(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 970 681 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
23.03.2022 Bulletin 2022/12

(21) Application number: **21183639.0**

(22) Date of filing: **05.07.2021**

(51) International Patent Classification (IPC):
A61H 1/02 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
A61H 1/0262; A61H 2201/1207; A61H 2201/1619; A61H 2201/1626; A61H 2201/1633; A61H 2201/1635; A61H 2201/1642; A61H 2201/1666; A61H 2203/0406; A61H 2203/0431; A63B 2071/0018

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

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(54) MOTOR REHABILITATION MACHINE

(57) The present invention relates to a patient motor rehabilitation machine, particularly for gait rehabilitation.

In particular, the invention relates to a machine (1) for the motor rehabilitation of a patient (P), comprising a frame (3) which supports movable supporting means (2) for the patient (P) and a gait simulation system (4), **characterized in that** the gait simulation system (4) comprises a moving mechanism (36) for each of the patient's leg, configured for a roto-translation movement adapted to reproduce the gait, said moving mechanism (36) comprising:

- a carriage (64) comprising a base plate (75) sliding on a track (73),
- a movable plate (79) hinged to the base plate (75), the movable plate (79) rocking with reciprocating high-low motion,
- a footboard (43) fixed in an adjustable manner on the movable plate (79) to be able to adapt it to the foot of the patient (P),
- a shin support (91) hinged at a lower end (93a) to the movable plate (79) and connected at a front face (92b) to the movable plate (79) through an actuator (95) such that the shin support (91) rocks relative to the movable plate (79),
- motorization means (71, 72) configured to implement the translation of the carriage (64) along the track (73) and rocking of the movable plate (79) with said reciprocating high-low motion.

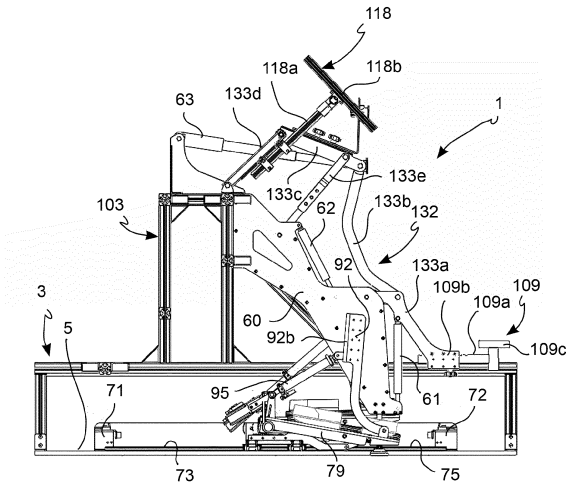

FIG. 14B

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Description

[0001] The present invention relates to a patient motor rehabilitation machine, particularly for gait rehabilitation.

[0002] Motor rehabilitation is necessary when events occur which inhibit or even destroy a person's ability in the physical, mental, or social contexts.

[0003] Specifically, motor dysfunctions may be divided into two categories:

- of neurological type, i.e. all the pathologies concerning brain dysfunctions. Muscle activation is no longer induced by neurons, and therefore the individual is unable to perform the desired movements. This type of situation can be determined by a variety of causes, such as cerebral palsy, stroke, brain or spinal cord trauma, etc.;
- of orthopedic type, dysfunctions listed in this category are usually the result of damage to the limb, such as bone fractures, tendon injuries or tears, crushing, or any mechanical traumatic cause. In these cases, rehabilitation therapy is aimed at regaining the functional characteristics of the organ.

[0004] The typical categories of patients requiring motor rehabilitation treatment are those with:

- paraparesis: a neurological condition manifested by partial loss of motor skills in both lower limbs;
- paraplegia: the condition in which the lower part of the body of a person is affected by motor paralysis and/or functional deficiency; it differs from the previous one because the motor ability is totally absent;
- quadriplegia: is a paralysis of the torso and all four limbs resulting from trauma or disease;
- hemiplegia: is a motor deficit, i.e., a paralysis affecting one side part of the body.

[0005] There are numerous devices usable in motor rehabilitation. These devices can be divided into two categories:

- lower limb rehabilitation devices: apparatuses consisting of more or less complex architectures which are intended to provide general rehabilitation of the lower limbs. These machines usually mobilize only one limb at a time; the patient is either seated or lying down and the limb in need of therapy is placed on a moving slide;
- devices dedicated to gait rehabilitation: in general, these devices are more complex than the previous ones; they consist of a suspension system and a movement system of the lower limbs aimed at simulating gait. They can be equipped with verticalization systems to facilitate machine set-up and quicken the patient preparation operations. These devices simultaneously move both lower limbs. The movement can take place through articulated system structures or through *end-effector* instruments.

[0006] The Applicant is the holder of European patent EP 2 865 363 B1, relating to an instrument for physical exercise and rehabilitation of upper and lower limbs, usable in both passive and active therapies, comprising a differential kinematic mechanism consisting of six pulleys of equal pitch diameter: four of these, the outermost, are constrained to the frame, while the remaining two are aboard a carriage free to run along a rail, which also serves as a structural element. A double-toothed belt connects all six pulleys. Two of the four outermost pulleys are actuated by electric motors, while all others are idle. With this architecture, the system receives two angular velocities as inputs, provided by the two motors, and, as a function of their difference, returns a motion consisting of the combination of a rotation and a translation. This combined law of motion of translation and rotation acts on the carriage which translates on the rail and is provided with two rotating pulleys.

[0007] It is an object of the present invention to make available a machine for motor rehabilitation, particularly for gait rehabilitation, which can be used use quickly, is provided with high comfort and safety standards, and promotes weight relief during the patient's exercise and verticalization.

[0008] Such an object is achieved by a motor rehabilitation machine as outlined in the accompanying claims, the definitions of which form an integral part of the present description.

[0009] It is thus an object of the invention a machine for the motor rehabilitation of a patient, comprising a frame which supports movable supporting means for the patient and a gait simulation system, **characterized in that** the gait simulation system comprises a moving mechanism for each of the patient's leg, configured for a roto-translation movement adapted to reproduce the gait, said moving mechanism comprising:

- a carriage comprising a base plate sliding on a track,
- a movable plate hinged to the base plate, the movable plate rocking with reciprocating high-low motion,
- a footboard is fixed in an adjustable manner on the movable plate to be able to adapt it to the foot of the patient,
- a shin support hinged at a lower end to the movable plate and connected at a front face to the movable plate through an actuator so that the shin support rocks relative to the movable plate,
- motorization means configured to implement the translation of the carriage along the track and the rocking of the movable plate with said reciprocating high-low motion.

[0010] Further features and advantages of the present invention will be more apparent from the description of some examples of embodiment, given here by way of

non-limiting example with reference to the following figures:

Figure 1 shows a prospective view of the rehabilitation machine according to the invention;
Figures 2A, 2B, and 2C show sequential perspective views of a step of verticalization of a patient before starting the rehabilitation exercise;
Figure 3 shows a perspective view of the frame of the rehabilitation machine according to the invention;
Figure 4 shows a perspective view of the detail of the seat;
Figures 5A-5B show perspective views of the seat in figure 4 in two different operating conditions;
Figures 6A-6B show two different perspective views of the rehabilitation machine of the invention under two different operating conditions;
Figure 7 shows a perspective view of the detail of the table of the rehabilitation machine according to the invention;
Figure 7A shows a perspective view of a detail of the table in figure 7;
Figures 8A-8B show two different views of steps of operation of the rehabilitation machine of the invention;
Figure 9 shows a diagrammatic front view of the table in figure 7 in a first operative configuration;
Figure 10 shows in simplified side view a verticalization sequence of a patient using the rehabilitation machine of the invention;
Figure 11 shows a diagrammatic side view of the gait simulation mechanism;
Figure 12 shows a diagrammatic side view of an embodiment of the moving mechanism of the footboards of the rehabilitation machine of the invention;
Figure 13 shows a perspective view of the detail of a first embodiment of the articulated system for the patient's leg;
Figures 14A and 14B show side views of a different embodiment of the invention, in two different operating conditions;
Figures 14C and 14D show a perspective view of the embodiment in figures 14A-14B in said operating conditions;
Figure 15 shows a perspective view of a different embodiment of the gait simulation mechanism;
Figure 16 shows a perspective view of a detail of the gait simulation mechanism in figure 15;
Figure 17 shows a section front view of the detail in figure 16;
Figure 18 shows a side view of the detail in figure 16.

[0011] With reference to the figures, according to a particular embodiment, the rehabilitation machine according to the invention, indicated by reference numeral 1 as a whole, comprises a frame 3 which supports movable supporting means 2 of the patient P and a gait simulation system 4.

[0012] The movable supporting means 2, in turn, comprise a tilting seat 9 and a resting table 10.

[0013] Referring to figure 3, the frame 3 comprises a base 5 on which a supporting structure 103 comprising a front post 6 and a handrail element 7 is attached.

[0014] The base 5 is C-shaped or horseshoe-shaped, with the open side facing the patient station. The base 5 is sized to provide a stable support for the machine 1.

[0015] The handrail element 7 has, in top plan view, a C-shaped or horseshoe shape, substantially corresponding to that of the basement 5, and comprises front side portions 7a, which develop according to a direction substantially perpendicular to the base 5, and a curved connecting portion 7b which develops anteriorly up to correspond to the front post 6, with which it is integral. In embodiments, the connecting portion 7b comprises inclined stretches 7c on both sides.

[0016] The front post 6 comprises a supporting element 8 onto which the moving system of the tilting seat 9 and of the resting table 10 are hinged, positioned above the integralization point between the handrail element 7 and the front post 6.

[0017] In the embodiment shown in the drawings, the front post 6 further supports a video screen 31, for displaying information relative to the rehabilitation or of another type.

[0018] Referring to figures 4, 5A and 5B, the tilting seat 9 comprises an L-shaped supporting bar 11 comprising an upper end 11a and a lower end 11b corresponding to the end of the horizontal stretch of the L.

[0019] The upper end 11a is fixed to a connecting structure 11c, which in turn is hinged to a fixed element 12 (omitted in figure 3, but visible in the side view in figure 6A). The fixed element 12 is integral with the front post 6 and extends in the direction of the open side of the base 5.

[0020] In some embodiments, the supporting bar 11 may slide in a vertical direction relative to the connecting structure 11c (see the vertical arrow in figure 5A) and may be fixed at different heights by means of conventional locking means to adjust the seating according to the patient's needs.

[0021] A first T-shaped seating element 13 comprising a mating portion 13a with the supporting bar 11 and a transverse portion 13b is fixed to the front end 11b of the supporting bar 11. Both the mating portion 13a and the transverse portion 13b preferably comprise a padded seating surface to improve the patient's comfort.

[0022] The first seating element 13 internally comprises a tubular bar (not shown) which constitutes the continuation of the horizontal stretch of the L-shaped supporting bar 11. A second seating element 14 is slidingly associated with such a tubular bar by means of a telescopic bar 15 (figure 5B). In this manner, the second seating element 14 may be arranged either in a retracted position (figure 5A) or in an extended position (figure 5B). The second seating element 14 further comprises an upholstered seating surface.

[0023] Third seating elements 16a, 16b are hinged to the transverse portion 13b of the first seating element 13 to flank the coupling portion 13a. The third seating elements 16a, 16b tilt perpendicularly to the plane of the first seating element 13, in the direction opposite to the vertical stretch of the L of the supporting bar 11 (figure 5B).

