

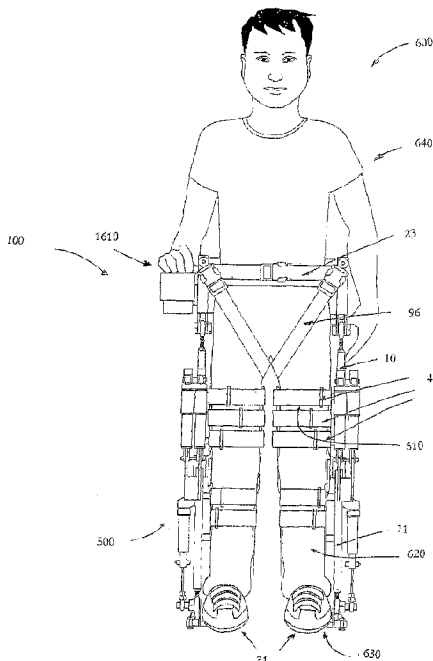


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(54) Titre : DEAMBULATEUR EXOSQUELETTIQUE ALIMENTE AUTONOME DESTINE A UN UTILISATEUR HANDICAPE

(54) Title: SELF-CONTAINED POWERED EXOSKELETON WALKER FOR A DISABLED USER



(57) **Abrégé/Abstract:**

A walker for use by a mobility impaired disabled user. The walker supports the user while moving them through a set of movements correlating to a walking motion. The walker includes an exoskeleton, a power source in the form of a battery pack or other similar onboard power pack together with its associated power supply cables, and a control system. The exoskeleton includes a rigid pelvic support member including a pelvic harness and a pair of leg structures. Each of the leg structures comprise an upper leg structural member, a lower leg structural member, a foot member, a main hip actuator, a knee actuator and a main foot actuator.

ABSTRACT

A walker for use by a mobility impaired disabled user. The walker supports the user while moving them through a set of movements correlating to a walking motion. The walker includes an exoskeleton, a power source in the form of a battery pack or other similar onboard power pack together with its associated power supply cables, and a control system. The exoskeleton includes a rigid pelvic support member including a pelvic harness and a pair of leg structures. Each of the leg structures comprise an upper leg structural member, a lower leg structural member, a foot member, a main hip actuator, a knee actuator and a main foot actuator.

SELF-CONTAINED POWERED EXOSKELETON WALKER FOR A DISABLED USER

FIELD OF THE INVENTION

The present invention relates to a mobility aid or walking aid (WA) suitable for supporting a mobility impaired disabled user. In particular but not solely the present invention relates to a robotic exoskeleton that a mobility impaired disabled user is supportable by and that can assist and support the user while being moveable in a 'normal' walking range of motions. The present invention may also consist in features relating to the structural geometry of the WA. The present invention may also consist in a WA that includes orthotic support to the user wherein the orthotic support may be releasably engaged to the exoskeleton. In particular but not solely the present invention may also consist in a moveable walkable support frame for supporting a person. In particular but not solely the present invention may also consist in an exoskeleton for a mobility aid or walking aid (WA). The present invention may also be a medical device to assist in reducing adverse effects of immobility of the leg or legs of a mobility impaired disabled user.

SUMMARY OF INVENTION

According to one aspect of the invention, there is provided a self-contained powered exoskeleton walker for a disabled user that at least substitutes fully disabled functions of a user required for walking, said walker comprising: an exoskeleton comprising: a rigid pelvic support member including a user securing arrangement for securely fastening the user to at least the pelvic support member to fully support said user operationally at or towards a pelvic region of the user, so that the user's legs do not support the weight of the user, a first leg structure and a second leg structure, each of the first leg structure and the second leg structure being coupled to and extending from said pelvic support member for operational location adjacent a respective leg of the user, each of the first leg structure and second leg structure comprising an upper leg structural member for engagement with the upper leg of the user, the upper leg structural member being pivotally engaged at a first end thereof to the pelvic support member by a passive hip joint, wherein the hip joint is configured to be driven and for facilitating multi axis rotational movement of said upper leg structural member relative to said pelvic support member towards and away from a coronal plane of the user's body, and toward and away from a sagittal plane of the user's body for adduction and abduction, a lower leg structural member for engagement with the lower leg of the

