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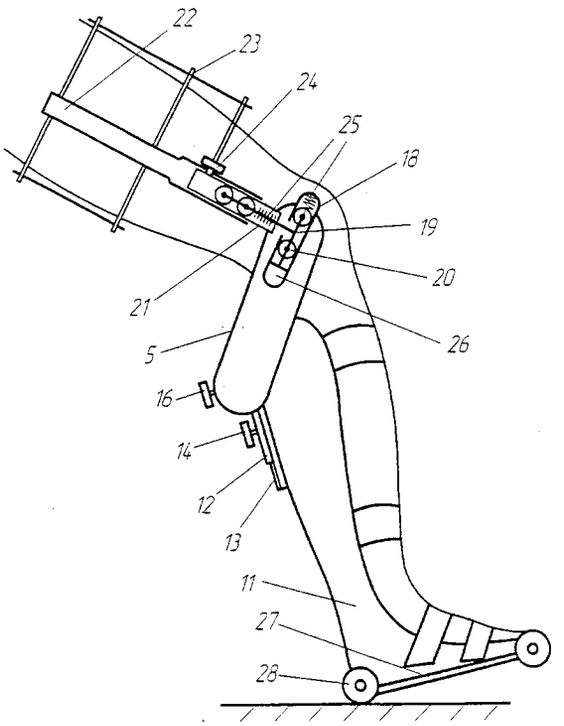
(54) DEVICE FOR RESTORING THE MOBILITY OF JOINTS

(57) The present invention relates to a device that comprises an electric actuator having a body in the form of U- type frame and comprising two output shafts coaxially arranged at the ends of the frame. A support system for one of the adjacent segments forming the joint is connected to central portion of the actuator body trouth adjustment and fixation members. The second support system is connected to the output shafts of a reduction gear through a mechanism for transmitting rotation between two non-coaxial shafts. This electric device is compact, fits directly to the extremities of a patient and also includes a control system. This device may further include additional electric actuators for operating the joints on two director-plane or for reducing the load onto the joint surface.



Фиг 2

EP 1 120 098 A1

Description

FIELD OF THE INVENTION

[0001] This invention is concerned with the field of medicine techniques, particularly with the device for restoring the mobility of joints.

BACKGROUND OF THE INVENTION

[0002] The Soviet Union inventors sertificate No. 1653770, A61H 1/02 disclosed the device for restoring the mobility of joints, inclusive the base with fixed lodgment, frame conjuncted with the base by a pin-joint. The frame has an electric drive with a transmission. The transmission is accomplished as a screw-nut pair, in wich the nut is connected with a rocker; the rocker has a fixed tie with levers of link gear; the slider of the link gear is fixed on the moving lodgement.

[0003] This device decreases the load to joint which takes place because of misalignments of the joint axis and the device axis.

[0004] However, the peculiarity of this transmission limits the range of motion of joints by the length of guidescrew and lower efficiency.

[0005] By this reason this device has a large weight and dimensions and may be accomplished only in stationary mode. It is necessary to fix limbs and body while using the device, which decreases the effectiveness of the restoring the mobility of joints.

CONTENT OF THE INVENTION

[0006] The goals of this invention are:

a) To increase the effectiveness of restoring the mobility of joints

- due to compact dimensions, low weight, good functionality of device and simple adjusting to joints of any type. This allows to combine the long mechanotherapy treatments with rest or some other practice;
- due to possibility of repairing bone breaking and function of joint simultaneously, by using device of external fixation;
- due to possibility of movement of joints in two director-planes simultaneously;
- due to possibility of reducing of load to a joint surface by means of displacing onto the supporting units.

b) Decreasing of healing cost due to simplicity and universality of device, possibility of using the device at home.

[0007] This task is solved in the following manner: the device for restoring the mobility of joints contains at least one electric actuator, control system, unmoved and drive support units for adjacent segments forming joint; electric actuator has a body in the form of U-type frame and has two output shafts coaxially arranged at the ends of it; the middle part of U-type frame, named supporting module, has unmoved support unit; drive support unit is connected with output shafts through a mechanism for transmitting rotation between two non-coaxial shafts.

