that is inserted into the axial hole of the handle of a table tennis racket

Since the technologies of application of electromagnetic resonance spectroscopy have very good prospects for use, including in technologies of functional and physiological rehabilitation, the author offers to the attention of readers a brief presentation of the theory and practice of application of sensors based on electromagnetic resonance spectroscopy (RIST);

Potential applications of resonant sensor technology in medicine and biology

I. Measurement of concentration and composition of components in liquids

This includes mixtures such as solutions and dispersed systems: emulsions, suspensions and biological fluids (blood, milk, lymph, urine, etc.). Due to the high sensitivity of RIST sensors, the proposed technology can be widely used:

1. In the pharmaceutical industry in technological processes for the production of medicines;
2. For laboratory and non-laboratory analysis of biological fluids: blood, milk, urine, etc.;
3. In medical, technical and food microbiology for monitoring the concentration of microorganisms.

II. Measurement of electromagnetic impedance of biological tissues of the body

Currently, measuring the impedance of biological tissues at different frequencies of alternating current is widely used in diagnostics, as well as in biological and medical research. For example, a significant increase in tissue impedance at low frequencies allows you to detect inflammation already at the first stages. Some thyroid diseases are diagnosed by changing the phase shift angle between current and voltage. Electromagnetic resonance mammography is an effective method for early diagnosis of breast cancer. Measuring the impedance of the skin helps diagnose skin diseases, for example, to detect unpainted malignant melanoma. Endoscopic impedance measurement can be used to detect pathology of internal organs. This also includes non-invasive blood tests, for example, for high sugar levels, and an analysis of the state of the lymphatic fluid.

RIST technology can make a contribution to all the above-mentioned areas of application of electromagnetic resonance measurements, significantly increasing the sensitivity of this type of measurement.

III. Use of technology in biosensors

The term "biosensor" is usually understood as a device in which a sensitive layer containing biological material: enzymes, tissues, bacteria, yeast, antigens/antibodies, liposomes, organelles, receptors, DNA, directly reacting to the presence of the component being determined, generates a signal functionally related to the concentration of this component. Structurally, a biosensor is a combined device consisting of two converters, or flat coils - biochemical and physical, in close contact with each other. The biochemical converter performs the function of a biological recognition element, converting the component being determined, or more precisely, information about chemical bonds into a physical or chemical property or signal, and the physical converter records this property using special equipment.

In this case, a fundamentally new method of obtaining information about the chemical composition of a solution is implemented. The presence of biomaterial with unique properties in the device allows for the high selectivity of determining the required compounds in a complex mixture, without resorting to any additional operations associated with the use of other reagents, concentration, etc. (hence the name - reagent-free methods of analysis).

There is a wide variety of physical combined sensors: electrochemical, spectroscopic, thermal, piezoelectric, surface acoustic wave, etc.

Technologies based on electromagnetic resonance spectroscopy can be used to create a highly sensitive physical sensor that responds to changes in the resonance of a biochemical transducer in the presence of a component being determined.

Methodology for selecting operating frequencies of sensors

This method describes the first stage necessary for building a system for monitoring the concentration of components of the mixture under study. A mixture is any set of components, one of which is predominant in volume and is considered a conditional solvent, while the others are considered conditional dissolved components. The concept of a conditional solvent is not limited to a liquid single-component substance capable of forming solutions with other substances; it can also be a mixture of either gaseous or liquid or even solid substances (an example is a compound), which can serve as a basis for the formation of not only solutions, but also suspensions, foam mists. Accordingly, conditional dissolved components can not only be dissolved, but also present in solutions as suspensions, bacterial colonies, fog droplets, gas bubbles in foam or filler particles in compounds.

Search for the optimal operating frequency of a sensor for constructing a monitoring system for one component of a mixture.

Such a monitoring system can be used in technological processes in which the concentration of one component may change, while the concentrations of other components remain unchanged.

Preparing samples for measurement

It is necessary to prepare two samples with concentrations of the component under study corresponding to the boundaries of the expected range of change of this concentration.

Scanning

Using special equipment, scan the prepared samples by frequency, using the entire bandwidth (in our case: from 0.100 MHz to 170 MHz). During the scanning process, readings are taken and recorded in the form of changes in the amplitude and phase shift of the current flowing through the sample relative to the harmonically changing probing voltage with a stabilized constant amplitude.

Analysis of results

Based on the scanning results, it is necessary to select several frequencies at which the difference between the amplitudes of the studied samples reaches the greatest values and several frequencies at which the difference in phase shifts reaches the greatest values. The selected frequencies will be the initial data for designing the manufacture of trial resonant sensors.