user, the lower leg structural member being pivotally engaged at a first end thereof to a second end of the upper leg structural member by a knee joint providing an axis of rotation, a foot member for engagement with a foot of the user, the foot member being pivotally engaged to a second end of the lower leg member by a foot joint, a linear main hip actuator configured for actuating pivotal movement and for controlling the position of said upper leg structural member relative to said pelvic support member about said hip joint, and to pivot the upper leg structural member towards and away from the coronal plane of the body of the user, the main hip actuator connected at (i) a proximal end to the pelvic support member at an offset distance below and posterior to a pivotal axis of the hip joint and (ii) a distal end to the upper leg structural member at an offset distance above the knee joint, a linear secondary hip actuator, configured for actuating pivotal movement and control the position of said upper leg structural member relative the pelvic support member about said hip joint towards and away from the sagittal plane of the body of the user for adduction and abduction, the secondary hip actuator connected at (i) a proximal end to the pelvic support member at an offset distance collinear to the pivotal axis of the hip joint and (ii) a distal end to the upper leg structural member at an offset distance posterior of the knee joint, a knee actuator configured for actuating pivotal movement and control the position of said lower leg structural member relative said upper leg structural member about said knee joint, a main foot actuator configured for actuating pivotal movement and controlling the position of said foot member relative said lower leg structural member a power source configurable for providing power to at least one or more actuators selected from said main hip actuators, knee actuators, and main foot actuators, a control system configurable for controlling movement of at least one or more actuators selected from said main and secondary hip actuators, knee actuators, and main foot actuators, thereby to move the exoskeleton relative to ground on which the walker is positioned, for at least the purposes of effecting a walking motion to said user, wherein the control system is configured to receive user input via a human interface device to input control instructions to the control system, and wherein the human interface device is one of a control pad, a keypad, a joystick, or a touch screen; and wherein said control system includes a gyroscope configured for defining a reference frame for purposes of positional control of the exoskeleton or part of the exoskeleton.

According to one aspect of the invention, there is provided an exoskeleton device worn by a paraplegic user for device controlled walking of the user, said exoskeleton device comprising: a rigid pelvic support member including a user securing arrangement for engaging with the user at or towards the pelvis of the user to support said user operationally, so that the user's legs do not support the weight of the user, a first leg structure and a second leg structure, each of the first leg structure and the second leg structure being coupled to and extending from said pelvic support member for operational location adjacent a respective leg of the user, each of the first leg structure and second leg structure comprising an upper leg structural member for engagement with the upper leg of the user, the upper leg structural member being pivotally engaged at a first end thereof to the pelvic support member by a hip joint, wherein the hip joint is configured for facilitating multi axis rotational movement of said upper leg structural member relative to said pelvic support member towards and away from the user's coronal plane in operation; a lower leg structural member for engagement with the lower leg of the user, the lower leg structural member being pivotally engaged at a first end thereof to a second end of the upper leg structural member by a knee joint, a foot member for engagement with the foot of the user, the foot member being pivotally engaged to a second end of the lower leg member by a passive foot joint configured to be driven and for facilitating multi axis rotational movement of said foot member relative to said lower leg member towards and away from a transverse plane of the user's body for dorsiflexion and plantar flexion of the foot member, and towards and away from a sagittal plane of the user's body for inversion and eversion of the foot member, a main hip actuator configured for actuating pivotal movement and control the position of said upper leg structural member relative to said pelvic support member about said hip joint, and to pivot the upper leg structural member towards and away from the coronal plane of the body of the user, a knee actuator configured for actuating pivotal movement and control the position of said lower leg structural member relative said upper leg structural member about said knee joint, a linear main foot actuator configured for actuating pivotal movement and controlling the position of said foot member relative said lower leg structural member for dorsiflexion and plantar flexion about said foot joint, the main foot actuator connected at (i) a proximal end to the foot member at an offset distance below and posterior to the pivotal axis the foot joint and (ii) a distal end to the lower leg structural member at an offset distance below and posterior to the knee joint; and a linear secondary foot actuator configured for actuating pivotal movement and control the position of said foot member relative said lower

leg structural member for inversion and eversion of the foot member about said foot joint, the secondary foot actuator connected at (i) a proximal end to the foot member at an offset distance below and posterior to the pivotal axis of the foot joint and (ii) a distal end to the lower leg structural member at an offset distance below and posterior to the knee joint; and a control system configurable for controlling movement of at least one or more actuators selected from said main hip actuator, knee actuator, and main and secondary foot actuators, thereby to move the exoskeleton relative to ground on which the exoskeleton is positioned, for at least the purposes of effecting a walking motion to said user, wherein the control system is configured to receive user input via a human interface device to input control instructions to the control system, and wherein the human interface device is one of a control pad, a keypad, a joystick, or a touch screen; and wherein said control system includes a gyroscope configured for defining a reference frame for purposes of positional control of the exoskeleton or part of the exoskeleton.