[0008] Supporting module may be removable or telescopic and includes means of adjusting and fixation of unmoved supporting unit. It may be accomplished in form of empty body with motor inside it. The motor is connected to output shaft by means of reduction gears, the case of these reduction gears makes both sides of U-type frame.

[0009] Mechanism for transmitting rotation between two non-coaxial shafts may be accomplished in form of two links fixed on output shafts of electric actuator; each of the links is connected with its guide, fixed on drive support units by means of connecting-rod; connecting-rod is joined with its guides by means of springy connection and with links by means of actuator of linear movement.

[0010] This mechanism provides linearly dependence between angle of wind of output shafts of electric drive and the angle of wind of supporting unit and reduces the load to a joint surface by means of displacing onto the supporting unit.

[0011] Mechanism for transmitting rotation between two non-coaxial shafts may be accomplished in form of levers with adjustable length, fixed on output shafts of reduction gears; levers are connected on free ends with common support, which has swivel connected with crosshead; guide of this crosshead is mounted on drive support unit.

[0012] Roller or ball-and-socket attachment is used as a crosshead which is connected with its guides by means of springy connection.

[0013] This type of construction is simple and compact with the high level of specific power, and conveniently adjusting to joints of any type, may be used at any phase of healing process. It's very simple and may be used without highly qualified personnel.

[0014] For providing movement of joints in two director-plane simultaneously, supporting module may contain additional electric drive of unmoved supporting unit.

[0015] Electric drives may have clutches, which provides free movements of joints while this device is fixed to the patient limb. The data of movement amplitude enteres into the programmer automatically.

[0016] Any orthopedic external holder may be used as a supporting unit. Foot support unit may comprise rollers for making the movement in knee-joint easier.

LIST OF FIGURES AND DRAWINGS

[0017] Figure 1. General appearance of device for restoring a knee-joint.

[0018] Figure 2. The same - side view.

[0019] Figure 3. Scheme of unit of displacement and fixation of unmoved supporting unit.

[0020] Figure 4. Scheme of electro drives assemblied for restoring joints in two direct planes.

[0021] Figure 5. General appearance of device for restoring ankle joints in two direct planes.

[0022] Figure 6. The same - Side view.

CONFIRMING OF POSSIBILITY OF INVENTION ACCOMPLISHING

[0023] Device for restoring the mobility of joints (figures 1,2) contains U-type frame electro drive. Middle part of U-type frame - supporting module 1 - is accomplished as an empty body with reverse motor 2 in it. This motor has two output shafts 3. 4- sensing element of winding speed forms signals for motor speed controlling. Case of supporting module 1 is connected with cases of reduction gears 5, which constitute side base of frame. The output shafts of motor are connected with input shafts of these reduction gears. Each reduction gear 5 consists of two reduction gear - 7 - motor reduction gear and 8 - output reduction gear. 6 - clutches which connect reduction gears 5 and 8.

[0024] Clutches 6 disconnect reduction gears 8 from other part of actuator. This disconnection allows free winding of output shaft of actuator which are arranged coaxially (axis O-O).

[0025] Such disconnection of clutches is allowed to detect the range of motion of patient say nothing of providing the convenience while the device is affixed to the patient limb. Additionally these clutches may be used for limiting maximum value of load. 10 sensing element of output shafts position. Supporting module 1 has mechanism of adjusting and fixing unmoved supporting unit 11. It is a leg lodgment in our example. This unit (fig. 2,3) consists of linear movement guide and guided detail 13, which is mounted on the leg lodgment 11. Screw 14 fixes the leg lodgment position. Guide way 12 is mounted onto supported module 1 (fig. 3) with the virtual winding round axis 15. An angle of winding is adjusted by screw 16 with a help of mechanism 17. This mechanism allows to orient the device to the patient limb.

[0026] The output shafts of device are connected to a mechanism for transmitting rotation between the two non-coaxial shafts. This mechanism is appointed for transmitting winding between the output shafts of device on the patient joint, which plays role of the second shaft. The axis of this shaft (patient joint) may be not coaxial to the axis O-O.

