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(54) Kinematic system of the machine for treating, rehabilitating and sports training of the spine and thorax muscles of the human body

(57) Kinematic system for treating, rehabilitating and sports training of the spine and thorax muscles of the human body is equipped with a rotary seat (5), which is connected with the rotary arm(s) (4) by the means of a backward mechanism (2). Said backward unit comprises two rotary backward elements (15, 15a, 15b, and 17, 17a, 17b) connected with the elements of transmission (16, 16a, 16b, 16c, 16d). Additionally along the axis at the top of the mechanism there is a off-load frame (8) used for suspending the user of this mechanism.

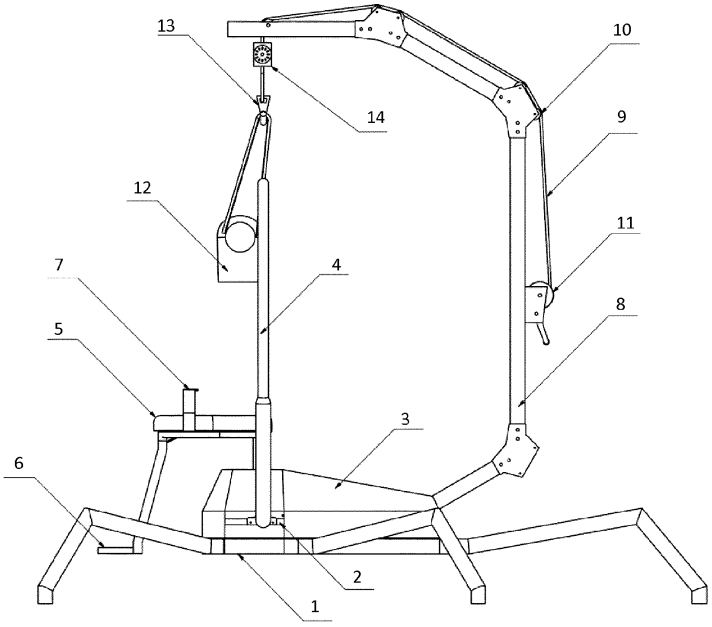

Fig.2

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Description

[0001] The item of the present innovation relates to a kinematic system and the device for implementing this system. It is devoted to use in treating, rehabilitating and sports training of the spine and thorax muscles of the human body.

[0002] The human spine is a very complex system, which allows to keep an upright position of the body. It also constitutes the element for absorbing shocks (thus guarding the central nervous system) and protects the spinal cord. All spinal diseases, such as scoliosis or degeneration, impair all the functions of the spine, which in turn has a negative impact on the functions of many other human systems such as nervous, muscles or digestive systems.

[0003] Spinal diseases may result from congenital defects, injuries (both: perinatal and those that occurred in the course of life), illnesses and, more and more often nowadays, from unhealthy lifestyle. Sedentary lifestyle and less physical activity as well as improper performance of such activities as lifting the objects, lead to undesired changes in such mechanical system as our spine. Mentioned changes are connected, among others, with the weakening of the muscles responsible for the stabilisation of the spine. When the back muscles and the abdominal muscles are no longer able to properly stabilise and reduce loads of the spine there is more strain on the ligaments, vertebrae and intervertebral discs.

[0004] One of the most common disease, which can appear as soon as in the childhood, is scoliosis. It can result from improper foetal development, but it is very often connected with child's unhealthy lifestyle. Proper and in time rehabilitation may cure, or at least stop the process of spine curving and save the patient from the serious surgery.

[0005] Scoliosis rehabilitation is a long lasting and complicated process. It requires the application of many treatments: physiotherapy and kinesitherapy. Said kinesitherapy is connected with practising physical exercises, which aim at improving the spinal flexion at the same time lowering the improper muscle tensions and increasing the strength of the stabilising muscles. Such exercises may consist of active or passive movements against particular axes of the human body - sagittal axis, vertical axis and horizontal axis.

[0006] One of the known methods of strengthening the thorax muscles is an exercise consisting of rotation of the spine round the vertical axis. The patient, sitting on the firm seat and keeping his/her hands on the handles, has to perform rotating movements. This exercise allows to strengthen mostly the lumbar muscles. Exercise machine proposed by the RehabDynamics Company is an example of a solution for that kind of exercise.

[0007] Another example of a machine for treatment of the scoliosis, which utilizes the multidimensional movement is a machine presented in the patent application PL391612. This method is based on imposing the rotary movement on the patient's spine. The treated person stands on the platform twisted into one side and with both hands holds the handle above him/her. This handle is twisted into the opposite side. Additionally there comes a twist of the platform and the handle in the lateral plane done by the straining elements. The patients tries to untwist the body posture and thus he/she applies active rehabilitation. The limitation of the said machine is a possibility of replacing the rotary movement of the spine (a desired movement) by the movement of the limbs only, which results in improper performance of the rehabilitating exercise.

[0008] A very popular method of rehabilitating the people with scoliosis is so called traction. It is a delicate, axial stretching of chosen parts of the spine, which in turn leads to moving apart the articular surfaces of neighbouring vertebrae. This procedure is used in the treatment and relief of symptoms of clinical disease of the spine caused by the narrowing of the intervertebral space and straining of other structures (eg. intervertebral joints and ligaments). The traction of the spine is often used together with other methods of treatment.