BRIEF DESCRIPTION OF THE INVENTION

According to one aspect, the invention may be said to broadly consist in a walking aid suitable for supporting a mobility impaired disabled user comprising:

an exoskeleton comprising:

a rigid pelvic support member including a user securing arrangement for securely fastening a user to at least the pelvic support member to fully support said user operationally,

a first leg structure and a second leg structure, each of the first leg structure and the second leg structure being coupled to and extending from said pelvic support member for operational location adjacent a respective leg of a user, each of the first leg structure and second leg structure comprising:

5 an upper leg structural member for engagement with the upper leg of the user, the upper leg structural member being pivotally engaged at a first end thereof to the pelvic support member by a hip joint, wherein the hip joint is configured for facilitating the multi axis rotational capability of said upper leg structural member relative to said pelvic support member in at least the anterior posterior plane and
10 the medial/lateral plane for abduction and adduction;

 a lower leg structural member for engagement with the lower leg of the user, the lower leg structural member being pivotally engaged at a first end thereof to a second end of the upper leg structural member by a knee joint,

 a foot member for engagement with the foot of a user, the foot member
15 being pivotally engaged to a second end of the lower leg member by a foot joint,

 a main hip actuator configured for actuating rotation of said upper leg structural member relative to said pelvic support member about said hip joint, to in use pivot the upper leg structural member in an anterior/posterior plane,

 a secondary hip actuator, configured for actuating rotation of said upper
20 leg structural member in a medial/lateral plane in adduction or abduction about said pelvic support member;

 a knee actuator configured for actuating rotation of said lower leg structural member relative said upper leg structural member about said knee joint,

a main foot actuator configured for actuating rotation of said foot member relative said lower leg structural member about said foot joint about an axis of rotation substantially parallel to the axis of rotation of the knee joint;

a power source configurable for providing power to at least one or more selected
5 from said main hip actuators, knee actuators, and main foot actuators,

a control system configurable for controlling movement of at least one or more selected from said main hip actuators, knee actuators, and main foot actuators, thereby to move the exoskeleton relative to the ground on which the walking aid is positioned, for at least the purposes of effecting a walking motion to said user.

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Preferably, said secondary hip actuator is configured for actuating said pivotal movement of said upper leg structural member to either side of a plane parallel to the sagittal plane and passing through said hip joint.

15

Preferably, said hip joint is one selected from a rose joint, universal joint or ball and socket joint, configured for facilitating a multi axis rotational capability of said upper leg structural member relative to said pelvic support member.

Preferably, pivotal movement of the upper leg structural member by the main hip actuator is
20 about an axis of rotation extending laterally from said sagittal plane and downwardly at an angle of between 1 and 6 degrees to the transverse plane.

Preferably, the knee joint is offset rearwardly from the upper leg structural member to align substantially with an axis of rotation of the user's knee in operation.

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Preferably, the knee joint is a polycentric knee joint.

Preferably, said foot joint is a rose joint, a universal joint or ball and socket joint, configured for facilitating multi axis rotational capability of said foot member relative said lower leg structural member.

Preferably, said exoskeleton comprises, for each of the first leg structure and second leg structure, a secondary foot actuator, configured for actuating rotation of said foot member about an axis of rotation extending parallel to said sagittal plane.

10

Preferably, each foot joint is configured for pivotal movement of the foot member by the main foot actuator with the axis of the foot joint extending laterally of the sagittal plane and downwardly at an angle of between zero and 6 degrees to the transverse plane.

Preferably, the foot joint is configured for pivotal movement of the foot member by the secondary foot actuator in a range of about six degrees to either side of a vertical plane .

Preferably, each of said upper leg structural member and lower leg structural member include a fastener to fasten to the legs of the user.

20

Preferably, each said fastener comprise an orthotic device affixed to a said upper leg structural member and lower leg structural member and that is shaped to receive the rear part of the users legs and a strap to hold said leg to said orthotic device.

Preferably, each of said upper leg structural members has engaged thereto an upper leg orthotic device to facilitate the upper leg of the user, in use, being rigidly held relative a respective said upper leg structural member and wherein each said lower leg structural member has engaged thereto a lower leg orthotic device to facilitate the lower leg of the user, in use, being rigidly held
5 relative a respective said lower leg structural member.

Preferably, each of said upper leg orthotic devices each carry at least one strap to secure said upper leg to said orthotic device and each said lower leg orthotic device carries at least one strap to secure said lower leg to said orthotic device.

10

Preferably, the lower leg lengthening insert is securable to the lower leg structural member by one or more selected from a thread formation, a bayonet-type formation, a snap fit formation, or the like.

15 Preferably, the user securing arrangement includes one or more selected from
a pelvic harness suitable for securing the user's pelvis to the pelvic support member;
a packing arrangement for snugly fitting a user's hips against the pelvic support member; and
20 a fastener arrangement for securing each of the user's legs to an associated leg structure.

Preferably, said exoskeleton includes a torso support that, in use engages to a user above said user securing arrangement.

25

Preferably, a plurality of sensors are provided for providing information to the control system for facilitating control of movement of the exoskeleton.

Preferably, the plurality of sensors are configured for sensing a characteristic to be sensed, and
5 generating a signal indicative of that characteristic, and transmitting the signal to the control system for facilitating the control of movement of the exoskeleton.