[0027] In this example kinematical scheme may be considered as modifying analogue of cross-clutch. This clutch allows to reduce the react force in joint. Mechanism consists of two synchronously operating units. On each output shafts 9 mounted guide way 18. Connecting-rods 19 with rollers 20 conjunct links 18 with guides 21. These guides are part of telescope levers 22 which are connected with adjustable supporting unit. This is femur external fixing apparatus in our example. Screw 24 fixes the length of a lever. Springs 25 determine the initial position of a connectihg-rod and prevent displacing it in outside position. The using of springs allows smooth response to relative displacement of axes of the joint and the device. Drive of linear displacement compensates extreme pressure onto joint surface. It uses polarized electromagnets as a drive of linear displacement.

[0028] Shin lodgment has foot prop 27 with roller 28 and allows training knee-joint both in lying and sitting positions without any special support. Femur and knee joints are trained simultaneously in a lying position.

[0029] Modifying scheme of our device for training ankle joint in two direct planes is presented in figures 4-6. Supporting module 1 (figure 4) contains additional actuator for a wind unmoved support unit 29. The output shaft 30 of this actuater is connected with guide linear displacement 12. The reduction gears 5 are provided with own motors. The output shafts 9 of these reduction gears are connected with mechanism for transmittion rotation between two non coaxial shafts. This mechanism consists of telescope levers 31 conjunct by common holder 32. The ball-and-socket attachment 33 makes role of crosshead and is mounted onto this holder. The ball-and-socket attachment compensates a foot slew, which takes place because of non coaxiality of axis joint and device. The crosshead is connected with its guide 34 by the springy detail 35. The guide 34 is fixed on drive supporting unit 23. This is a shin lodgment in our example. The screw 36 fixes the length of levers 31.

[0030] Elements 11-16 (figures 5,6) fix foot prop 11 thus an ankle joint is placed in sphere of axis O-O. Screw 16 adjusts an position of driving gear 29 relative to supporting module 1.

[0031] Operating of the device is described by example of training of knee joint in special condition when the femur has external fixation apparatus 23 (figure 1,2).

[0032] In this case the shin lodgment is used as fixing supporting unit 11 supplied with foot prop 27 with roller 28. After fixation of the lodgment on shin, the screw 14 is loosed and by the screw 16 and frame displacement alongside guides 12,13 the axes of joint and device are combined. The screw 14 fixes favorable position. The favorable length of levers 22 is fixed by screws 24. The device is ready to operate.

[0033] In this condition clutches 6 are disengaged. A patient makes free joint movement. The signal from sensitive element of output shafts 10 of device goes to controller. A signal of speed and amplitude of patient moving is transferred to controller in the same way. This data are used in controlling process.

[0034] The controller forms controlling signals for motor 2, clutch 6 and electromagnet 26.

[0035] The device operating begins with turning on of clutch 6, then motor 2 is turning on. The winding of output shafts of motor is transmitted onto output shafts 9

by reduction gear 5 and by means of elements 18, 21, 22, 23 is transferred onto external fixation apparatus 23. The knee joint begins to flex.

[0036] The bias of joint axis from the output shafts 9 is compensated by displacement of connecting-rod in link 18 and guides 21.

Claims

1. The device for restoring the mobility of joints contains at least one electric actuator, control system, unmoved and drive support units for adjacent segments forming joint differing thus, that

its electric actuator has a body in the form of U-type frame and has two output shafts coaxially arrange at the end of it;
the middle part of U-type frame, named supporting module, has unmoved support unit;
drive support unit is connected with output shafts through a mechanism for transmitting rotation between two non-coaxial shafts.

2. The device as in claim 1, has a supporting module, which may be removable or telescopic and further comprising means of adjusting and fixation of unmoved supporting unit.

3. The device as in claim 1 or 2 may be accomplished in form of empty body with motor inside it and motor is connected to output shaft by means of reduction gears, the body of which is constructed by the both sides of U-type frame.