[0009] Traction is very often done by the physiotherapist, who uses only his hands. It is not a very effective activity because of limited strength that a man is able to generate and because of time limitations. That is why people more and more often use machines that enable them to conduct such exercise. An example of such a machine is the one presented in the patent application ES2025407. The traction is done by the suspending the patient in the machine. This is a passive method. The patient does not perform any exercises during the treatment. It means that in spite of improvement of the posture the effect may be short lasting without the strengthening of the muscles.

[0010] The machine which joins the traction with other exercises is presented in the patent PL173405. The author of this solution used traction done during performing the exercises of the spine in the sagittal and coronal planes of the patient. Traction is done with the use of the patient's strength or with the use of the engine. The example of off-loading given in this solution is not precise. What is more, the construction of the machine does not allow to make twisting movements of the patient's body, thus limiting the number of muscles being strengthened during the exercise.

[0011] The patent CN101947175 presents the machine which makes it possible to perform the bending and twisting movements of the lumbar spine. The device looks like a table divided into sections supporting the head, chest, pelvis and legs. The section which supports the head enables the traction of the cervical spine. The bending movements in the coronal plane and sagittal plane are performed by the movement of the head section and chest section. Both sections remain rigid in relation to each other. The rotation of the lumbar spine is performed by the rotary movement of the section supporting

the pelvis and legs. Those sections also remain rigid in relation to each other. All the movements are made with the use of the applied drive. The patient does the exercise passively, which may not result in strengthening the back muscles.

[0012] Another example may be the machine presented in the patent application JP2001212163. It enables the traction of a patient both - in the sitting and standing position. In the course of traction the rotary movements of the pelvis are applied with the simultaneous pressure and massage of the lumbar spine.

[0013] The aim of the present invention is to construct a kinematic system and a machine based on that system, which would join the traction and the backward rotation and which would allow to perform both those exercises simultaneously. It will not only allow to increase the progress of the rehabilitation but will also reduce the amount of time which should be devoted for this rehabilitation.

[0014] The kinematic system of this machine, whose axe is basically put vertically, consists of rotary elements, the seat, off-load frame and rotary arm(s). The rotary seat is connect with the rotary arm(s) by the means of backward mechanism. At the same time the backward mechanism consists of two backward elements connected with the elements of transmission ratios. Additionally an off-load frame, used for suspending the user, is mounted at the top of the machine. The elements of gear transmission, belt transmission, friction gear or backward joint mechanism are used for transmission ratio of the backward mechanism. The transmission ratio preferably is a gear transmission, belt transmission, friction gear or backward joint mechanism. The axis of the unit rotation preferably is vertical and coincidental with the rotation of the patient's spine. In the embodiment of the machine, in which the backward mechanism contains transmission, preferably bevel gear, belt or friction transmission, one gear of the transmission is firmly coupled to the arm(s) of the machine by the means of firm housing. The said gear is connected to the second gear of the transmission unit by the means of transmission element - counter drive gears articulately mounted on a rigid frame connected to the base of the machine. This second gear of the transmission unit is firmly connected to the seat. The backward mechanism optionally comprises the bevel gear with three rows of teeth which differ with the number of teeth. With the use of the clutch it is possible to switch the reduction gear or multiplicative gear. This possibility permits to change the angle of the seat rotation to angle of arms rotation ratio. The backward mechanism, in which an joint mechanism is used, has two crosses mounted axially on the column and the third cross between them which does not rotate. The crosses are connected to one another with the means of ball joints. The lower cross is firmly coupled to the arm(s) and the upper cross is firmly coupled to the seat. The middle cross preferably is the one with adjustable height for changing the proportion between the angles of seat rotation and arm(s) rotation. The machine is mounted on a base which consists, for example, of bowed legs. An off-load frame with a set of lines and pulleys is used for suspending the user of the machine. At the end of that frame a suspension ring is mounted along the axis of rotation of the device. The regulation of the off-load may be done by the movable off-load frame controlled by the means of an engine or a servomotor or by a rigid off-load frame, where the regulation is done by the means of a pulling line pulled along the frame and through pulleys and a manual winch. Optionally the arm(s), held by the user with his/her hands, are attached to the base with elastic elements.

[0015] The kinematic system described above permits backward rotary exercises with simultaneous off-load of the spine. A proper performance of the exercise will result in strengthening the thorax muscles responsible for stabilising the spine as well as will improve the blood supply to the spine, at the same time lowering the pressure on the vertebral discs and diminishing the friction between the vertebrae surfaces during the exercise.

[0016] The embodiment of the present invention is shown in the drawings where:

Fig.1 is a front view of the exercise machine in accordance with the innovation with a bevel gear and a manual regulation of the off-load.

Fig.2 is a side view of the machine.

Fig.3 presents a schematic view of the kinematic system which comprises block arrangement of the backward mechanism.

Fig.4 presents the construction of the backward mechanism in the embodiment of the invention with the use of the bevel gear, while Fig. 5 and 6 show the same mechanism with the use of joint backward mechanism.