Preferably, said sensors are selected from at least one of:

an accelerometer to measure an acceleration of at least one or more selected from
10 said pelvic support member, the upper leg structural members, the lower leg structural members and the foot members,

an inclinometer to measure an inclination of at least one or more selected from
said pelvic support member, the upper leg structural members, the lower leg structural members and the foot members,

15 distance sensors configured for determining a slope of the ground anteriorly, posteriorly and laterally of the walker,

pressure sensors disposed on the foot member to determine pressure being applied
by the foot member to the ground, and

20 position sensors for determining position and velocity of the actuators.

Preferably, said controller includes a gyroscope configured for defining a reference frame for purposes of positional control of the exoskeleton or part of the exoskeleton.

Preferably, said walker includes a human interface device.

25

Preferably, the exoskeleton is configurable into a sitting position for facilitating transfer of the user to and from the walker, said exoskeleton comprising support surfaces configured and dimensioned to be engageable by a user for facilitating transfer of the user to and/or from the walker when in the sitting position.

5

Preferably, the secondary hip actuator is configured for actuating rotation of said upper leg structural member in medial/lateral plane in a range of about ten degrees to either side of vertical.

10

Preferably, the secondary hip actuator is configured for actuating rotation of said upper leg structural member in medial/lateral plane in a range of about six degrees to either side of vertical.

Preferably, the hip joint is one selected from a rose joint, universal joint or ball and socket joint, configured for facilitating the multi axis rotational capability of said upper leg structural member relative to said pelvic support member.

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Preferably, the hip joint is configured for providing pivotal movement of the upper leg structural member in a medial/lateral plane and an anterior/posterior plane about said pelvic support member, while at least partially preventing pivoting movement of the upper leg structural member about its longitudinal axis.

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Preferably, each hip joint is configured with its axis of rotation extending downwardly in a lateral direction at an angle of between zero and 6 degrees.

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Preferably, each hip joint is configured with its axis of rotation extending downwardly in a lateral direction at an angle of about four degrees.

Preferably, the knee joint is offset rearwardly from the upper leg structural member to align substantially with an axis of rotation of a user's knee in operation.

- 5 Preferably, the knee joint includes a roller bearing for facilitating rotation of the knee joint.

Preferably, the knee joint also includes a thrust bearing for resisting axial forces on the knee joint.

- 10 Preferably, the exoskeleton comprises, for each of the first leg structure and second leg structure, a secondary foot actuator, configured for actuating rotation of said foot member in a substantially medial/lateral plane about said foot joint.

- 15 Preferably, the secondary foot actuator is configured for actuating rotation of said upper leg structural member in medial/lateral plane in a range of about six degrees to either side of vertical.

- Preferably, the foot joint is a rose joint, a universal joint or ball and socket joint, configured for facilitating the multi axis rotational capability of said foot member relative said lower leg structural member.

- 20 Preferably, each foot joint is configured with its axis of rotation extending downwardly in a lateral direction at an angle of between zero and 6 degrees.

- Preferably, each foot joint is configured with its axis of rotation extending downwardly in a lateral direction at an angle of about four degrees.

25

Preferably, the foot joint is configured for providing pivotal movement of the upper leg structural member in a medial/lateral plane and an anterior/posterior plane about said pelvic support member, while at least partially preventing pivoting movement of the lower leg structural member relative to the foot member about its longitudinal axis.

5

Preferably, each of said upper leg structural member and lower leg structural member include fasteners to fasten to the legs of a user.

10

Preferably, the fasteners comprise an orthotic device shaped to conform to part of the users legs to which it is to be engaged and a strap to hold said leg to said orthotic device.

Preferably, the fasteners comprises an adjustable strap for securing at least partially about a user's leg.

15

Preferably, the adjustable strap includes an adjustable fastening arrangement.

Preferably, the adjustable fastening arrangement comprises at least one selected from a hook and loop formation, a buckle formation, a ratchet formation and a catch formation.

20

Preferably, each of said upper leg structural members has engaged thereto an upper leg orthotic device by which the upper leg of a user, in use, is rigidly held relative a respective said upper leg structural member and wherein each said lower leg structural member has engaged thereto a lower leg orthotic device by which the lower leg of a user, in use, is rigidly held relative a respective said lower leg structural member.

25

Preferably, each of said upper leg orthotics includes at least one strap to secure said upper leg orthotic to the users leg and each said lower leg orthotic include at least one strap to secure said lower leg orthotic to the users leg.

- 5 Preferably, each of said orthotic device is releasably engageable to the exoskeleton.

Preferably, the exoskeleton includes fasteners to releasably engage each said orthotic device to hold such in an appropriate location relative said exoskeleton.

- 10 Preferably, the fasteners allow for the orthotic devices to be engaged in a variety of positions.