4. The device as in claim 1,2 or 3, has the mechanism for transmitting rotation between two non-coaxial shafts which may be accomplished in form of two links fixed on output shafts of electric actuator;

each of links is connected with guide, fixed on drive support units by means of a connecting-rod;
connecting-rod is joined with its guides by means of springy connection and with links by means of actuator of linear movement.

5. The device as in claim 1,2 or 3, has the mechanism for transmitting rotation between two non-coaxial shafts which may be accomplished in form of levers with adjustable length, fixed onto output shifts of electric actuator, while levers are connected with common support on free ends, which has swing joint with crosshead; guide of this crosshead is mounted on drive support unit.

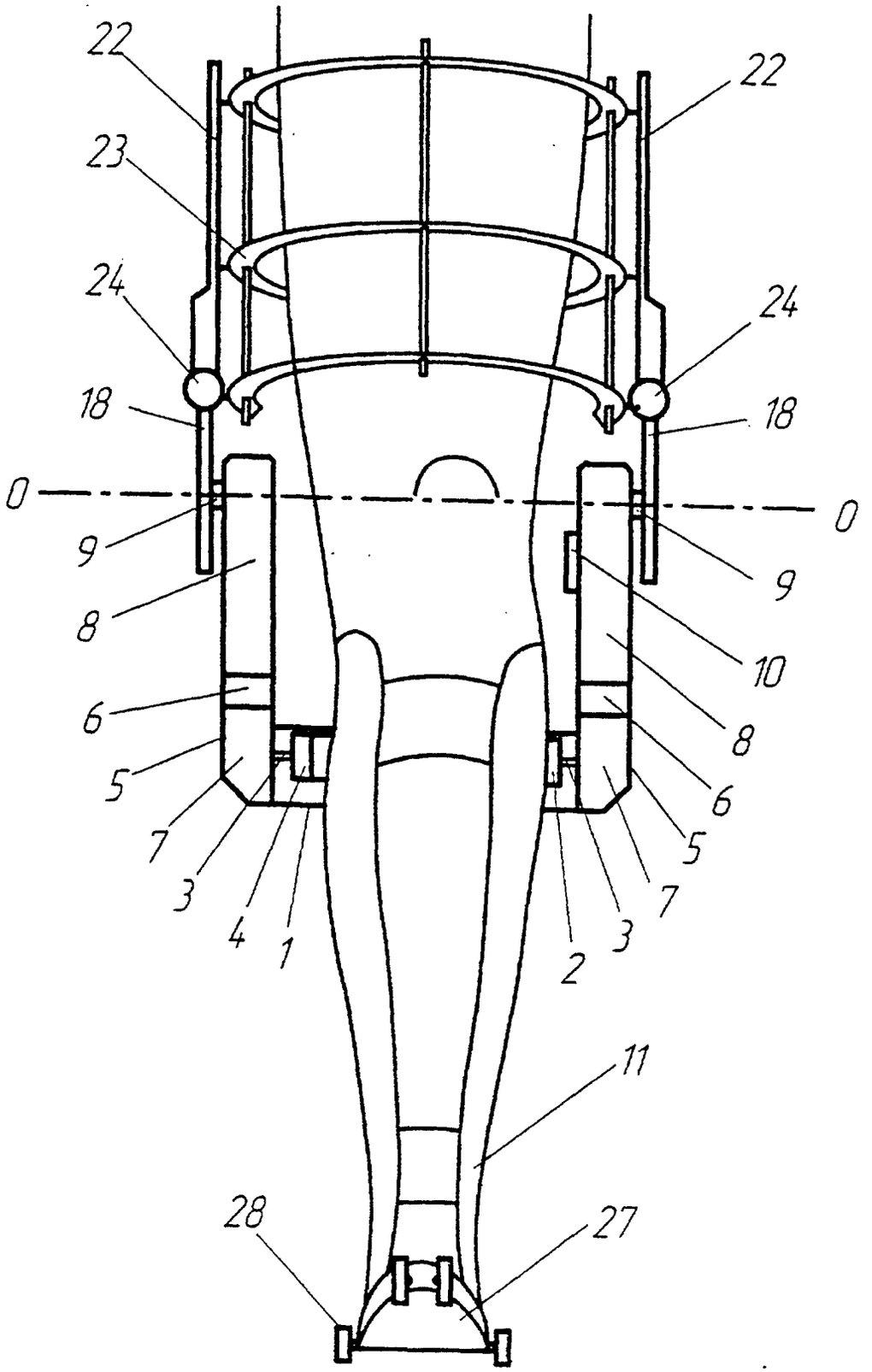
6. The device as in claim 5 has the roller or spherical bearing is used as a crosshead, which is connected with own guides by means of springy connection.