Selecting the optimal sensor

The selection of a set of frequencies based on the results of scanning samples using special equipment is preliminary. To decide on the optimal operating frequency of a single-component concentration monitoring system, it is necessary to test each trial resonant sensor, but not with two, but with at least 10 samples with different concentrations of the component under study, located within the expected range of its change. After testing all the prototype sensors, you can select the best one, while preference should be given to sensors that, along with good sensitivity, have a monotonous change in readings in accordance with the change in the concentration of the controlled component (for the convenience of subsequent calibration). At the same time, lower frequencies are preferable from the point of view of ensuring noise immunity. Also, when choosing a sensor, it is necessary to take into account the design limitations

Search for optimal operating frequencies of sensors for constructing a monitoring system for two components of a mixture.

Such a monitoring system can be used in technological processes in which the concentration of two components can change, while the concentrations of other components remain unchanged.

Preparing samples for measurement

It is necessary to prepare two samples for each component being studied with concentrations corresponding to the limits of the expected range of change in these concentrations, as well as a sample in which these components are completely absent.

Scanning

Using special equipment, scan the prepared samples by frequency, using the entire bandwidth (in our case: from 0.100 MHz to 170 MHz). During the scanning process, readings are taken and recorded in the form of changes in the amplitude and phase shift of the current flowing through the sample relative to the harmonically changing probing voltage with a stabilized constant amplitude.

Analysis of results

For each component under study, based on the scanning results, it is necessary to select several frequencies at which the difference between the amplitudes of the samples under study reaches the greatest values, several frequencies at which the difference in phase shifts reaches the greatest values, and frequencies (or frequency ranges) at which there is no sensitivity to one component, but there is sensitivity to another. Analyze the obtained frequency samples. Depending on the comparison

results, there are several possible algorithms for selecting the operating frequencies of the sensors.

An option when there are frequencies at which there is sensitivity to only one component.

This option is the most preferable for constructing a system for monitoring the concentrations of the components being studied.

If such frequencies exist for both components, then the choice of operating frequencies is obvious: to manufacture prototypes of resonant sensors, it is necessary to select operating frequencies at which, in the absence of sensitivity to one component, the sensitivity to the other is maximum. Such frequencies must be selected, at least one for each component.

If such frequencies exist only for one of the components, then to manufacture prototypes of resonant sensors for this component, it is necessary to select such operating frequencies at which, in the absence of sensitivity to one component, the sensitivity to the other is maximum; for the other component, from its set of frequencies, it is necessary to select such operating frequencies at which the difference in sensitivity to the components under study is greatest.

A variant when there are no frequencies at which there is sensitivity to only one component, but the obtained frequency samples do not coincide with each other.

In this case, to manufacture prototypes of resonant sensors, it is necessary to select from each set of frequencies those operating frequencies at which the difference in sensitivity to the components being studied is greatest.

A variant when the obtained frequency samples coincide with each other.

This option is the most difficult for building a system for monitoring the concentrations of the components under study. If the frequency set for one component completely coincides with the set for another, it is necessary to check whether the proportion between the changes in the amplitude or phase shift for one component and the changes in the amplitude or phase shift for one component is preserved at all frequencies. If everything coincides, then you should try to repeat the scan using other values of the probing voltage. If you cannot achieve differences, then most likely the components under study are indistinguishable from the point of view of electrochemical spectroscopy. Nevertheless, even in this case, you can try to make several prototypes of sensors with different operating frequencies corresponding to the greatest sensitivity to changes in the concentrations of the components under study, since the resonant sensor has a more complex effect (the effect of the magnetic field is added) on the sample under study than the effect of special equipment. If testing of these sensors at least at one of the frequencies shows the presence of a change in the proportion of sensitivity to changes in concentrations, then there is a fundamental possibility of constructing a system for monitoring the concentration of the components being studied, and the selectivity of this system will be higher, the greater the difference in proportion.

Selecting the optimal sensors

The selection of a set of frequencies based on the results of scanning samples using special equipment is preliminary. To decide on the optimal operating frequencies of a two-component concentration monitoring system, it is necessary to test each trial resonant sensor, but not with two, but with at least 10 samples with different concentrations of the components under study, within the expected range of their change.

After testing all the prototypes of the sensors, the best pair can be selected, and preference should be given to sensors that, along with good sensitivity, have a monotonous change in readings in accordance with the change in the concentration of the components being monitored (for the convenience of subsequent calibration). In this case, lower frequencies are the most preferable from the point of view of ensuring noise immunity.