Fig.7 a and b shows two views of the mechanism embodiment with the frame used for patient's traction in a movable version regulated by the means of servomotor mounted at the base.

[0017] The kinematic system defines movements done by the working parts of the machine. The course of the component movements and geometric coupling are called the motion structure. The mechanism which allows to obtain needed coupling in the motion structure, otherwise called the kinematic system, is an internal kinematic chain. The kinematic chain is defined as a set of mechanisms which transfer the driving force from its source to the specific part of the mechanism. In the mechanism in accordance with the present invention there are both: mechanical and nonmechanical couplings. The kinematic chain it is a whole unit, that is its mechanical part and not-mechanical part, which provides a proper coupling. The machine comprises the base 1, the backward system

2 in a housing 3, arms 4, seat 5 with footrests 6 and a security belt 7, which secures the patient's legs in such a way that he/she sits firmly during the exercise. The base comprises four legs - placed in an even distance from one another and bent at 90 degree angle-and a fifth one, which is longer and placed at the back of the machine. The fifth leg is used to stabilise the machine. From the base of the machine upward there is the off-load frame 8 with a set of lines 9 and pulleys 10 at the top, regulated for example by the means of the manual winch 11. The user is stabilised in the harness 12 which is suspended on the loop 13, where also is the a gouging component for measuring the off-load 14. The backward mechanism 2, which does the backward rotary movement in the embodiment of the invention is made basing on the kinematic chain shown in the fig. 3. The rotary element 15 is joined with the arms of the machine 4. The motion of the arms caused by the patient results in transmission of the rotation - by the means of the transmitting elements 16 - onto the second rotary element of the backward mechanism 17 which is joined with the seat 5. Fig. 4 presents an example of realisation of the kinematic chain model in accordance with the embodiment of the invention. The mechanism comprises two bevel gears elements 15a and 17a with the same module and with the gear ratio from 0,1 to 1 - optimally chosen for the process of rehabilitation. The wheel from the first gear 15a is connected with the arms of the mechanism 4 by the means of rigid cover 18. The arms movement caused by the patient results in transmitting the rotation, via transmission elements - three toothed wheels 16a, mounted articulately on a rigid frame 19 joined with the base 1 of the machine - to the second part of the transmission 17a connected to the seat 5

[0018] In the embodiment of the invention fig.1 and fig. 2 a double bevel gear was used in order to execute and connect the rotary movement of the seat 5 with the arms 4 of the machine. A rigid off-load frame 8 with attached lines 9 and pulleys 10 together with a manual winch 11 was also used in order to enable performance of a traction by an accompanying person, for example a doctor. The level of the off-load can be controlled by the operator by the means of elastic element, a linear scale, placed between the harness and the line.

[0019] In the embodiment of the backward joint system (fig. 5 and fig. 6) the arms 4 are connected with the lower cross 15b, while the seat 5 is connected with the upper cross 17b. Both crosses 15b and 17b are placed in an axis oriented manner on the column 20. On the said column there is also a cross 16b mounted in such a way that it cannot rotate round the column. All three crosses are connected to one another by the means of bars 16c with the use of ball joints 16d. Rotation of the lower cross 15b results in deflection of the bars 16c round the joint on the middle cross 16d and causes the backward rotation of the upper cross 17b. The movement of the middle cross 16b along the column axis 20 results in the change of the ratio of the angle of rotation between the lower cross 15b and the upper cross 17b.

[0020] In another embodiment of the invention (fig. 7 a and b) apart from the double bevel gear used in order to execute and connect the rotary movement of the seat 5 with the arms 4 of the machine, a movable off-load frame 21 was also used. A servomotor or electric engine 22 with automatically controlled off-load level was used as an operating device. Additionally the elastic elements 23 were mounted between the arms 4 and the base 1 in order to evoke resistance during exercises.

Claims

1. Kinematic system of the machine for treating, rehabilitating and sports training of the spine and thorax muscles of the human body in which the axis of the said machine is basically vertical and the machine comprises rotary elements, seat, off-load frame, rotary arm(s), **wherein** a rotary seat (5) is connected with a rotary arm(s) (4) by the means of backward mechanism (2), while the said backward mechanism includes two backward rotary elements (15, 15a, 15b, and 17, 17a, 17b) connected to a transmission elements (16, 16a, 16b, 16c, 16d), additionally there is an off -load frame (8) for suspending the user of the machine mounted along the axis of the system.

2. The system as defined in claim 1, **wherein** the rotary elements (15, 17) consist of gear transmission, belt transmission, friction transmission or elements of joint mechanism.

3. The system as defined in claim 1, **wherein** the transmission elements (16) of preferably regulated backward mechanism (2) are gear transmission, belt transmission, friction transmission or elements of joint mechanism.

4. The system as defined in claim 1, wherein the axis or rotation of the system is preferably vertical and coincidental with the axial rotation of the patient's spine.

5. The system as defined in claim 1, **wherein** the backward mechanism contains transmission, preferably bevel gear, belt transmission or friction transmission, in which the first wheel (15a) of the transmission is firmly coupled to the arm(s) (4) of the machine by the means of firm housing (18). The said wheel is connected to the second wheel (17a) of the gear unit by the means of a counter drive gears (16a) and articulately mounted on a rigid frame (19) connected to the base of the machine (1), while the second gear (17a) of the transmission is firmly connected to the seat (5).