7. The device as in claim 6 has the supporting module comprises additional electric drive of fixed supporting unit.

8. The device as in claim 1, 2, 3 or 7 has electric actuators comprise automate clutches.

9. The device as in claim 1, 2, 3 or 8 has the orthopedic external holders which are used as support units.

10. The device as in claim 1, 2, 3 or 9 has the foot support unit may comprise rollers.



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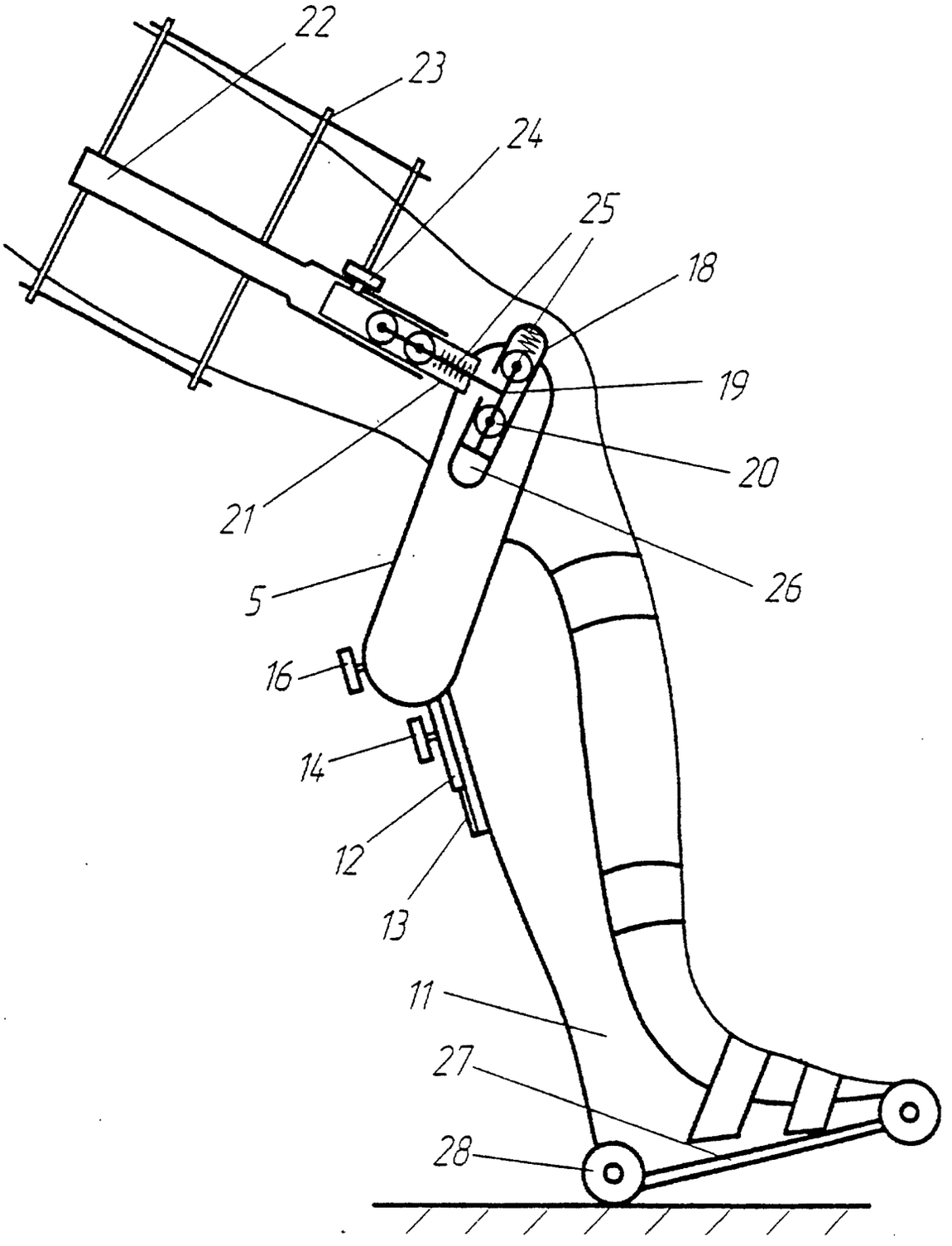