LIST OF USED LITERATURE, PATENT AND LICENSE INFORMATION

APPENDIX 1

United States Patent **10,065,068**
Wilson **September 4, 2018**

Adjustable ankle rehabilitation apparatus

Abstract

Various embodiments provide an adjustable ankle ***rehabilitation device*** for rehabilitating torn ligaments associated with a sprained ankle. The ***rehabilitation device*** can include a planar platform secured to a shoe, and a balancing rail adjustably attached to the bottom of the platform and extending fore to aft. The balancing rail is configured to selectively place a desired amount of ***stress*** on the medial muscle or, alternatively, the lateral muscle by adjusting the balancing rail from side-to-side. The ***device*** can include adjustable fasteners to secure the balancing rail at a desired position adjacent the bottom of the platform.

APPENDIX 2

United States Patent **9,616,283**
Heineck, et al. **April 11, 2017**

Therapeutic device

Abstract

A low ***stress*** therapeutic ***device*** is provided by efficient foot plates and guide rails having operationally tracking surfaces of a low coefficient of friction supported by a platform. The ***device*** includes a rail stabilizer equipped with extending longitudinally recess or slot and a slideably mounted foot plate having upon its underside a longitudinal projection slideably retained within the rail recess. The therapeutic ***device*** may be designed to operate under relatively effortless strain at a low coefficient of friction. The therapeutic ***device*** is useful for knee replacement, stroke victims, ACL repair, and other therapeutic treatments requiring a nominal initiating effort of movement for ***rehabilitation*** . The ***device*** may be provided as a one or two footed ***device*** of a light weight particularly useful in a patient sitting or lying position. The foot plates may be appropriately equipped with longitudinally underside tracking guides reciprocating sliding within longitudinal slots provided by a tracking rail.

APPENDIX 3

United States Patent **9,532,916**
Tsui, et al. **January 3, 2017**

Wearable power assistive device for hand rehabilitation

Abstract

A wearable power assistive ***device*** for hand ***rehabilitation*** includes a hand brace having an external platform and an internal platform connected to and spaced inwardly from the external platform. Five finger assemblies are adjustably mounted on and extending from the distal end of the external platform. Each finger assembly includes a proximal follower assembly for a metacarpophalangeal joint. Five motors are used to activate the five finger assemblies respectively. Each motor is mounted in close proximity to the external platform and has one end connected to the external platform and another end coupled to its proximal follower assembly by a ball joint in order to facilitate transfer of force and minimize mechanical ***stress*** on the other parts of the ***device*** .

APPENDIX 4

United States Patent **7,255,619**
Rasmussen **August 14, 2007**

Variable resistance aquatic device and methods of using the same

Abstract

An aquatic ***device*** is usable in an aquatic environment for a variety of purposes, such as physical therapy, ***rehabilitation,*** and/or exercise. The aquatic ***device*** permits a person to simulate a walking or running gait cycle in the aquatic environment, reducing the ***stress*** /strain associated with walking or running on the ground. An aquatic ***device*** includes a foot-receiving member rotationally coupled to a fin member. The fin member, when in an extended position, provides increased resistance as the person attempts to walk or run in the aquatic environment. During a walking or running gait, the fin member moves into a folded position, thus reducing the resistance of the water on the aquatic ***device*** . The aquatic ***device*** is adaptable and modifiable to have varying shapes, designs, sizes, resistance levels, and/or other aspects.

APPENDIX 5

United States Patent **6,056,613**
Pike **May 2, 2000**

Multi-purpose floatation device for recreation, exercise, instruction and rehabilitation purposes

Abstract

A recently popular form of exercise and therapy, aquatic exercise devices present unique operating conditions to the body because of their use of water resistance and their buoyancy. By making proper use of water resistance, such devices can provide the body with excellent muscular and cardiovascular training, at the same time, the buoyancy offered by these devices eliminates the ***stress*** and injuries