6. The system as defined in claim 5, **wherein** the back-

ward mechanism comprises the gear, where the rotary elements preferably with a changeable number of teeth on the toothed wheel rim permit to change the proportion between the angles of the seat rotation and arms rotation.

7. The system as defined in claim 1, **wherein** the backward mechanism (2) preferably contains a joint mechanism, in which two crosses (15b, 17b) are axially mounted on the column (20) and another unmovable cross (16b) is mounted between them. The crosses are connected to one another with bars (16c) by the means of ball joints (16d). The lower cross (15b) is firmly coupled to the arm(s) (4), and the upper cross (17b) is firmly coupled to the seat (5).

8. The system as defined in claim 7, **wherein** backward joint mechanism contains the middle cross (16b), preferably with adjustable height for changing the proportion between the angles of seat (5) rotation and arm(s) (4) rotation.

9. The system as defined in claim 1, **wherein** an off - load frame (8) for suspending the user of the machine comprises a line (9) pulled through the pulleys (10) and along the off-load frame (8) and the manual winch (11), where the end of the said line is mounted along the rotation axis of the device.

10. The system as defined in claim 1, **wherein** the movable off-load frame (21) is supported and regulated by the means of an engine or a servomotor (22).

11. The system as defined in claim 1, **w**herein the elastic elements (23) are mounted between the arms (4) and the base (1) in order to evoke resistance during exercises.

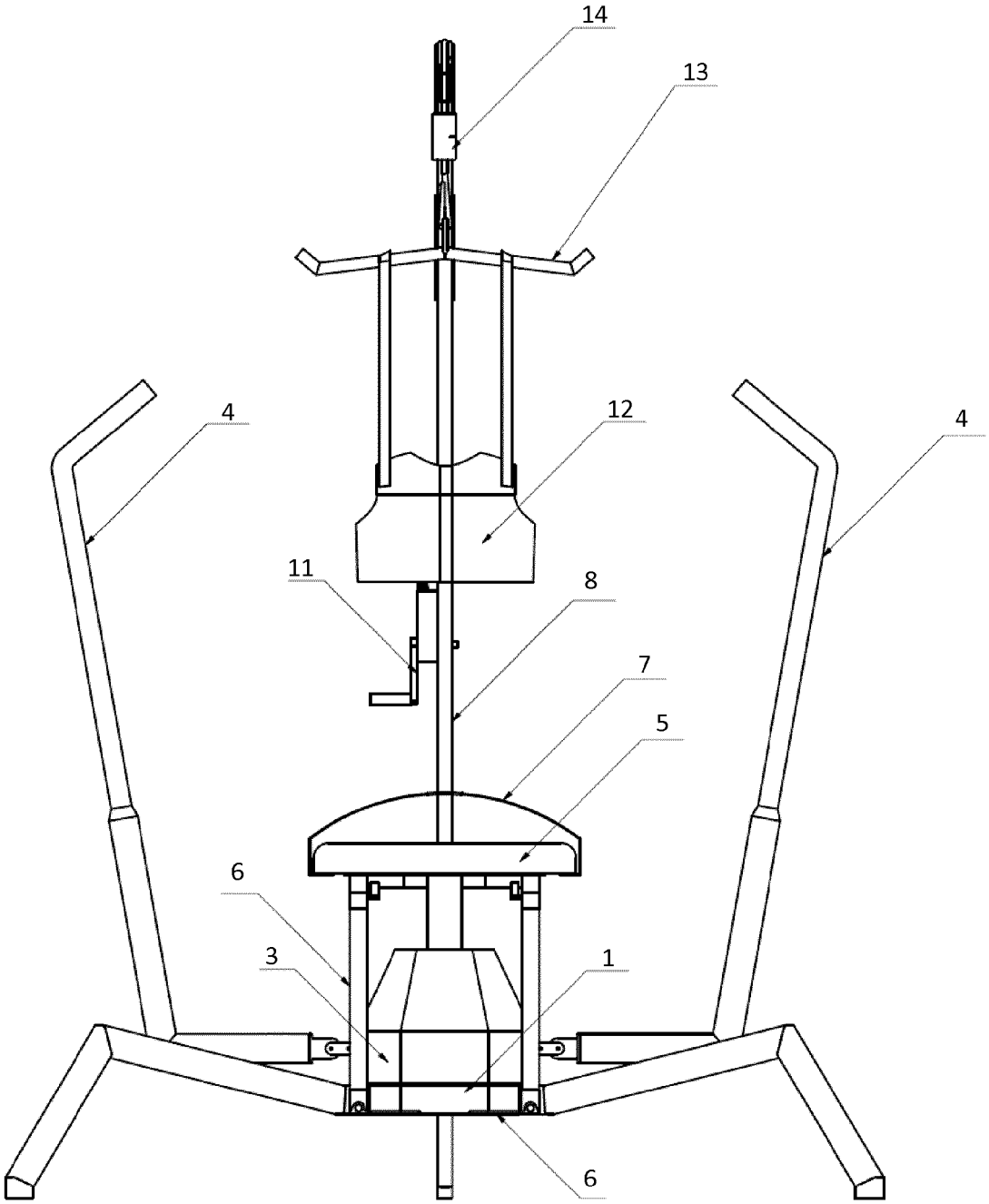

Fig. 1.