[0024] The tilting seat 9 thus implements a seating which is sufficiently wide and comfortable for the patient during the step of transitioning from the wheelchair or other aid to the machine 1 of the invention (figures 2A-2B and 6A). Furthermore, in the step of verticalization and in the successive step of rehabilitation exercise (figures 2C and 6B), the tilting of the third seating elements 16a, 16b avoids the interference with the patient's gait, while the extension of the second seating element 14 provides good support for the patient's back.

[0025] The tilting seat can be moved and adjusted either manually or by means of appropriate actuators according to the arrows in figure 5A.

[0026] Referring to figures 7, 7A, 8A-8B, and 9, the resting table 10 comprises a platform 17 onto which two side bars 18a, 18b adapted to be gripped by the patient are fixed.

[0027] In preferred embodiments, the side bars 18a, 18b comprise a first portion 19a, 19b and a second portion 20a, 20b, both of which develop substantially perpendicular to the platform 17, wherein the first portion 19a, 19b is placed proximal to the patient, and the second portion 20a, 20b is positioned distal therefrom. Such first portions 19a, 19b and second portions 20a, 20b of the side bars 18a, 18b constitute a grip for the patient, respectively, in the step of approaching the rehabilitation machine 1 (figure 8A) and in the step of using the machine 1 during the rehabilitation exercise (figure 8B).

[0028] A pair of resting elements 21a, 21b for the patient's forearms are arranged on the platform 17 aligned with the side bars 18a, 18b and between the first portions 19a, 19b and the second portions 20a, 20b thereof. The resting elements 21a, 21b preferably have an anatomical shape, e.g. a concave shape longitudinal to the patient's forearm, and are made of padded material to ensure the patient's comfort.

[0029] The platform 17 has a semicircular profile 22 on the side facing the patient, in which semicircular profile 22 the restraining elements 23 of the patient's torso are arranged. The restraining elements 23 comprise a center cushion 24 and two side cushions 25a, 25b and are arranged to support the patient's torso both anteriorly and relative to a sidewards oscillation, such as that which may be caused by the ambulatory activity.

[0030] The restraining elements 23 are mounted on a semicircular element 26, which substantially corresponds to the semicircular profile 22 of the platform 17 and comprises at its ends two sleeves 27a, 27b sliding perpendicularly to the platform 17 along respective guides 28a, 28b. The sleeves 27a, 27b may be moved and locked, respectively, by either loosening or tightening the locking screws 29 maneuverable by means of appropriate knobs 30. In this manner, the restraining elements 23 can be adjusted according to the patient's height.

[0031] The side cushions 25a, 25b are hinged onto the semicircular element 26 so that they can rock about an axis perpendicular to the platform 17. In this manner, the restraining elements 23 can be adjusted to the size of the patient's torso. In an optimal condition of use, the patient's torso must adhere to the restraining elements 23 on the front and side.

[0032] The adjustment of the restraining elements 23 can also be motorized.

[0033] In some embodiments, as shown in figure 9, the resting table 10 is mounted in a laterally rocking manner, i.e., about an axis substantially perpendicular to the patient's torso (arrow in figure 9), to accommodate the patient's oscillatory movement during the gait simulation, thereby improving comfort.

[0034] In some embodiments, the restraining elements 23 further comprise pre-tensioned belts (not shown) which allow for improved support of the patient's torso, which is useful for patients with particularly impaired motor skills.

[0035] As shown in figure 10, the tilting seat 9 and the resting table 10 are movably coupled to an articulated system 32, e.g. a double articulated parallelogram system, which is mounted to the fixed element 12 by means of appropriate hinges.

[0036] In greater detail, the articulated double parallelogram system 32 comprises a first arm 33a, a second arm 33b, a third arm 33c, and a fourth arm 33d, wherein:

- the first arm 33a is hinged onto the connecting structure 11c of the tilting seat 9, in a position distal to the hinging point of the connecting structure 11c on the fixed element 12, and on the second arm 33b, at a position intermediate between the ends thereof,
- the second arm 33b is hinged onto the fixed element 12 and to one end of the fourth arm 33d,
- the third arm 33c is hinged on the fixed element 12 and in the intermediate position of the fourth arm 33d,
- the fourth arm 33d is hinged at an intermediate position at the end of the arm 33c and, at its lower end, at the end of the second arm 33b opposite to the fixed element 12.

[0037] In this manner, once the patient is seated on the tilting seat 9, a coordinated movement of tilting the tilting seat 9 and approaching the resting table 10 can be accomplished, the sequence of movements of which is shown in figure 10. The final result is shown in the last right image of figure 10, in which the step of verticalization of the patient is completed and the patient is supported posteriorly by the tilting seat, in its extended condition of figure 5B, and anteriorly and laterally by the restraining elements 23.

[0038] Such a movement is enabled by a linear actuator 34 (shown in figure 6A), hinged on the supporting

element 8 and acting by means of a shaft 35 on a point near the hinge point of the first arm 33a on the second arm 33b.

[0039] In a different embodiment, shown in figures 14A and 14B, the supporting structure 103 comprises a supporting element 60 for an articulated system 132 to which a tilting seat 109 and a handlebar 118 are movably coupled.

[0040] The tilting seat 109 may be the same as that previously described for the first embodiment, or it may consist of a simple platform 109c, preferably anatomical, fixed to a rod 109a adjustable in height by sliding in a tubular housing 109b, e.g. by screw fastening.

[0041] The handlebar 118 comprises one or more supporting rods 118a (in the example of the figures, two supporting rods) and a pair of grips 118b. The supporting rods 118a can be adjustable in height by sliding in special tubular seats.

[0042] The articulated system 132 comprises a first, a second, a third, a fourth, and a fifth arm 133a, 133b, 133c, 133d, 133e, wherein:

- the first arm 133a is associated with the tilting seat 109, the first arm being hinged to the supporting element 60 by means of two piston springs 61, 62 (e.g., gas springs);
- the second arm 133b comprises a first end hinged to the first arm 133a and a second end hinged to a first end of the third arm 133c;
- the third arm 133c comprises a second end hinged to a first end of the fourth arm 133d;
- the fourth arm 133d comprises a second end hinged to the supporting element 60;
- the fifth arm 133e comprises a first end hinged proximate to the first end of the third arm 133c and a second end hinged to the supporting element 60.

[0043] A linear actuator 63 is further hinged on one side to the supporting element 60 and on the other side to the junction point between the second arm 133b and the third arm 133c. For example, the linear actuator 63 is an electric screw actuator.

[0044] Figures 14B and 14C show the rehabilitation machine according to this embodiment in the position that it assumes when a patient in a wheelchair approaches. The tilting seat 109 is in a horizontal position and the handlebar 118 is inclined to facilitate grasping by the patient.

[0045] Figures 14A and 14D, on the other hand, show the machine in an operating condition, i.e. when the patient is placed in an upright position, a condition achieved by virtue of the tilting of the tilting seat 109 (which is in a vertical position to support the rear part of the user's torso) and raising of the handlebar 118.

[0046] Referring to figures 11-13, the gait simulation system 4 comprises a moving mechanism 36 for each leg of the patient, which allows a roto-translation movement adapted to reproduce the gait.

[0047] In an embodiment, shown in figure 11, the movement mechanism 36 is of the type described in EP 2 865 363 B1, to which reference is made for a better understanding of operation, which comprises a differential kinematic mechanism comprising six pulleys 37, 38 of equal pitch diameter: the four outer pulleys 37 are constrained to a casing 39, while the other two pulleys 38 are mounted on a carriage 40 free to slide along a rail (not shown in the drawings), which also performs the function of a structural element. A double-toothed belt 41 connects all six pulleys 37, 38. Two of the four outer pulleys 37 are driven by electric motors, while all others are idle. With this architecture, the system receives two angular velocities as inputs, provided by the two motors, and, as a function of their difference, returns a motion consisting of the combination of a rotation and a translation. This combined law of motion for translation and rotation acts on the carriage 40 which translates on the rail, while the respective pulleys 38 are subject to rotary movement.

[0048] Two connecting rods 42 are hinged on the pulleys 38 mounted on the carriage 40. Instead, the opposite ends of the connecting rods 42 are hinged to a footboard 43, as will be more fully described hereafter.

[0049] The two moving mechanisms 36 act in an offset manner, giving each footboard 43 a substantially elliptical movement, according to a law of motion which simulates walking.

[0050] In preferred embodiments, the carriage 40 is replaced by a linear recirculating ball bearing guide on which connecting rods 42 are mounted, one of which is idle and the other of which is motorized. In this manner, the structural strength required by the machine, which must fully support the patient's weight, is increased. In other embodiments, both connecting rods may be motorized.

[0051] In other embodiments, the aforesaid moving mechanism is replaced by a system comprising a first actuator for linear translation of the carriage 40 or linear recirculating ball bearing guide and a second actuator for rotational/rocking movement of the footboard 43. For example, the first actuator may act on a worm screw associated with the carriage 40 or with the linear guide, while the second actuator may be, for example, a linear actuator mounted on the carriage 40.

[0052] Referring now to figure 13, the footboard 43 is comprised in an articulated system 44 for the patient's leg.

[0053] The articulated system 44 comprises an upper rod 45 which, as shown in figure 1, is hinged to the handrail element 7 and to a lower rod 46. The lower rod 46 is, in turn, hinged to the footboard 43. The upper rod 45 has a flexed shape, while the lower rod has a curved shape with the concavity facing the back of the patient's leg. The articulated system is moved, through connecting rods 42, by the moving mechanism 36. In practice, the movement of upper rod 45 simulates the movement of the patient's hip, the hinge point between upper rod 45

and lower rod 46 simulates the knee joint, and the hinge point of lower rod 46 with footboard 43 simulates the ankle joint.

[0054] The lower rod 46 comprises an anteriorly extending spacer bar 47, to the distal end 48 of which a vertically arranged supporting cushion 49 is fixed at a height slightly below that of the patient's knee to provide an anterior barrier for supporting the patient's shin, avoiding the bending of the limb and thus sliding the downward slipping of the vertically arranged patient.

[0055] Finally, the footboard 43 comprises a heel pad 50 which prevents the patient's foot from slipping backwards.

[0056] In some embodiments, the rods of the articulating system 44 are height-adjustable, either manually or in a motorized manner, to adapt them to the patient's height.

[0057] In a different embodiment, shown in figures 15 and 16, the moving mechanism 36 is similar to the one described in Italian patent application No. 102018000010921 filed on 10 December 2018. This mechanism 36 comprises translational-rotational members comprising:

- a movable carriage 64 on a rail 73;
- a first shaft 65 passing through the carriage 64;
- a second shaft 67 passing through the carriage 64, said second shaft 67 being vertically aligned with the first shaft 65;
- a first redirecting pulley 66 integral with the first shaft 65 on a first side 90a of the mechanism 36;
- a second redirecting pulley 68 integral with the second shaft 67 on a second side 90b of the mechanism 36;
- a first toothed wheel 77 integral with a third shaft 82 on the second side 90b of the mechanism 36;
- first and second motorization means 71, 72 placed on appropriate supports 5', 5" at the ends of the track 73;
- a first pair of pulleys 71bis, one of which, located on the second side 90b of the mechanism 36, integral with the shaft of the first motorization means 71, and the other idle, located on the first side 90a of the mechanism 36;
- a second pair of pulleys 72bis, one of which, located on the second side 90a of the mechanism 36, integral with the shaft of the first motorization means 72, and the other idle, located on the first side 90b of the mechanism 36;
- a first transmission member 69 located on the first side 90a of the mechanism 36, said first transmission member 69 being configured to operatively connect the second motorization means 72 to the first redirecting pulley 66;
- a second transmission member 70 located on the second side 90b of the mechanism 36, said second transmission member 70 being configurated to operatively connect the first motorization means 71 to the second redirecting pulley 68;

  wherein the first and second redirecting pulleys 66, 68 are operatively connected, through a second toothed wheel 77', to the first toothed wheel 77.