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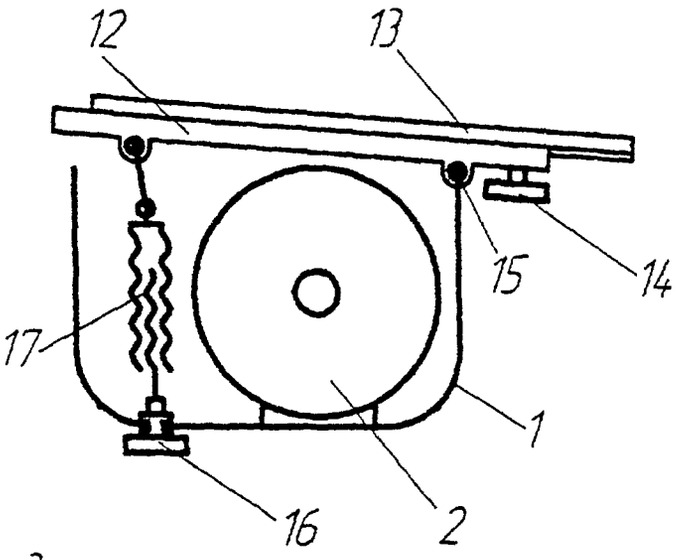

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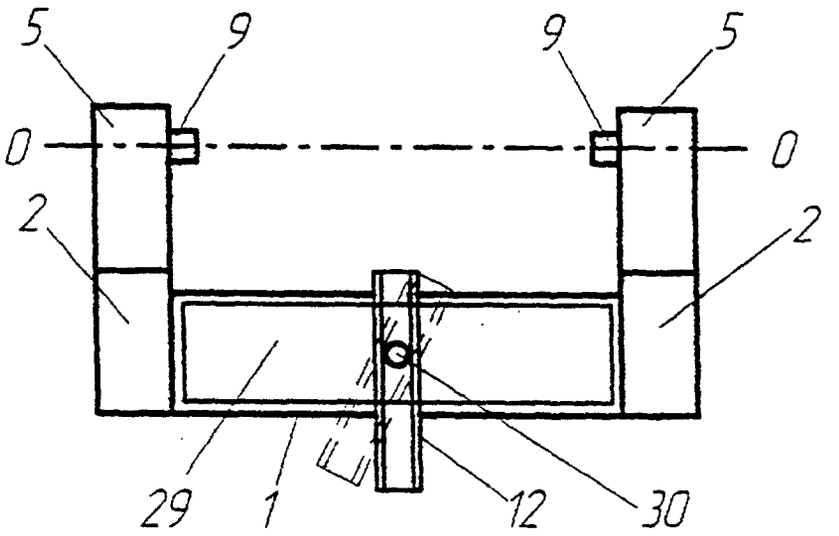