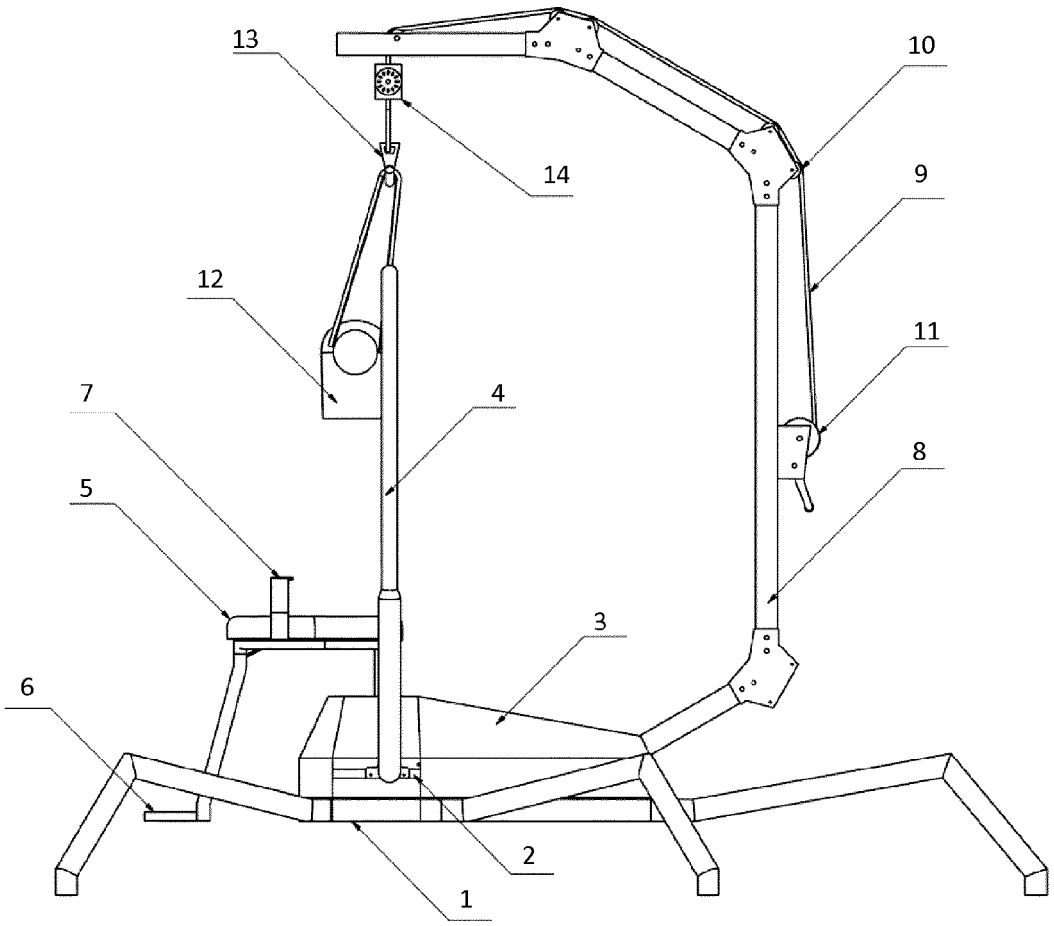

Fig.2

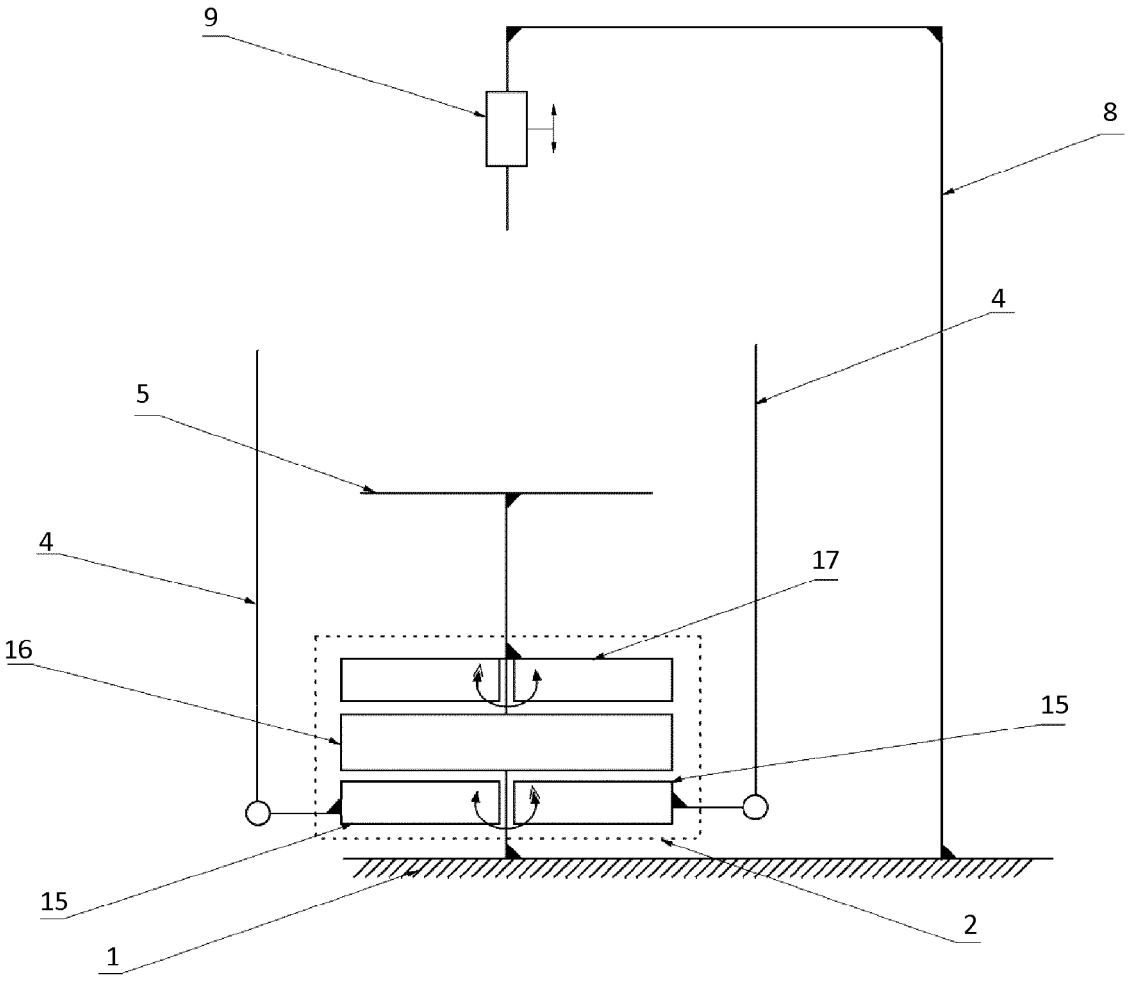

Fig.3

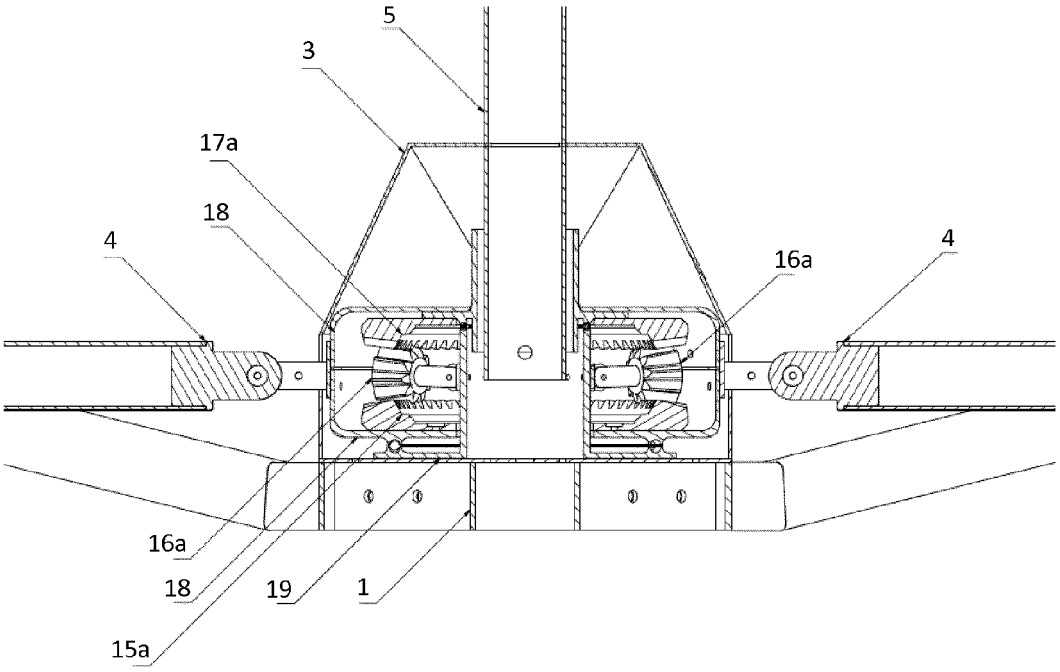
5