associated with the jarring impact of such landbased exercises as running and aerobics. It is also an object of the present invention to provide an aquatic exercise devise that is a singular unit. The inventor began attending a water aerobic class in 1995 for health reasons. Exercising in the water took most of the pain out of the movement, but the inventor found that she was still hurting herself. She sought to reach a truly weightless state in which to condition her body. She tried the various devices provided by the pool facility but none proved effective in granting her the non-impact workout she was determined to find. With a problem to solve the inventor experimented, altered and designed a new and improved floatation ***device*** that is uniquely different in its adaptability to numerous applications. A uniquely different floatation ***device*** this invention goes beyond the restrictive designs of prior art designed to address one or another aspect of aquatic safety, exercise, ***rehabilitation*** or recreation. This invention adapts to usage in a multitude of expressions from water yoga, a unique synergy of ancient eastern culture and modern day technology; to aqua aerobic exercises including cardiovascular enhancement activities; ***rehabilitation*** of physical injury or illness; as well as addressing the basic aspects of water safety and learning how to swim. A floatation ***device*** for various exercises, instruction, ***rehabilitation,*** therapeutic and/or recreational purposes; this invention provides floatation support as no other product on the market because of its unique design and flexibility and the multiple number of ways in which it can be used. With this invention its possible to float supine, moving through various water yoga relaxation movements and stretches; ride it like a bicycle seat; sit on it like a swing; wrap it around the torso and clip it on for deep water workout and/or for those who are uncomfortable in water, but who must get in for health and/or ***rehabilitation*** purposes; hold it with hands; slip it under arms, front to back, or back to front; all to move through various exercises for health, ***rehabilitation*** and fun. The variation is used to provide superior floatation in a clip on style. With this invention secured around the torso, up the chest and around the back of the neck, the wearer is provided with no-hands support. While wearing the invention the wearer can float forward to swim and learn strokes; tread water in an upright position; and/or float supine; all with complete range of motion of limbs and/or torso. This variation of the invention can be used in swimming instruction, pool safety, ***rehabilitation,*** recreation, instruction and general poolside safety.

APPENDIX 6

United States Patent **5,476,429**
Bigelow, et al. **December 19, 1995**

Treadmill for use with a wheelchair

Abstract

An exercise ***device*** for the occupant of a wheelchair acting as a treadmill which may be used for cardiac ***stress*** testing, cardiac or stroke ***rehabilitation,*** fitness training, aerobic training or educational/physical games, with the ***device*** including a generally inclined ramp having parallel sides, a forward entrance portion, a movable dolly mounted on rails on the sides of the ramp, the dolly having a pair of laterally movable caster capture plates with openings to receive the caster fronters of a wheelchair and angular rods cooperating with the wheelchair drive wheels acting to adjust the lateral spacing of said plates, locking means for the dolly to retain it in its forward position, separate locking means for locking the dolly in its rearward position when a wheelchair has been moved onto the ramp into operative position, a pair of enlarged openings adjacent the rear edge of the ramp, and a pair of longitudinally movable rollers beneath the ramp and movable between a rear retracted position allowing the wheelchair drive wheels to be partially received in the openings and a forward position under the drive wheels to engage and lift the drive wheels so that the user can manually rotate the wheelchair drive wheels to rotate the rollers and provide signals to a control apparatus for the desired type of training, testing or ***rehabilitation*** .

APPENDIX 7

United States Patent Application **20130261514**
Kind Code **A1**
TSUI; Michael Kam Fai; et al. **October 3, 2013**

WEARABLE POWER ASSISTIVE DEVICE FOR HAND REHABILITATION

Abstract

A wearable power assistive ***device*** for hand ***rehabilitation*** includes a hand brace having an external platform and an internal platform connected to and spaced inwardly from the external platform. Five finger assemblies are adjustably mounted on and extending from the distal end of the external platform. Each finger

assembly includes a proximal follower assembly for a metacarpophalangeal joint. Five motors are used to activate the five finger assemblies respectively. Each motor is mounted in close proximity to the external platform and has one end connected to the external platform and another end coupled to its proximal follower assembly by a ball joint in order to facilitate transfer of force and minimize mechanical ***stress*** on the other parts of the ***device*** .

APPENDIX 8

United States Patent Application **20120329611**
Kind Code **A1**
Bouchard; Marc; et al. **December 27, 2012**

Motorized Lower Body Rehabilitation Device and Method

Abstract

Disclosed is a motorized ***rehabilitation*** apparatus and method for disabled, impaired or injured individuals, which trains a proper gait, increases blood flow, relieves ***stress,*** and reconditions lower body muscles and joints. The ***device*** comprises a powered stationary bicycle having a seat, handle grips, and rotating foot pedals that receive motive input from an electric motor and user input. The ***device*** further includes a pair of thigh braces that are connected together between the user's thighs via a hingeable link and chain that controls and trains an individual's limbs through the pedal rotation. The disclosed method further combines the present bicycle ***device for rehabilitation*** in conjunction with visual stimuli in the way of a three dimensional television display that stimulates endorphins, relieves mental ***stress*** and allows the motive input from the bicycle and mild user input to exercise the limbs of a user without focusing on the ***rehabilitation*** activity.