[0058] The motion of the pulleys 66, 68 located on the carriage 64 is acted upon from the motion resulting from the diversified actuating of the motorization means 71, 72 and the transmission system through the belts 69, 70.

[0059] Referring to figure 17, the first redirecting pulley 66 is integral with the shaft 65 and the second redirecting pulley 68 is integral with the shaft 67. The first redirecting pulley 66 is put in rotation, through the first transmission member 69, by the second motorization means 72, and the second redirecting pulley 68 is put in rotation, through the second transmission element 70, by the first motorization means 71. Both the first shaft 65 and the second shaft 67 comprise respective gears 65', 67', which mesh, respectively, with a lower section and an upper section of a central toothed wheel 83, located in an intermediate position between said toothings 65', 67'. The central toothed wheel 83 is integral with a respective central shaft 84 which terminates, at the second side 90b of the mechanism 36, with the second toothed wheel 77' described above, which transmits motion to the first toothed wheel 77 with appropriate reduction.

[0060] Figures 15-18 show an embodiment in which the carriage 64 comprises a base plate 75 sliding on the track 73 by means of a pair of shoes 76. As described above, the first shaft 65 meshes with the lower section of the central toothed wheel 83, which is coupled, through the second toothed wheel 77', with the first toothed wheel 77, which in turn is integral with the third shaft 82. The first toothed wheel 77 has a larger diameter than the diameter of the second toothed wheel 77', to achieve a transmission ratio such that a fraction of a revolution of the third shaft 82 corresponds to a given number of revolutions of the first shaft 65. The end of the third shaft 82 opposite to the first toothed wheel 77 is integral with a movable plate 79. Furthermore, the third shaft 82 is also supported by a ball bearing system 78. The rotation of the central shaft 84 and thus the third shaft 82 causes the movable plate 79 to tilt up or down.

[0061] As a function of the diversified movement (i.e., with velocities in different modulus and direction) of the motorization means 71, 72 is determined:

- a translation only of the carriage 64: the pulleys 66, 68 are locked in rotation and the translation of the carriage 64 is determined by the feeding of the belts;
- a rotation only of the central shaft 84 and consequently of the shaft 82 and the movable plate 79;
- a combination of the two movements, which allows the movable plate 79, and thus the footboard 43, e.g., to implement the gait walking trajectory.

[0062] The footboard 43 is fixed in an adjustable manner on the movable plate 79. The footboard 43 comprises

a heel element 43a and a toe element 43b, both of which slide on a rail 80 so that the platform can be adapted to the patient's foot. The heel element 43a and the toe element 43b comprise respective raised edges 43', 43" along their outer perimeter to retain the patient's foot on the footboard 43.

[0063] Elastic means 81, preferably a gas spring, are arranged between the movable plate 79 and the base plate 75, which elastic means, by means of a rod linkage 81a, 81b, apply a force on the movable plate 79 such that the load resulting from the weight of the user is relieved, thereby contributing to relieving the torque load on the third shaft 82.

[0064] A support 91 for the user's shin is hinged to the movable plate 79. The shin support 91 comprises a plate 92 having a C-shaped cross-section, to retain the user's shin, and a connection portion 93, preferably curvilinear in shape, with the movable plate 79, by means of a hinge 94 located at the lower end 93a of the connecting portion 93.

[0065] The rear face 92a of the C-shaped plate 92 preferably comprises padding or an anatomical surface to improve the resting of the user's shin.

[0066] Indeed, the shin support 91 has the function of supporting the shin, constituting in this manner a constraint which allows the user to remain in an upright position even without exerting muscle strength.

[0067] An actuator 95 connects the front face 92b of the shin support 91 to the movable plate 79 by means of respective hinges 95a, 95b.

[0068] Referring to figure 18, the actuator 95 comprises a motor 96 connected by means of a coupling to a worm screw 97. The worm screw 97 is inserted into a tubular element 98 which comprises a hinge 95a connecting with the shin support 91 at one end and a scroll 99 at the opposite end. A circular element 100, which has the function of a sliding shoe for the screw itself inside the tubular element 98, is constrained at the head of the worm screw 97.

[0069] In this manner, the shin support 91 can rock relative to the movable plate 79 by virtue of the actuator 95 which, by virtue of its elongation and shortening, modifies the mutual angle between the movable plate 79 and the shin support 91.

[0070] The machine 1 of the invention will comprise two moving mechanisms 36 as described above, one for each leg of the patient P.

[0071] The machine 1 according to the invention may comprise a control unit configured to command the laws of motion of the gait simulation system 4 and the adjustments of the restraining means 23, the rods 45, 46 of the articulated system 44 and of the adjustable seat 9.

[0072] The machine 1 of the invention achieves the intended purposes, allowing the shortening of time in the assisted step of verticalization and ensuring maximum comfort and safety for the patient.

[0073] It is apparent that only some particular embodiments of the present invention have been described, to which a person skilled in the art will be able to make all the changes necessary to adapt it to particular applications, without because of this departing from the scope of protection of the present invention.

LIST OF DRAWINGS

[0074]

DRAWING 6/12
FIGURE 10
"Output 1: rotazione" = Output 1: rotation
"Output 2: traslazione" = Output 2: translation
"Input 1: rotazione 1" = Input 1: rotation 1

Claims

1. A machine (1) for the motor rehabilitation of a patient (P), comprising a frame (3) which supports movable supporting means (2) for the patient (P) and a gait simulation system (4), **characterized in that** the gait simulation system (4) comprises a moving mechanism (36) for each of the patient's leg, configured to reproduce a roto-translation movement adapted to reproduce a gait, said moving mechanism (36) comprising:

   - a carriage (64) comprising a base plate (75) sliding on a track (73),
   - a movable plate (79) hinged to the base plate (75), the movable plate (79) rocking with reciprocating up-down motion,
   - a footboard (43) fixed in an adjustable manner on the movable plate (79) to be able to adapt it to the foot of the patient (P),
   - a shin support (91) hinged at a lower end (93a) to the movable plate (79) and connected, at a front face (92b), to the movable plate (79) through an actuator (95), so that the shin support (91) rocks relative to the movable plate (79),
   - motorization means (71, 72) configured to implement the translation of the carriage (64) along the track (73) and rocking of the movable plate (79) with said reciprocating up-down motion.

2. The machine (1) according to claim 1, wherein the movable supporting means (2) are movably coupled to an articulated system (32, 132) and comprise:

   - a tilting seat (9, 109) and
   - a table (10) provided with side bars (18a, 18b) or a handlebar (118).

3. The machine (1) according to claim 1 or 2, wherein the moving mechanism (36) comprises:

   - a first shaft (65) passing through the carriage

(64);
- a first redirecting pulley (66) integral with the first shaft (65) on a first side (90a) of the mechanism (36);
- a second redirecting pulley (68) integral with the second shaft (67) on a second side (90b) of the mechanism (36);
- a first toothed wheel (77) integral with a third shaft (82) on the second side (90b) of the mechanism (36);
- first and second motorization means (71, 72) placed on appropriate supports (5', 5") at the ends of the track (73);
- a first pair of pulleys (71bis), one of which located on the second side (90b) of the mechanism, integral with the shaft of the first motorization means (71), and the other, idle, located on the first side (90a) of the mechanism (36);
- a second pair of pulleys (72bis), one of which located on the first side (90a) of the mechanism, integral with the shaft of the first motorization means (72), and the other, idle, located on the second side (90b) of the mechanism (36);
- a first transmission member (69), arranged on the first side (90a) of the mechanism (36), said first transmission member (69) being configured to operatively connect the second motorization means (72) to the first redirecting pulley (66);
- a second transmission member (70), arranged on the second side (90b) of the mechanism (36), said second transmission member (70) being configured to operatively connect the first motorization means (71) to the second redirecting pulley (68);
wherein the first and second redirecting pulleys (66, 68) are operatively connected, through a second toothed wheel (77'), to the first toothed wheel (77).

4. The machine (1) according to claim 3, wherein both the first shaft (65) and the second shaft (67) comprise respective toothings (65', 67'), which mesh, respectively, with a lower section and an upper section of a central toothed wheel (83), placed in an intermediate position between said toothings (65', 67'), the central toothed wheel (83) being integral with a respective central shaft (84) which ends, at the second side (90b) of the mechanism (36), with the second toothed wheel (77'), which second toothed wheel (77') transmits the motion to the first toothed wheel (77), the first toothed wheel (77) having a diameter greater than the diameter of the second toothed wheel (77'), to implement a transmission ratio so that a fraction of a revolution of the third shaft (82) corresponds to a given number of revolutions of the first shaft (65).

5. The machine (1) according to claim 3 or 4, wherein the end of the third shaft (82) opposite to the first toothed wheel (77) is integral with the movable plate (79), so that the rotation of the central shaft (84) and thus of the third shaft (82) causes the movable plate (79) to rock.

6. The machine (1) according to any one of the claims from 1 to 5, wherein elastic means (81), preferably a gas spring, are placed between the movable plate (79) and the base plate (75), which elastic means, through a rod linkage (81a, 81b), apply a force on the movable plate (79) such that the load resulting from the weight of the patient (P) is relieved.

7. The machine (1) according to any one of the claims from 1 to 6, wherein the actuator (95) comprises a motor (96) connected through a coupling to a worm screw (97), the worm screw (97) being inserted into a tubular element (98) which comprises at one end a hinge (95a) connecting to the shin support (91) and at the opposite end a scroll (99), a circular element (100) which has the function of a sliding shoe of the screw itself inside the tubular element (98) being preferably constrained at the head of the worm screw (97).

8. The machine (1) according to any one of the claims from 2 to 7, wherein the tilting seat (9, 109) comprises a first seat element (13), a second seat element (14) and third seat elements (16a, 16b), wherein the second seat element (14) is either extendable or retractable relative to the first seat element (13) and wherein the third seat elements (16a, 16b) are foldable perpendicular to the plane of the first seat element (13).

9. The machine (1) according to any one of the claims from 1 to 8, comprising restraining elements (23) which comprise a central cushion (24) and two side cushions (25a, 25b) and are arranged to support the patient's torso both anteriorly and relative to a side swing.

10. The machine (1) according to any one of the claims from 2 to 9, wherein the frame (3) comprises a supporting structure (103) which comprises a supporting element (60) for the articulated system (132), to which the tilting seat (109) and the handlebars (118) are movably coupled, wherein the articulated system (132) comprises first, second, third, fourth and fifth arms (133a, 133b, 133c, 133d, 133e), wherein:

- the first arm (133a) is associated with the tilting seat (109), the first arm being hinged to the supporting element (60) by means of two plunger springs (61, 62), e.g. gas springs;
- the second arm (133b) comprises a first end hinged to the first arm (133a) and a second end

hinged to a first end of the third arm (133c);
- the third arm (133c) comprises a second end hinged to a first end of the fourth arm (133d);
- the fourth arm (133d) comprises a second end hinged to the supporting element (60);
- the fifth arm (133e) comprises a first end hinged adjacent to the first end of the third arm (133c) and a second end hinged to the supporting element (60), a linear actuator (63) being hinged on one side to the supporting element (60) and on the other side to the junction between the second arm (133b) and the third arm (133c).