Preferably, each of said foot members includes a foot member structural component for guiding the movement of a user's feet operationally.

- 15 Preferably, each of said foot members includes a shoe into which the user can place their feet.

Preferably, the shoe is removably engageable to the foot member structural component.

- 20 Preferably, the shoe member includes securing formations configured for facilitating convenient securing association between the foot member structural component and the shoe.

Preferably, the securing formation allows for a clip-on and clip-off association between the foot member structural component and the shoe.

- 25 Preferably, the position of the shoe is adjustable relative the foot member structural component.

Preferably, the foot member includes a foot engaging formation for engaging directly or indirectly with a user's foot.

- 5 Preferably, the foot engaging formation is coupled to the foot member structural component.

Preferably, the position of the foot engaging formation is adjustable relative the foot member structural component.

- 10 Preferably, the length of each upper leg structural members can be varied to vary the distance between the hip joint and knee joint.

Preferably, each of said upper leg structural member comprises at least two parts that are movable relative each other to extend and contract the effective length of the upper leg structural member.

15

Preferably, the two parts of said upper leg structural member are, by virtue of (a) a threaded relationship, (b) a telescopic relationship or (c) sliding relationship to each other, adjustable in length.

- 20 Preferably, the upper leg structural member is configured for receiving an upper leg lengthening insert for extending the effective length of the upper leg structural member.

Preferably, the upper leg lengthening insert is securable to the upper leg structural member by one or more selected from a thread formation, a bayonet-type formation, a snap fit formation, or
25 the like.

Preferably, the length of each lower leg structural members can be varied to vary the distance between the foot joint and knee joint.

- 5 Preferably, each said lower leg structural member comprises at least two parts that are movable relative each other to extend and contract the effective length of the lower leg structural member.

Preferably, the two parts of said lower leg structural member are, by virtue of (a) a threaded relationship, (b) a telescopic relationship or (c) sliding relationship to each other, adjustable in
10 length.

Preferably, the lower leg structural member is configured for receiving a lower leg lengthening insert for extending the effective length of the lower leg structural member.

- 15 Preferably, the lower leg lengthening insert is securable to the lower leg structural member by one or more selected from a thread formation, a bayonet-type formation, a snap fit formation, or the like.

Preferably, a mobility impaired disabled user is supported by the user securing arrangement at or
20 towards the pelvic region of the user, so that that the legs of the user are supported in carrying the weight of the user.

Preferably, the user securing arrangement includes one or more selected from
a pelvic harness suitable for securing a user's pelvis to the pelvic support member;

a packing arrangement for snugly fitting a user's hips against the pelvic support member;
and

a fastener arrangement for securing each of the user's legs to an associated leg structure.

- 5 Preferably, the packing arrangement is an inflatable pressure vessel. Alternately, the packing arrangement is a foam cushion. Preferably the foam cushion is wedge shaped.

Preferably, the exoskeleton includes a torso harness that, in use engages to a user above said user securing arrangement.

10

Preferably, a plurality of sensors is provided, said sensors being configurable for providing information to the control system for facilitating the control of movement of the exoskeleton.

- Preferably, the plurality of sensors are configured for sensing a characteristic to be sensed, and
15 generating a signal indicative of that characteristic, and transmitting the signal to the control system for facilitating the control of movement of the exoskeleton.

Preferably, the sensors include position sensors for determining the position of the actuators.

- 20 Preferably, the sensors include pressure sensors disposed on the foot member to determine the pressure being applied by the foot member to the ground.

Preferably, the pressure sensors are configured for determining the pressure variation applied to the ground, across the bottom of the foot member.

25

Preferably, the sensors include distance sensors configured for determining the slope of the ground anteriorly, posteriorly and laterally of the walking aid.

5 Preferably, the distance sensors are configured to detect the slope of the ground medially of the walking aid, said distance sensors allowing the controller to control the actuators to take account of the slope of the ground surrounding the walking aid.

Preferably, the said sensors include an accelerometer to measure the acceleration of at least one or more selected from said pelvic support member, the upper leg structural members, the lower
10 leg structural members and the foot members.

Preferably, the said sensors include an inclinometer to measure the inclination of at least one or more selected from said pelvic support member, the upper leg structural members, the lower leg structural members and the foot members.

15

Preferably, the controller includes a gyroscope configured for defining a reference frame for the purposes of positional control of the or part of the exoskeleton.

Preferably, the walking aid includes a human interface device. Preferably, the human interface
20 device includes a joystick. Preferably, the human interface device includes a keypad.

Preferably, the human interface device is pivotable on a swing arm for convenient moving to a vertical position during transfer of a user to the walking aid.

Preferably, the exoskeleton is configurable in a sitting position, for facilitating the transfer of a user to and from the walking aid.