3
17a
18
4
16a
4
16a
18
19
1
15a

Fig.4

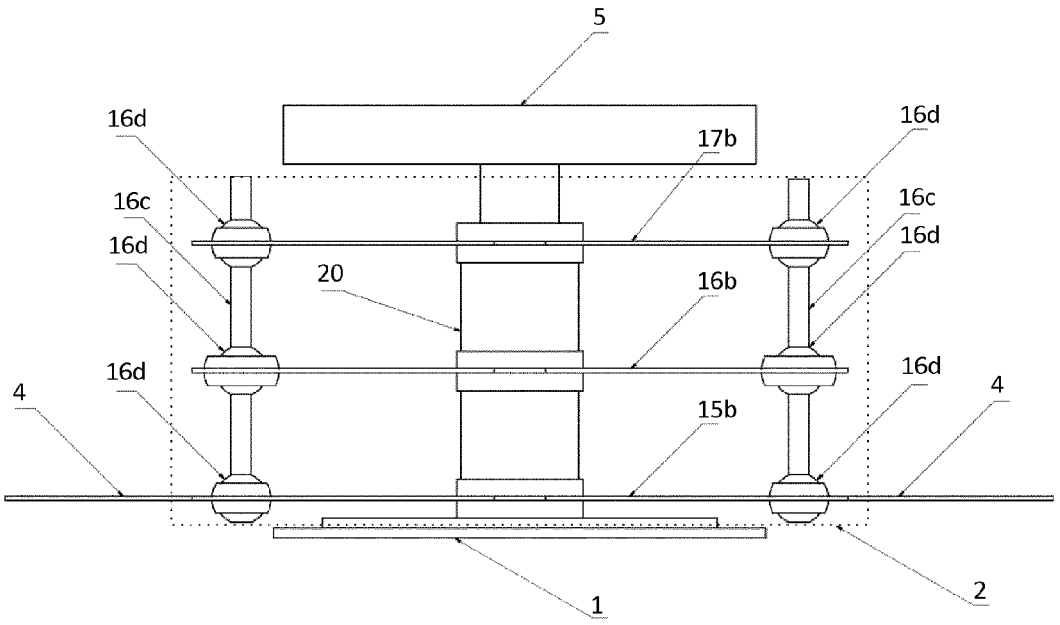
5
16d
17b
16d
16c
16c
16d
16d
20
16b
16d
16d
4
4
15b
1
2