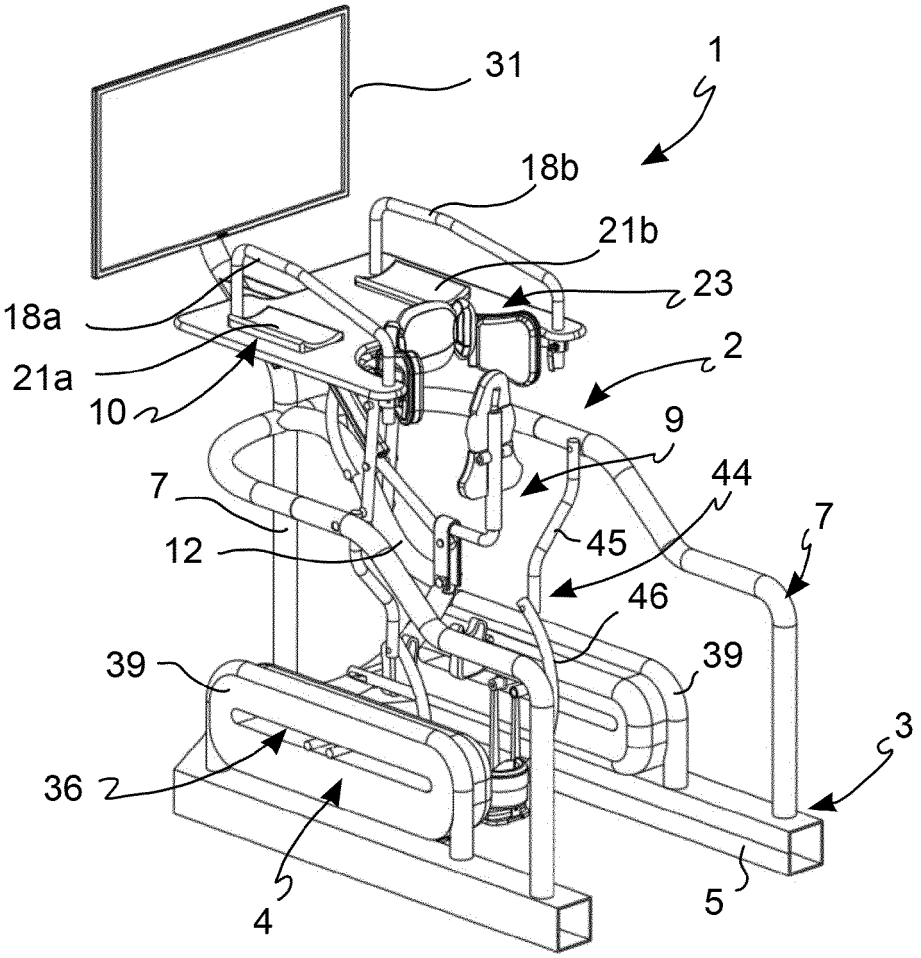


FIG. 1

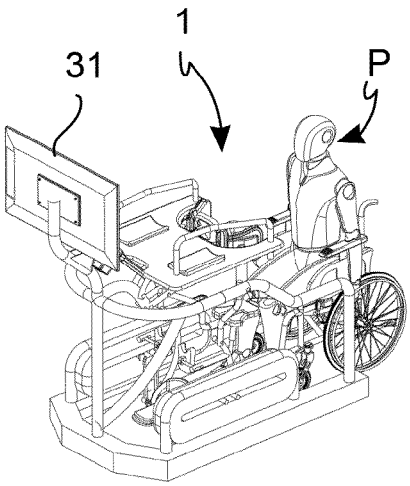


FIG. 2A

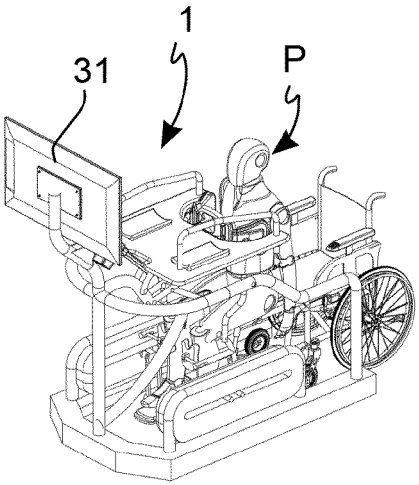


FIG. 2B

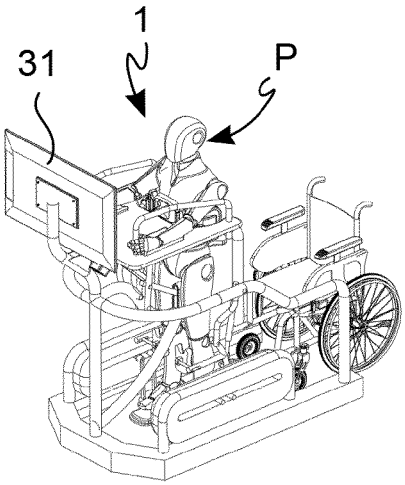


FIG. 2C

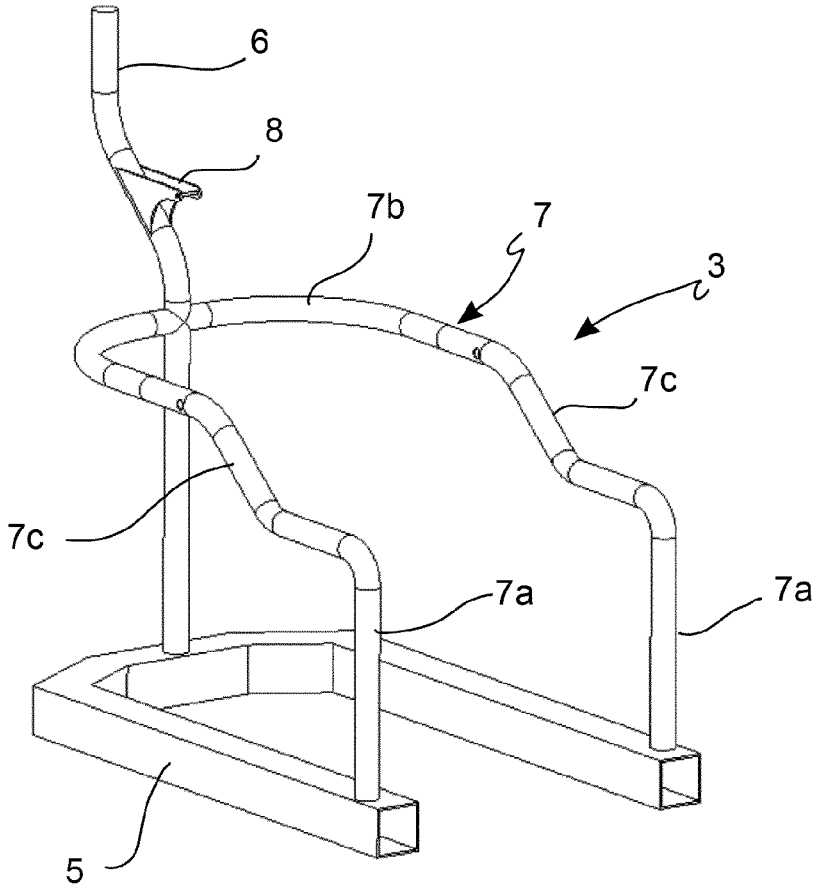


FIG. 3

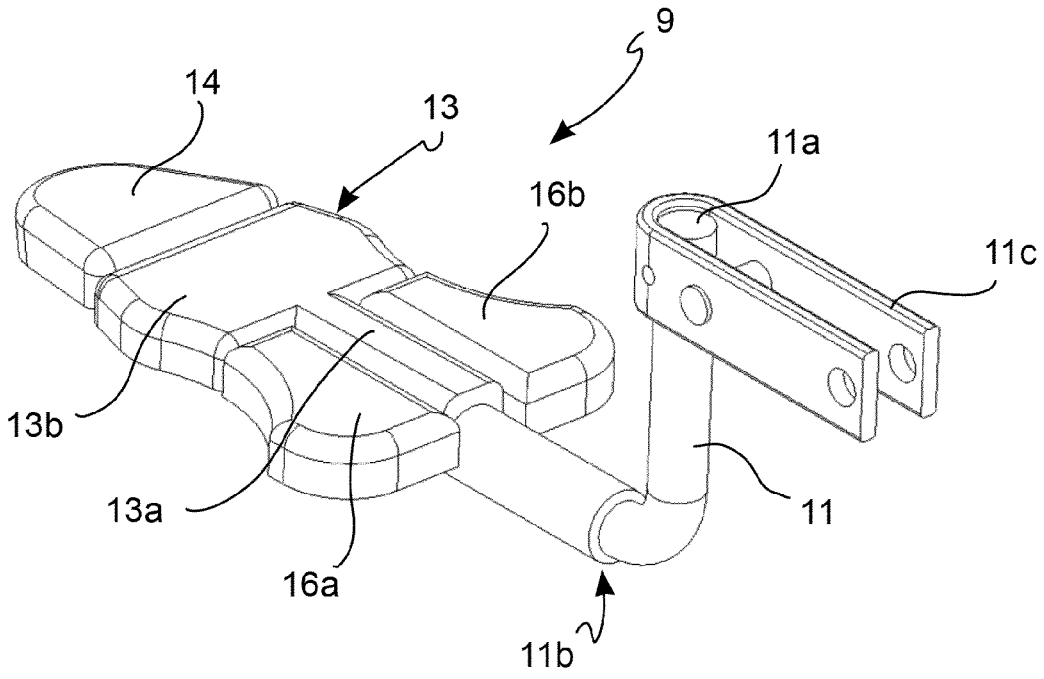


FIG. 4