Preferably, the exoskeleton includes support surfaces configured and dimensioned to be
5 engageable by a user for facilitating transfer of the user to and/or from the walking aid.

Preferably, the support surfaces are handles.

Preferably, the support surfaces are presented to be engageable by a user, when the walking aid
10 is in the sitting position.

Preferably, the handles are configured to extend substantially horizontally when the walking aid is in the sitting position.

15 Preferably, the support surfaces are defined by covers that cover at least part of the exoskeleton.

Preferably, the pelvic support member is moulded.

Preferably, the pelvic support member is moulded from one selected from carbon fibre or glass
20 fibre.

Preferably, the pelvic support member is moulded as single hollow unit.

Preferably, the pelvic support member is moulded as single hollow unit including shear webs
25 across the interior hollow space of the pelvic support member.

Preferably, the sensors on the foot members are sealed by a waterproof cover.

According to one aspect, the invention may be said to broadly consist in a walking aid suitable

5 for supporting a mobility impaired disabled user comprising:

an exoskeleton comprising:

a rigid pelvic support member including a user securing arrangement for securely fastening a user to at least the pelvic support member to fully support said user operationally,

10 a first leg structure and a second leg structure, each of the first leg structure and the second leg structure being coupled to and extending from said pelvic support member for operational location adjacent a respective leg of a user, each of the first leg structure and second leg structure comprising

an upper leg structural member for engagement with the upper leg of the user, the upper leg structural member being pivotally engaged at a first end thereof to the pelvic support member by a hip joint, wherein the hip joint is configured for facilitating the multi axis rotational capability of said upper leg structural member relative to said pelvic support member in at least the anterior posterior plane and the medial/lateral plane for abduction and adduction;

20 a lower leg structural member for engagement with the lower leg of the user, the lower leg structural member being pivotally engaged at a first end thereof to a second end of the upper leg structural member by a knee joint,

a foot member for engagement with the foot of a user, the foot member being pivotally engaged to a second end of the lower leg member by a foot joint,

a main hip actuator configured for actuating rotation of said upper leg structural member relative to said pelvic support member about said hip joint, to in use pivot the upper leg structural member in an anterior/posterior plane,

5 a secondary hip actuator, configured for actuating rotation of said upper leg structural member in a medial/lateral plane in adduction or abduction about said pelvic support member;

a knee actuator configured for actuating rotation of said lower leg structural member relative said upper leg structural member about said knee joint,

10 a main foot actuator configured for actuating rotation of said foot member relative said lower leg structural member about said foot joint about an axis of rotation substantially parallel to the axis of rotation of the knee joint;

a power source configurable for providing power to at least one or more selected from said main hip actuators, knee actuators, and main foot actuators,

15 a control system configurable for controlling movement of at least one or more selected from said main hip actuators, knee actuators, and main foot actuators, thereby to move the exoskeleton relative to the ground on which the walking aid is positioned, for at least the purposes of effecting a walking motion to said user.

20 Preferably, the secondary hip actuator is configured for actuating rotation of said upper leg structural member in medial/lateral plane in a range of about ten degrees to either side of vertical.

Preferably, the secondary hip actuator is configured for actuating rotation of said upper leg structural member in medial/lateral plane in a range of about six degrees to either side of vertical.

Preferably, the hip joint is one selected from a rose joint, universal joint or ball and socket joint, configured for facilitating the multi axis rotational capability of said upper leg structural member relative to said pelvic support member.

5 Preferably, the hip joint is configured for providing pivotal movement of the upper leg structural member in a medial/lateral plane and an anterior/posterior plane about said pelvic support member, while at least partially preventing pivoting movement of the upper leg structural member about its longitudinal axis.

10 Preferably, each hip joint is configured with its axis of rotation extending downwardly in a lateral direction at an angle of between zero and 6 degrees.

Preferably, each hip joint is configured with its axis of rotation extending downwardly in a lateral direction at an angle of about four degrees.

15

Preferably, the knee joint is offset rearwardly from the upper leg structural member to align substantially with an axis of rotation of a user's knee in operation.

Preferably, the knee joint includes a roller bearing for facilitating rotation of the knee joint.

20

Preferably, the knee joint also includes a thrust bearing for resisting axial forces on the knee joint.

Preferably, the exoskeleton comprises, for each of the first leg structure and second leg structure, a secondary foot actuator, configured for actuating rotation of said foot member in a substantially medial/lateral plane about said foot joint.

25

Preferably, the secondary foot actuator is configured for actuating rotation of said upper leg structural member in medial/lateral plane in a range of about six degrees to either side of vertical.

- 5 Preferably, the foot joint is a rose joint, a universal joint or ball and socket joint, configured for facilitating the multi axis rotational capability of said foot member relative said lower leg structural member.