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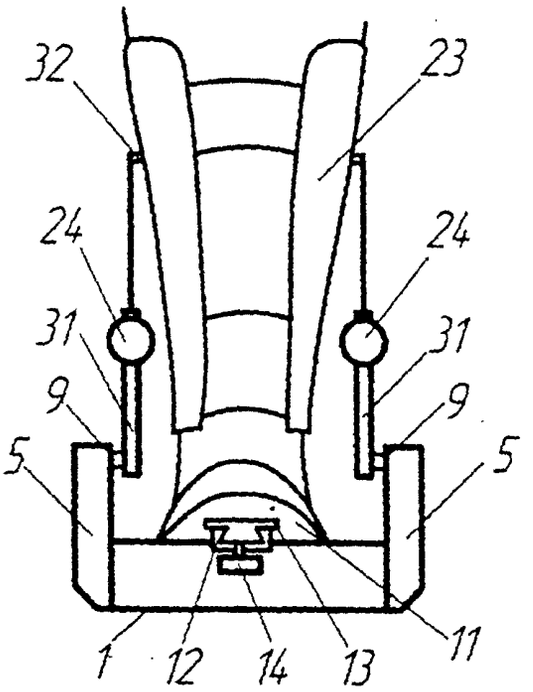

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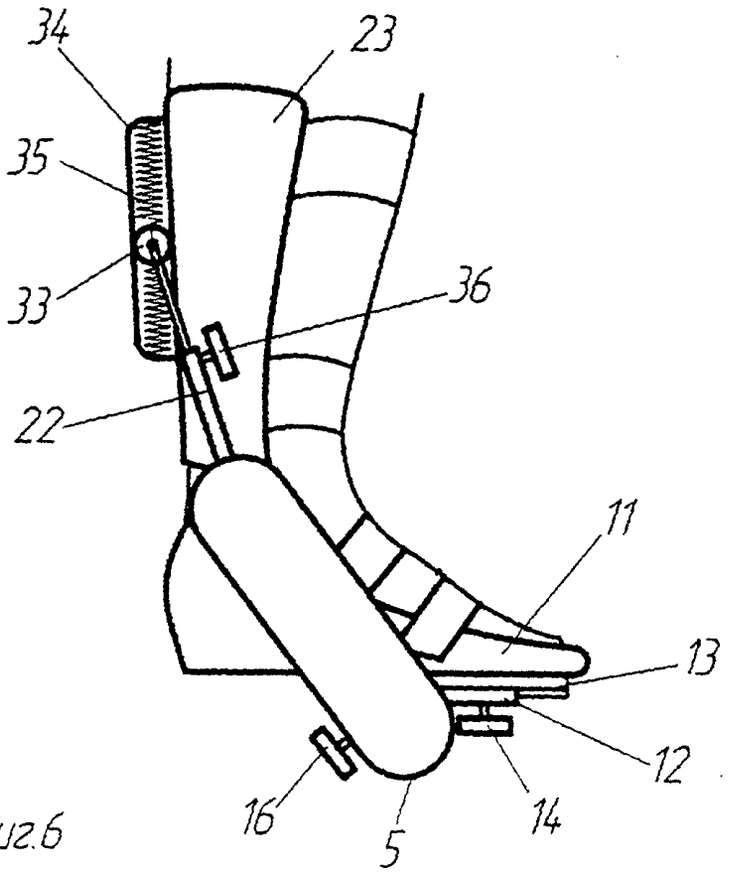

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/RU 99/00373

A. CLASSIFICATION OF SUBJECT MATTER [6]:

IPC 7 : A61H 1/02

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)

IPC 7 : A61H 1/00, 1/02; A61B 17/60

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)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0588464 A1 (SUTTER CORPORATION), 23 March 1994 (23.03.94), claims, figure 3.	1-10
A	WO 94/15571 A1 (MEDIREHA GMBH), 21 July 1994 (21.07.94), claims, figures 1,3.	1-10
A	US 4807601 A (THOMAS C.WRIGHT), 28 February 1989, (28.02.89), claims, figures 2,3.	1-10
A	US 4825852 A (CARMEN E.GENOVESE et al.), 02 May 1989 (02.05.89), claims, figure 1.	1-10
A	SU 1468533 A1 (JU.A. CHERNYAVSKY et al.), 30 March 1989 (30.03.89), claims, figure 1.	1-10
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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 November 1999 (24.11.99)	16 December 1999 (16.12.99)
Name and mailing address of the ISA/ R.U Facsimile No.	Authorized officer Telephone No.