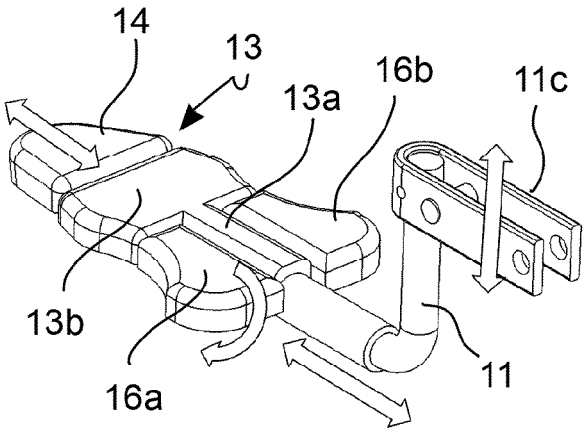


FIG. 5A

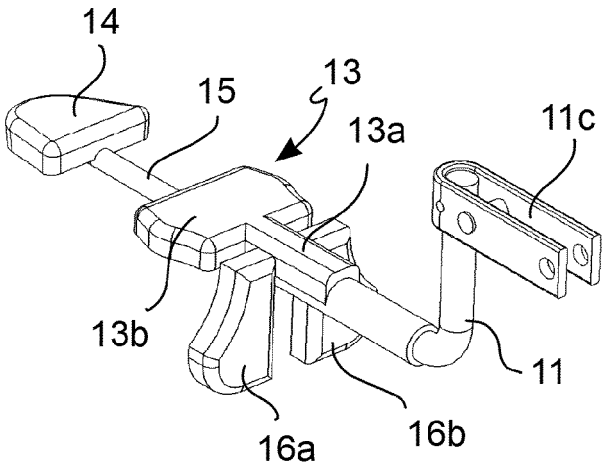


FIG. 5B

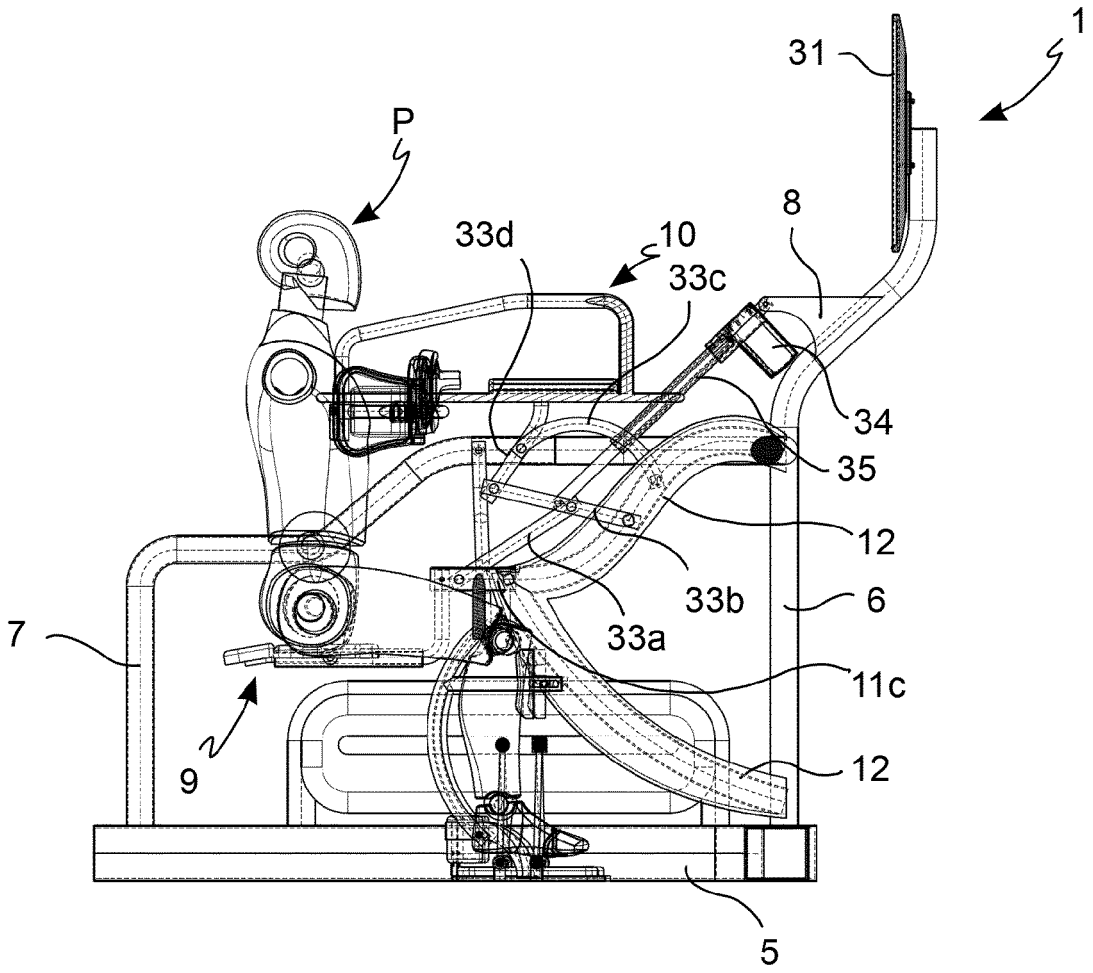


FIG. 6A

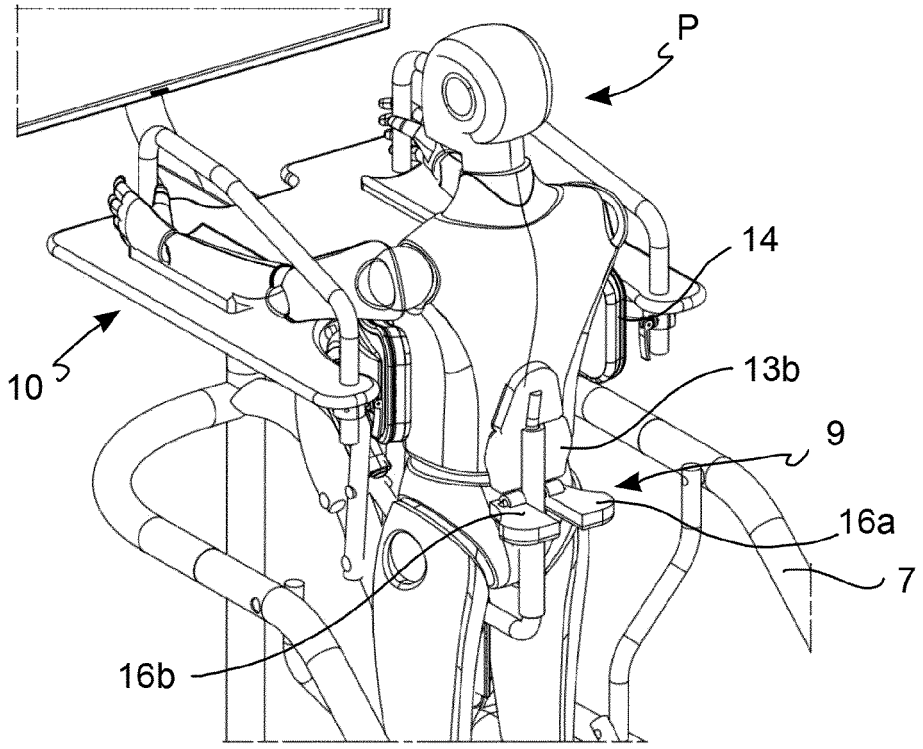


FIG. 6B

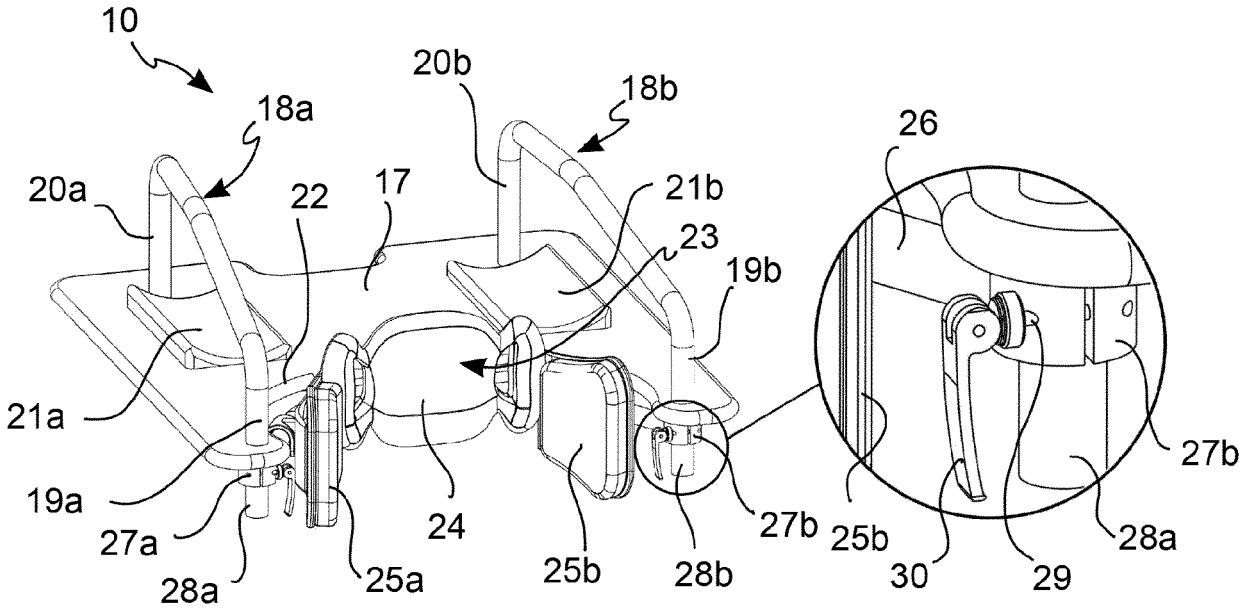


FIG. 7

FIG. 7A

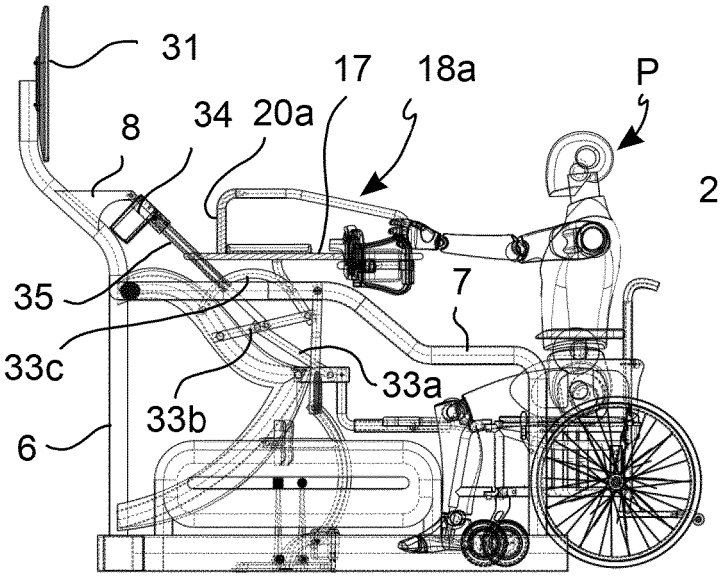


FIG. 8A