10 Preferably, each foot joint is configured with its axis of rotation extending downwardly in a lateral direction at an angle of between zero and 6 degrees.

Preferably, each foot joint is configured with its axis of rotation extending downwardly in a lateral direction at an angle of about four degrees.

- 15 Preferably, the foot joint is configured for providing pivotal movement of the upper leg structural member in a medial/lateral plane and an anterior/posterior plane about said pelvic support member, while at least partially preventing pivoting movement of the lower leg structural member relative to the foot member about its longitudinal axis.

- 20 Preferably, each of said upper leg structural member and lower leg structural member include fasteners to fasten to the legs of a user.

Preferably, the fasteners comprise an orthotic device shaped to conform to part of the users legs to which it is to be engaged and a strap to hold said leg to said orthotic device.

25

Preferably, the fasteners comprises an adjustable strap for securing at least partially about a user's leg.

Preferably, the adjustable strap includes an adjustable fastening arrangement.

5

Preferably, the adjustable fastening arrangement comprises at least one selected from a hook and loop formation, a buckle formation, a ratchet formation and a catch formation.

10

Preferably, each of said upper leg structural members has engaged thereto an upper leg orthotic device by which the upper leg of a user, in use, is rigidly held relative a respective said upper leg structural member and wherein each said lower leg structural member has engaged thereto a lower leg orthotic device by which the lower leg of a user, in use, is rigidly held relative a respective said lower leg structural member.

15

Preferably, each of said upper leg orthotics includes at least one strap to secure said upper leg orthotic to the users leg and each said lower leg orthotic include at least one strap to secure said lower leg orthotic to the users leg.

20

Preferably, each of said orthotic device is releasably engageable to the exoskeleton.

Preferably, the exoskeleton includes fasteners to releasably engage each said orthotic device to hold such in an appropriate location relative said exoskeleton.

25

Preferably, the fasteners allow for the orthotic devices to be engaged in a variety of positions.

Preferably, each of said foot members includes a foot member structural component for guiding the movement of a user's feet operationally.

Preferably, each of said foot members includes a shoe into which the user can place their feet.

5

Preferably, the shoe is removably engageable to the foot member structural component.

Preferably, the shoe member includes securing formations configured for facilitating convenient securing association between the foot member structural component and the shoe.

10

Preferably, the securing formation allows for a clip-on and clip-off association between the foot member structural component and the shoe.

Preferably, the position of the shoe is adjustable relative the foot member structural component.

15

Preferably, the foot member includes a foot engaging formation for engaging directly or indirectly with a user's foot.

Preferably, the foot engaging formation is coupled to the foot member structural component.

20

Preferably, the position of the foot engaging formation is adjustable relative the foot member structural component.

Preferably, the length of each upper leg structural members can be varied to vary the distance between the hip joint and knee joint.

25

Preferably, each of said upper leg structural member comprises at least two parts that are movable relative each other to extend and contract the effective length of the upper leg structural member.

- 5 Preferably, the two parts of said upper leg structural member are, by virtue of (a) a threaded relationship, (b) a telescopic relationship or (c) sliding relationship to each other, adjustable in length.

- 10 Preferably, the upper leg structural member is configured for receiving an upper leg lengthening insert for extending the effective length of the upper leg structural member.

Preferably, the upper leg lengthening insert is securable to the upper leg structural member by one or more selected from a thread formation, a bayonet-type formation, a snap fit formation, or the like.

15

Preferably, the length of each lower leg structural members can be varied to vary the distance between the foot joint and knee joint.

- 20 Preferably, each said lower leg structural member comprises at least two parts that are movable relative each other to extend and contract the effective length of the lower leg structural member.

Preferably, the two parts of said lower leg structural member are, by virtue of (a) a threaded relationship, (b) a telescopic relationship or (c) sliding relationship to each other, adjustable in length.

25

Preferably, the lower leg structural member is configured for receiving a lower leg lengthening insert for extending the effective length of the lower leg structural member.

Preferably, the lower leg lengthening insert is securable to the lower leg structural member by
5 one or more selected from a thread formation, a bayonet-type formation, a snap fit formation, or the like.

Preferably, a mobility impaired disabled user is supported by the user securing arrangement at or towards the pelvic region of the user, so that that the legs of the user are supported in carrying
10 the weight of the user.

Preferably, the user securing arrangement includes one or more selected from
a pelvic harness suitable for securing a user's pelvis to the pelvic support member;
a packing arrangement for snugly fitting a user's hips against the pelvic support member;
15 and
a fastener arrangement for securing each of the user's legs to an associated leg structure.

Preferably, the packing arrangement is an inflatable pressure vessel. Alternately, the packing arrangement is a foam cushion. Preferably the foam cushion is wedge shaped.

20 Preferably, the exoskeleton includes a torso harness that, in use engages to a user above said user securing arrangement.