Fig.5

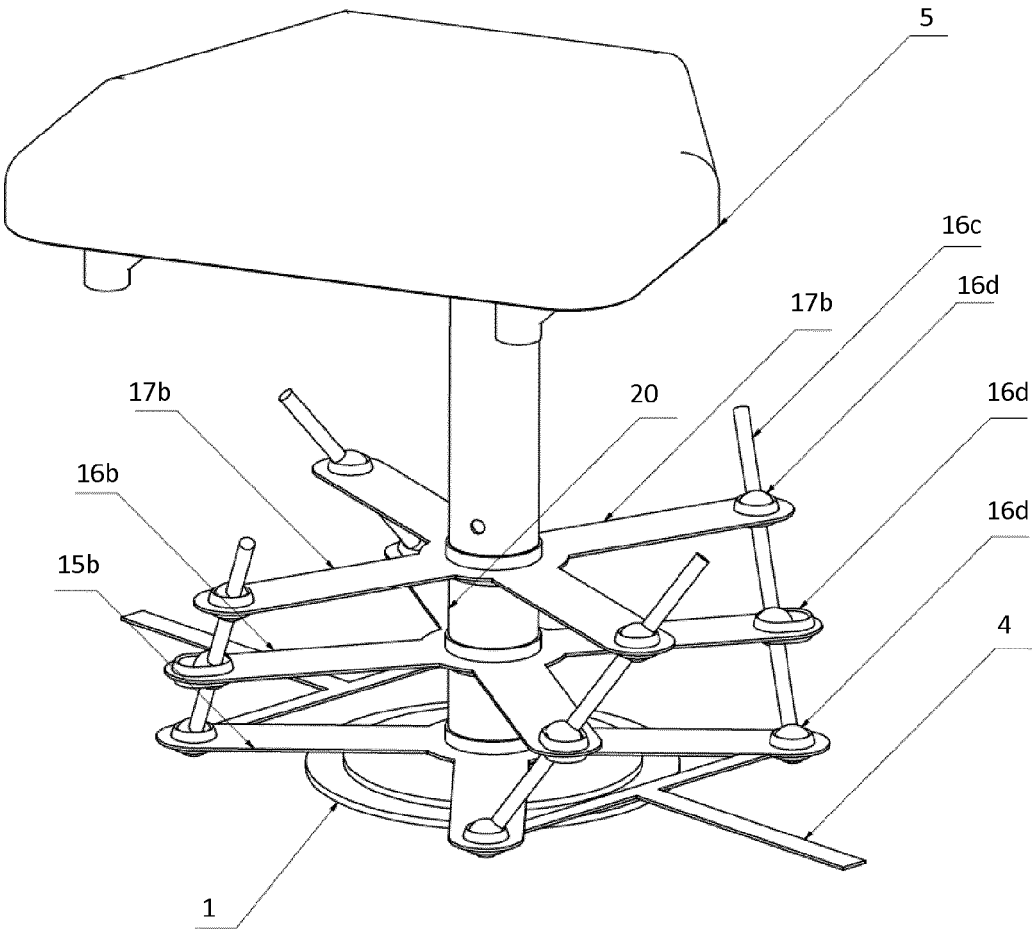

Fig. 6

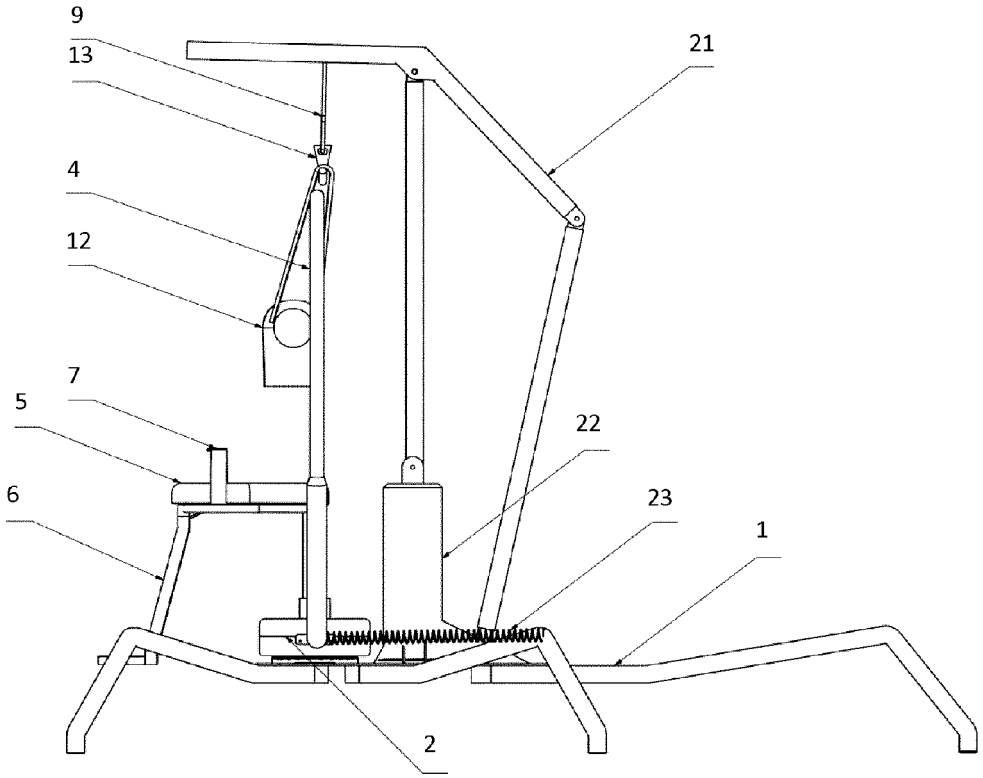

Fig.7

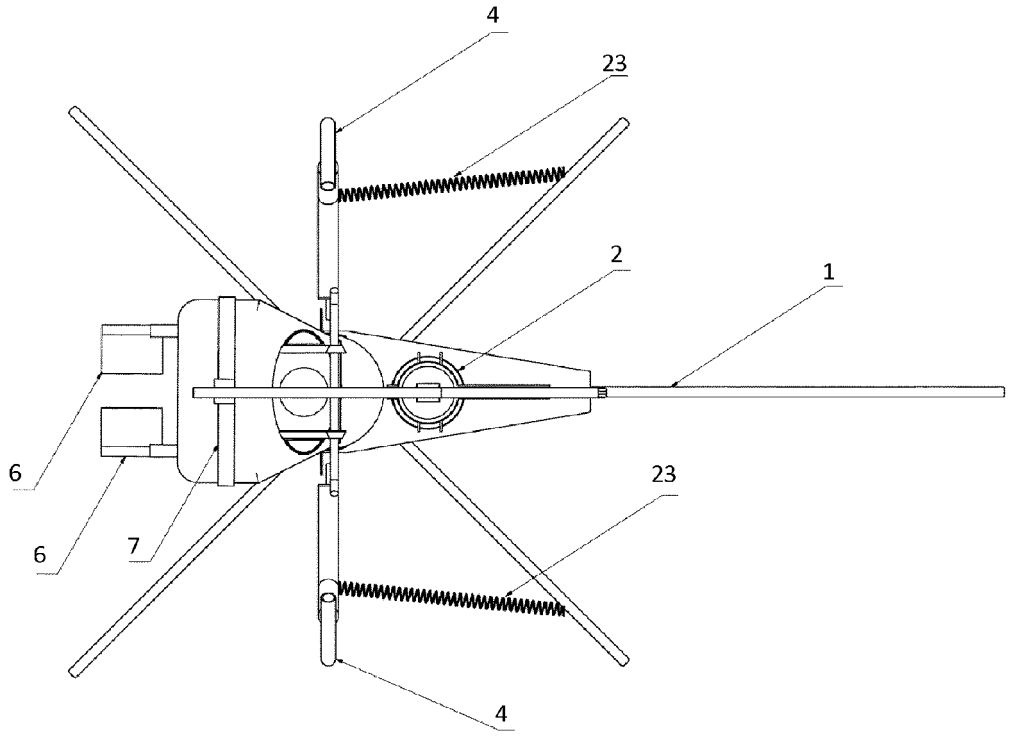

Fig.8

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EUROPEAN SEARCH REPORT

Application Number
EP 13 46 1531

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y	WO 2012/098506 A1 (KINETIC MEDICUS LTD [IL]; GUENNICHE YORAM FELIX [IL]; DEMER GAL [IL]) 26 July 2012 (2012-07-26) * page 7 - page 15; figures *	1-6,9-11	INV. A63B21/00 A63B69/00 A61H1/02 A63B22/00
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	27 September 2013	Borrás González, E

CATEGORY OF CITED DOCUMENTS

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27-09-2013

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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- PL 173405 **[0010]**
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- JP 2001212163 B **[0012]**