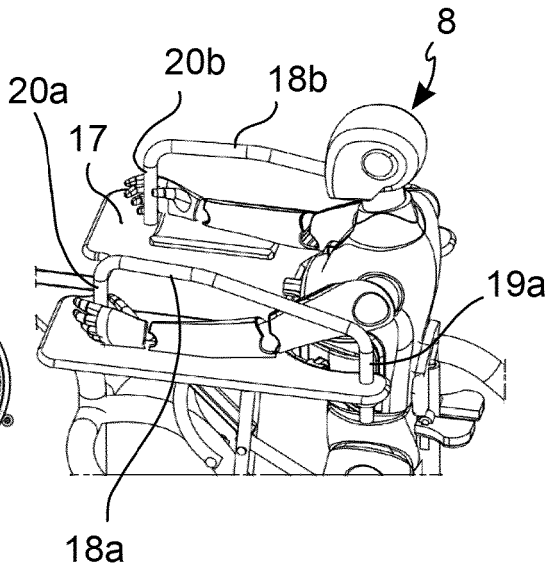


FIG. 8B

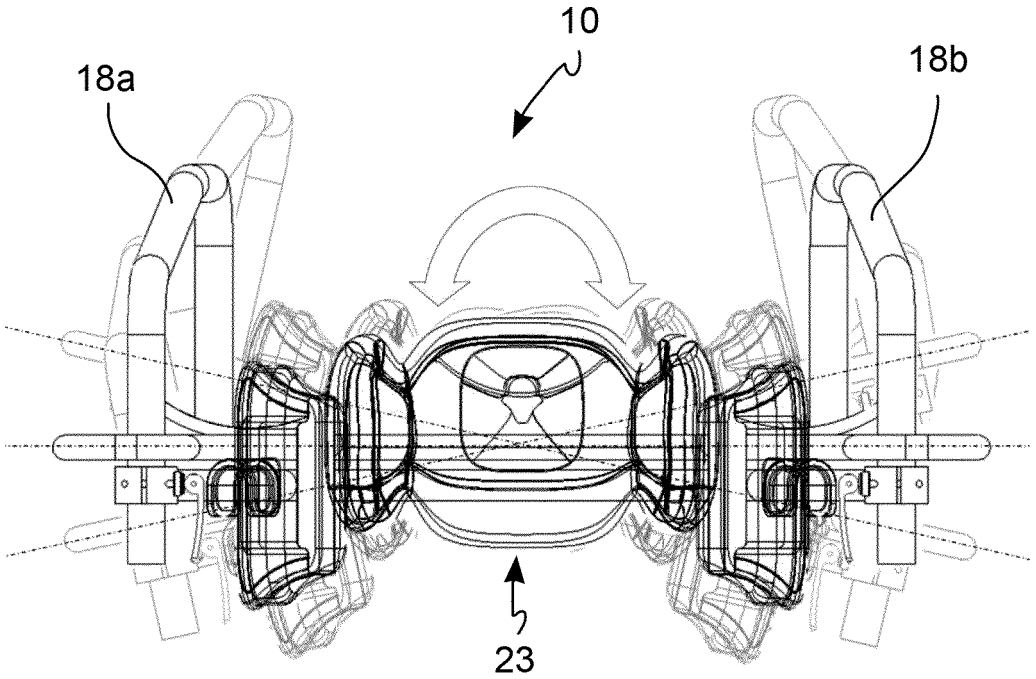


FIG. 9

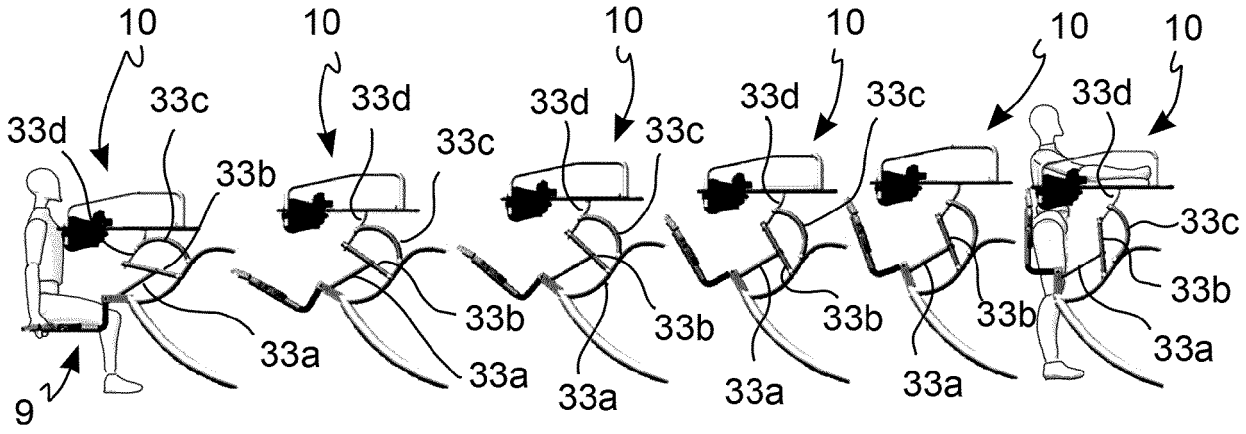


FIG. 10

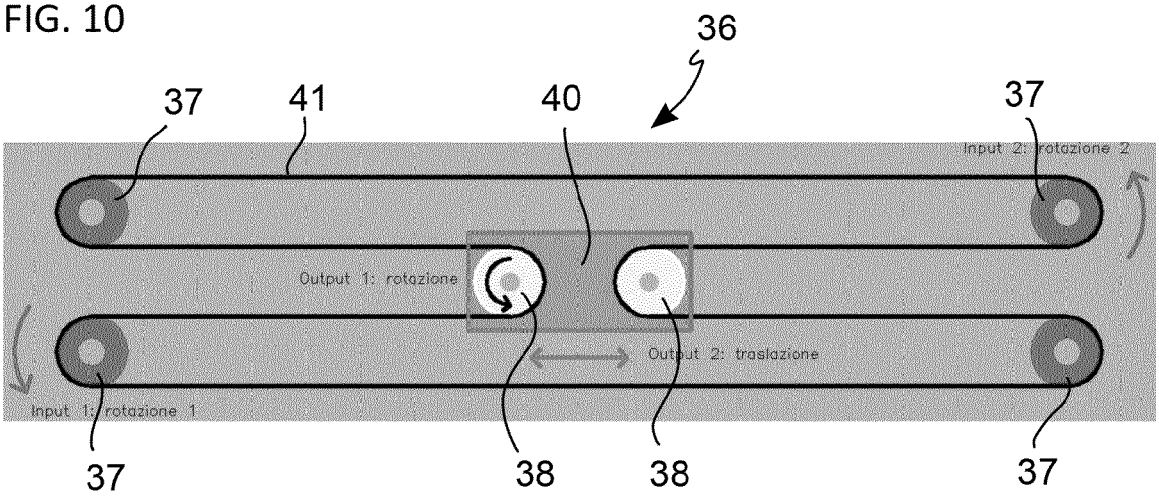


FIG. 11

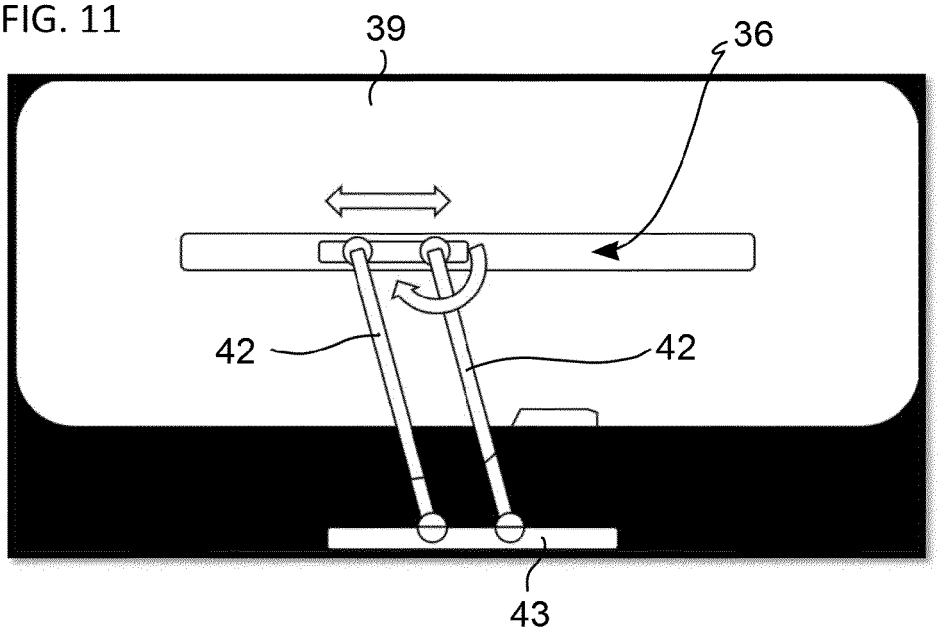


FIG. 12

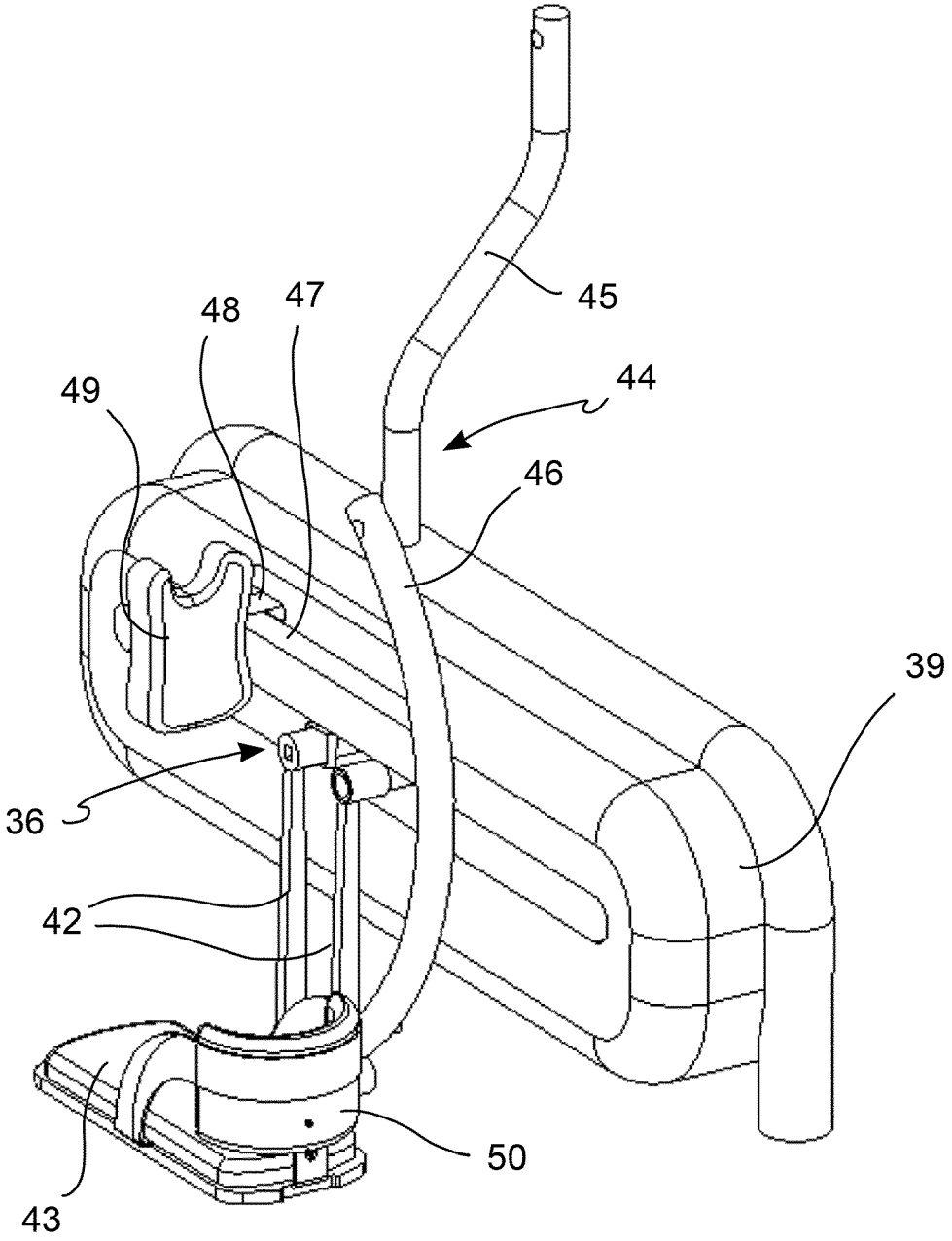
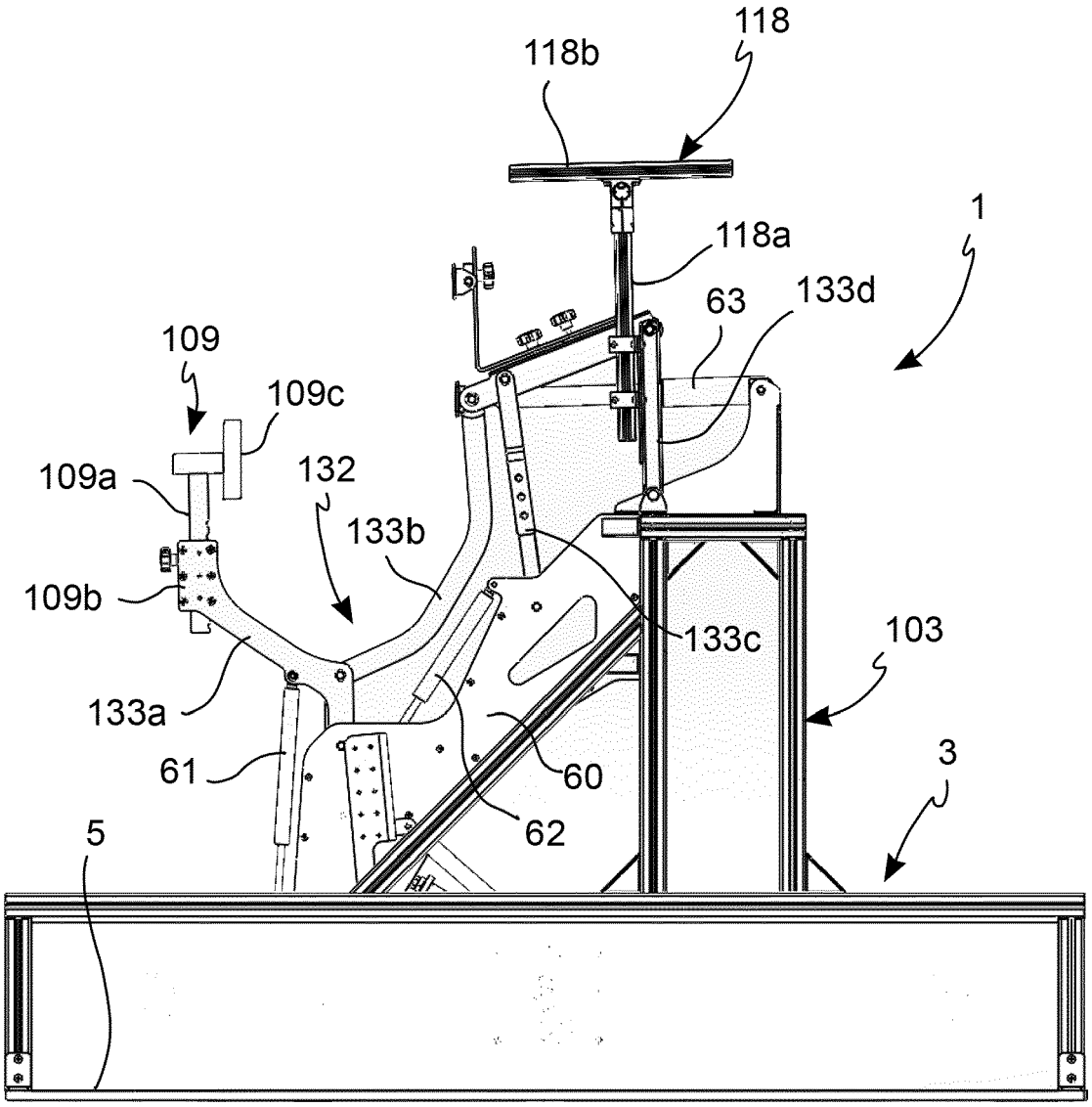