APPENDIX 9

United States Patent Application **20070093153**
Kind Code **A1**
Rasmussen; Scott K. **April 26, 2007**

Variable resistance aquatic device and methods of using the same

Abstract

An aquatic ***device*** is usable in an aquatic environment for a variety of purposes, such as physical therapy, ***rehabilitation,*** and/or exercise. The aquatic ***device*** permits a person to simulate a walking or running gait cycle in the aquatic environment, reducing the ***stress*** /strain associated with walking or running on the ground. An aquatic ***device*** includes a foot-receiving member rotationally coupled to a fin member. The fin member, when in an extended position, provides increased resistance as the person attempts to walk or run in the aquatic environment. During a walking or running gait, the fin member moves into a folded position, thus reducing the resistance of the water on the aquatic ***device*** . The aquatic ***device*** is adaptable and modifiable to have varying shapes, designs, sizes, resistance levels, and/or other aspects.

APPENDIX 10

United States Patent Application	**20060211937**
Kind Code	**A1**
Eldridge; Robert	**September 21, 2006**

Garment to facilitate use of a portable monitor device

Abstract

A garment configured to hold a portable medical ***device,*** and more particularly to a modified upper garment to hold, secure and conceal a heart monitor while allowing easy and unobtrusive access to cardiac lead points on a patient. The garment has an exterior pocket for a monitor. It further has a plurality of openings to allow attachment of monitor leads on a patient without the need to remove the garment. The openings may also have closure means. The garment provides modesty, comfort, durability and an attractive appearance. The garment may be configured for use in all cardiac ***rehabilitation*** situations including exercise and ***stress*** testing. The entire garment is made of x-ray transparent materials.

APPENDIX 11

United States Patent Application	**20060142680**
Kind Code	**A1**
Iarocci; Michael Anthony	**June 29, 2006**

Active assist for the ankle, knee and other human joints

Abstract

A human joint assist ***device*** that applies a torque at the joint to assist physical exercise forces, that is the load carrying task of the joint and surrounding muscles, tendons, and ligaments. The application of this ***device*** reduces the physical exercise force requirement, and may be adjusted with respect to assist level, to suit the issue associated with joint motion and is useful for joint ***rehabilitation*** and sports activities. Among other things, this results in a reduction of physical exercise force in a fashion that makes it easier to extend the levers (long bones) associated with extension against a given resistance. For example, standing from a squatted position with the assist of this ***device*** reduces the ***stress*** on physiological members associated with joint articulation.

APPENDIX 12

United States Patent Application	**20180001172**
Kind Code	**A1**
SUTTA; Peters; et al.	**January 4, 2018**

STRUCTURE OF ACCESSORY ELEMENT FOR EQUIPMENT OF FLOORBALL TRAINING COURT AND USE OF IT FOR FORMATION OF FLOORBALL SIMULATOR

Abstract

The invention refers to the equipment of the training rink for floorball, manufacturing of exerciser structural element, applying concept of ***tennis*** racket stringing. Proposed design of subsidiary element for floorball rink arrangement characterized with that it is made as latticework formed by: two parallel end plates;

several threaded rods as stiffening members; two elastic string structures disposed in two parallel planes, at that each of it presents one side of mentioned latticework and provided with: --holes for fastening threaded rods which ensure rigidity and load bearing capacity of the subsidiary element frame structure; --holes for criss-cross stringing in two parallel planes and string fastening at mentioned end plates independently one from another.

APPENDIX 13

United States Patent Application	**20160296815**
Kind Code	**A1**
Pindrik; Michael	**October 13, 2016**

More To Bouncing Ball

Abstract

Easy to assemble and disassemble gaming apparatus that allows a single player to play a game comparable to ***Tennis*** and/or Ping Pong in a limited space environment The proposed game apparatus also allows a single player to perfect his or her skill.

APPENDIX 14

United States Patent Application	**20070238561**
Kind Code	**A1**
Hu; Liang-Fa	**October 11, 2007**

Structure of toy tennis racket

Abstract

Structure of toy ***tennis*** racket, which mainly improves composition of hitting face of toy ***tennis*** racket; it stretches string that one side is adhesive across holes around

head of ***tennis*** racket in horizontal and longitudinal to make network, so that one side of this network is adhesive face and another side is the hitting face; such combination makes hitting face of toy ***tennis*** racket that can produce rebound force owing to the flexible network, furthermore, such racket may provide best ventilation effect to reduce wind resistance, you can hit ball easily as if playing with real ***tennis*** racket.