FIG. 13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118a
63
133d
109
109c
109a
132
133b
109b
133c
103
133a
61
60
3
62
5

FIG. 14A

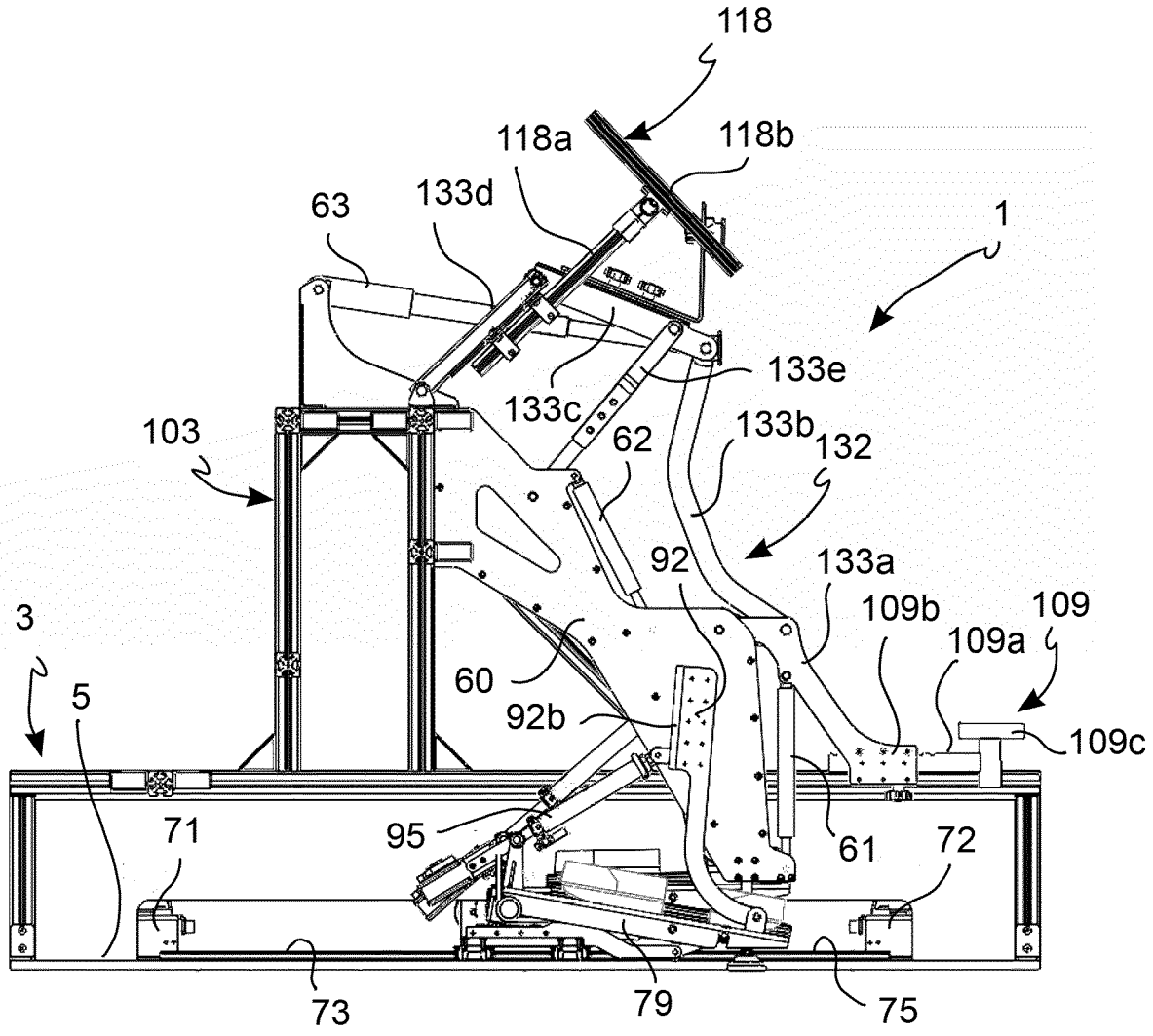
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FIG. 14B

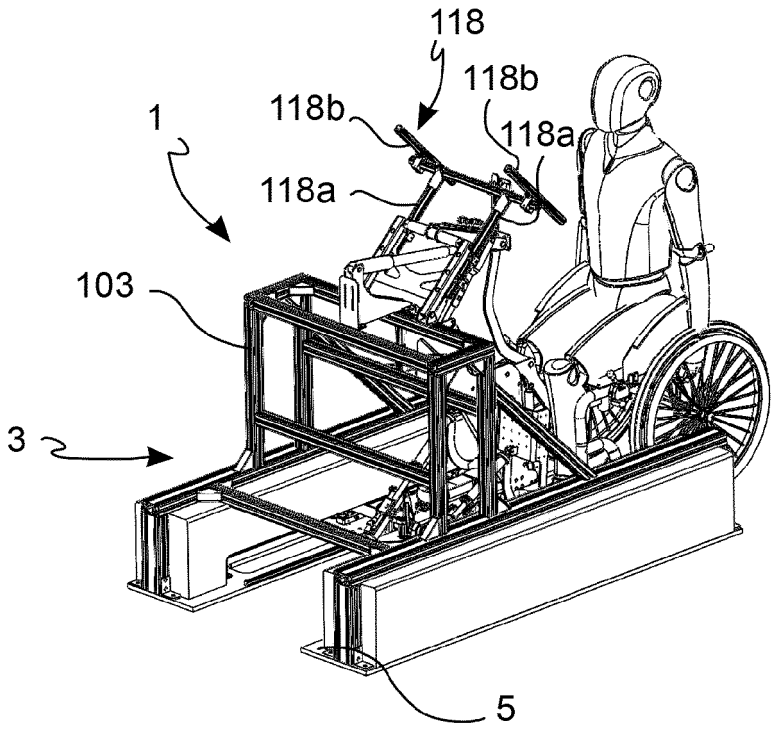


FIG. 14C

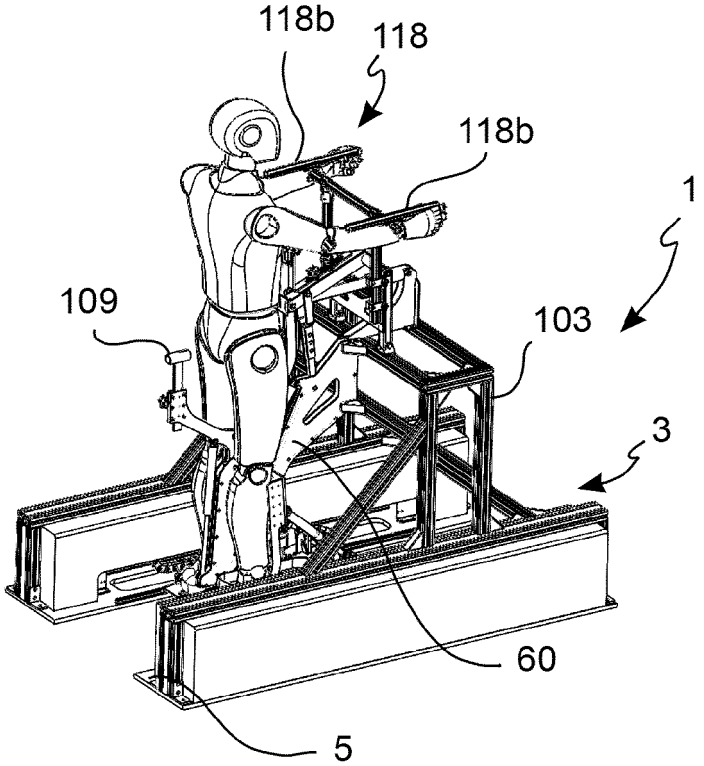
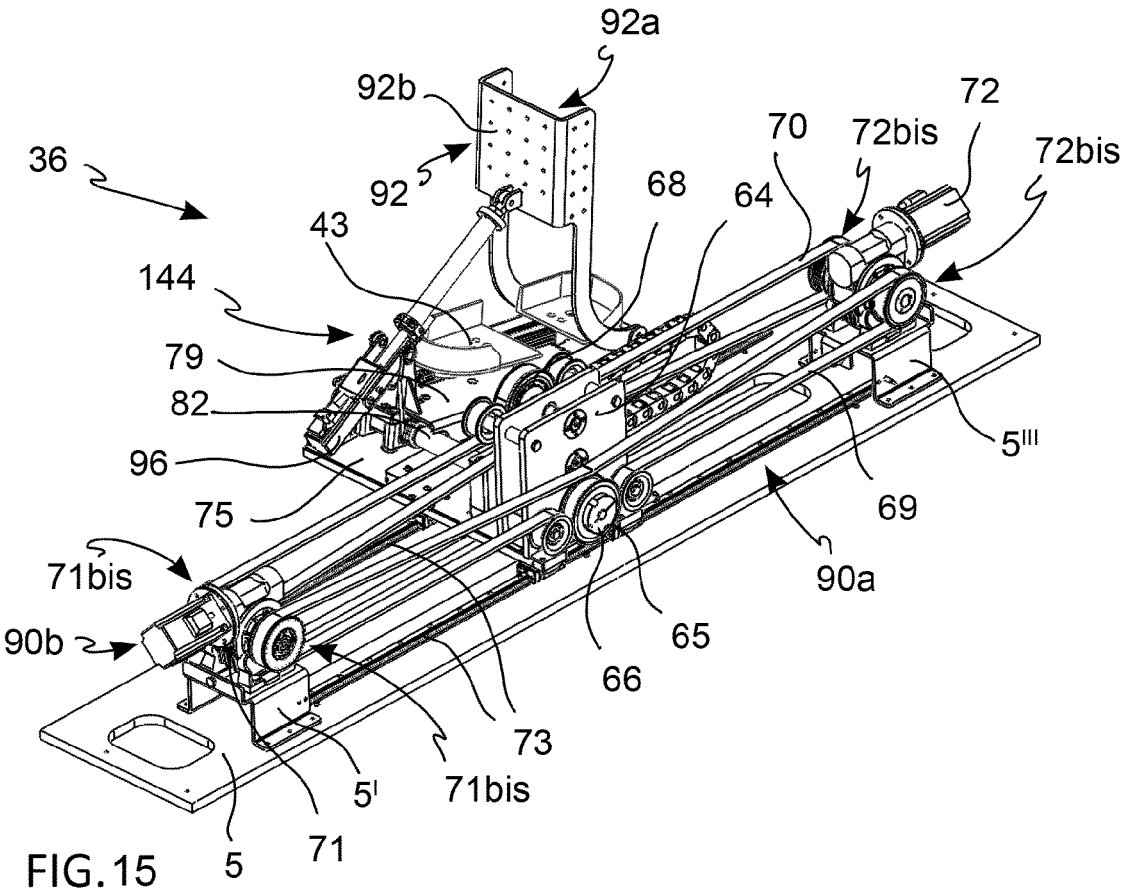


FIG. 14D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65
90a
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5III
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72bis
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72bis
68
64

FIG. 15

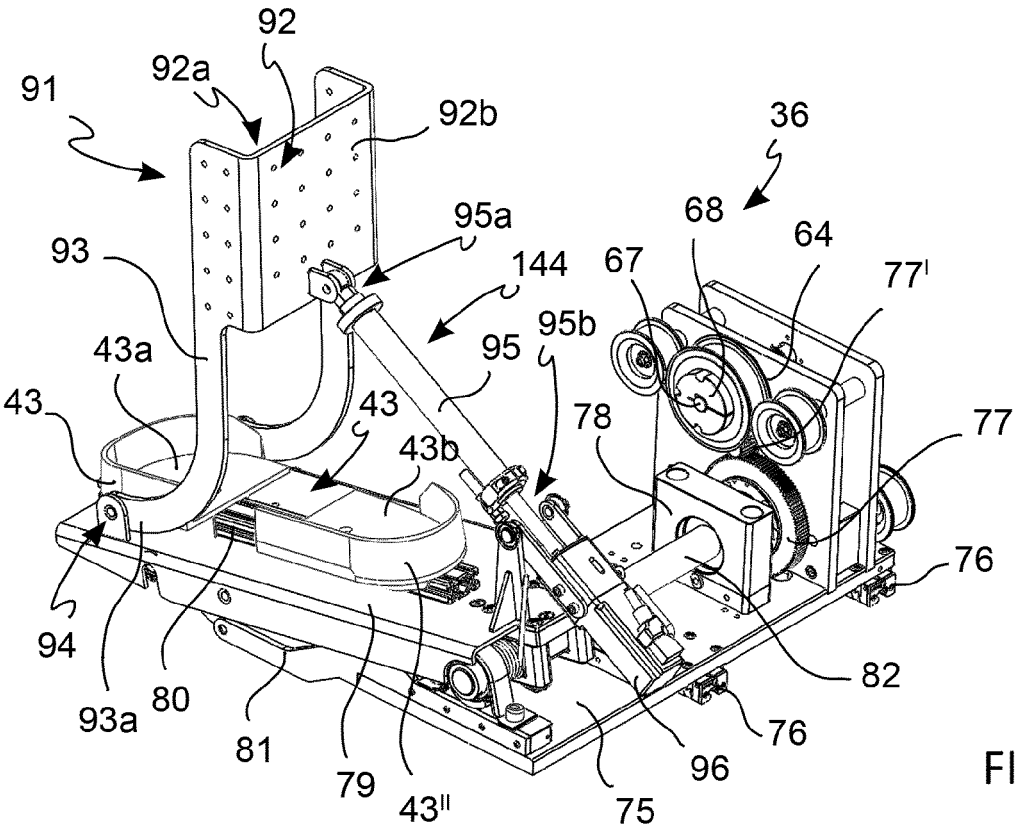
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FIG. 16

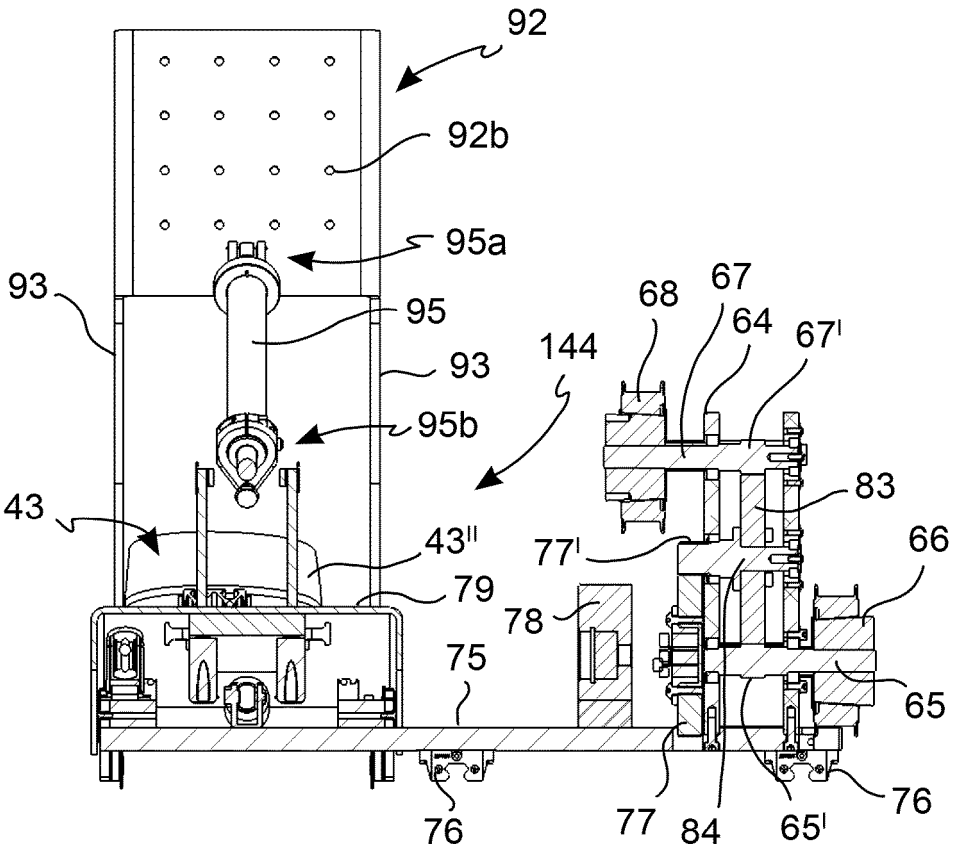
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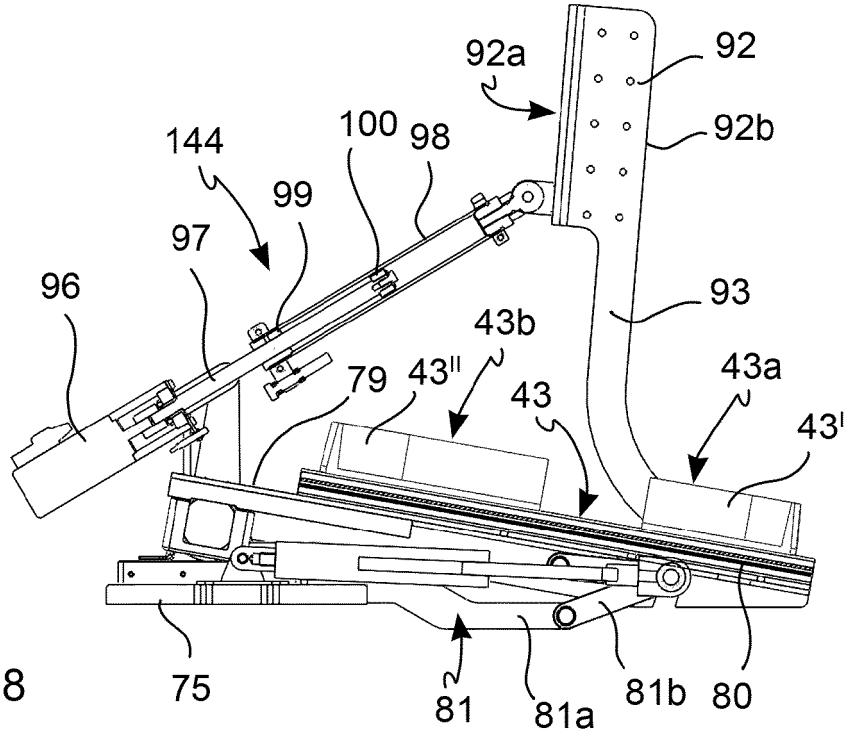
FIG. 17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81a
81b
80

FIG. 18

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EUROPEAN SEARCH REPORT

Application Number
EP 21 18 3639

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 9 248 071 B1 (BENDA SCOTT [US] ET AL) 2 February 2016 (2016-02-02) * figures *	1	INV. A61H1/02
A	US 3 824 994 A (SODERBERG R) 23 July 1974 (1974-07-23) * figures *	1	
A	US 11 045 381 B2 (BOSE CORP [US]) 29 June 2021 (2021-06-29) * figures *	1	
A	US 2019/231630 A1 (THOLKES ALAN [US] ET AL) 1 August 2019 (2019-08-01) * figures *	1,2,8,10	
A,D	EP 2 865 363 B1 (POLIBRIXIA S R L [IT]) 25 May 2016 (2016-05-25) * figures *	3-5	

TECHNICAL FIELDS SEARCHED (IPC)
A61H

2 The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	11 January 2022	Squeri, Michele

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11-01-2022

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US 11045381 B2	29-06-2021	NONE	
US 2019231630 A1	01-08-2019	NONE	
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		ES 2587983 T3	28-10-2016

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

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- EP 2865363 B1 **[0006] [0047]**
- IT 102018000010921 **[0057]**