Preferably, a plurality of sensors is provided, said sensors being configurable for providing
25 information to the control system for facilitating the control of movement of the exoskeleton.

Preferably, the plurality of sensors are configured for sensing a characteristic to be sensed, and generating a signal indicative of that characteristic, and transmitting the signal to the control system for facilitating the control of movement of the exoskeleton.

5

Preferably, the sensors include position sensors for determining the position of the actuators.

Preferably, the sensors include pressure sensors disposed on the foot member to determine the pressure being applied by the foot member to the ground.

10

Preferably, the pressure sensors are configured for determining the pressure variation applied to the ground, across the bottom of the foot member.

Preferably, the sensors include distance sensors configured for determining the slope of the ground anteriorly, posteriorly and laterally of the walking aid.

15

Preferably, the distance sensors are configured to detect the slope of the ground medially of the walking aid, said distance sensors allowing the controller to control the actuators to take account of the slope of the ground surrounding the walking aid.

20

Preferably, the said sensors include an accelerometer to measure the acceleration of at least one or more selected from said pelvic support member, the upper leg structural members, the lower leg structural members and the foot members.

Preferably, the said sensors include an inclinometer to measure the inclination of at least one or more selected from said pelvic support member, the upper leg structural members, the lower leg structural members and the foot members.

- 5 Preferably, the controller includes a gyroscope configured for defining a reference frame for the purposes of positional control of the or part of the exoskeleton.

Preferably, the walking aid includes a human interface device. Preferably, the human interface device includes a joystick. Preferably, the human interface device includes a keypad.

10

Preferably, the human interface device is pivotable on a swing arm for convenient moving to a vertical position during transfer of a user to the walking aid.

15

Preferably, the exoskeleton is configurable in a sitting position, for facilitating the transfer of a user to and from the walking aid.

Preferably, the exoskeleton includes support surfaces configured and dimensioned to be engageable by a user for facilitating transfer of the user to and/or from the walking aid.

20

Preferably, the support surfaces are handles.

Preferably, the support surfaces are presented to be engageable by a user, when the walking aid is in the sitting position.

Preferably, the handles are configured to extend substantially horizontally when the walking aid is in the sitting position.

Preferably, the support surfaces are defined by covers that cover at least part of the exoskeleton.

5

Preferably, the pelvic support member is moulded.

Preferably, the pelvic support member is moulded from one selected from carbon fibre or glass fibre.

10

Preferably, the pelvic support member is moulded as single hollow unit.

Preferably, the pelvic support member is moulded as single hollow unit including shear webs across the interior hollow space of the pelvic support member.

15

Preferably, the sensors on the foot members are sealed by a waterproof cover.

According to a further aspect the invention may be said to broadly consist in an exoskeleton suitable for use in a controllable walking aid for a mobility impaired disabled user, said exoskeleton comprising:

20

a rigid pelvic support member including a user securing arrangement for fastening to a user to fully support said user operationally,

a first leg structure and a second leg structure, each of the first leg structure and the second leg structure being coupled to and extending from said pelvic support member for

operational location adjacent a respective leg of a user, each of the first leg structure and second leg structure comprising

5 an upper leg structural member for engagement with the upper leg of the user, the upper leg structural member being pivotally engaged at a first end thereof to the pelvic support member by a hip joint, wherein the hip joint is configured for facilitating the multi axis rotational capability of said upper leg structural member relative to said pelvic support member in at least the anterior posterior plane and the medial/lateral plane for abduction and adduction;

10 a lower leg structural member for engagement with the lower leg of the user, the lower leg structural member being pivotally engaged at a first end thereof to a second end of the upper leg structural member by a knee joint,

a foot member for engagement with the foot of a user, the foot member being pivotally engaged to a second end of the lower leg member by a foot joint,

15 a main hip actuator configured for actuating rotation of said upper leg structural member relative to said pelvic support member about said hip joint, to in use pivot the upper leg structural member in an anterior/posterior plane,

a secondary hip actuator, configured for actuating rotation of said upper leg structural member in a medial/lateral plane in adduction or abduction about said pelvic support member;

20 a knee actuator configured for actuating rotation of said lower leg structural member relative said upper leg structural member about said knee joint, and

a main foot actuator configured for actuating rotation of said foot member relative said lower leg structural member about said foot joint about an axis of rotation substantially parallel to the axis of rotation of the knee joint.

25

Preferably, the exoskeleton comprises a power source configurable for providing power to at least one or more selected from said main hip actuators, secondary hip actuators, knee actuators, and main foot actuators.

- 5 Preferably, the secondary hip actuator is configured for actuating rotation of said upper leg structural member in medial/lateral plane in a range of about ten degrees to either side of vertical.

Preferably, the secondary hip actuator is configured for actuating rotation of said upper leg structural member in medial/lateral plane in a range of about six degrees to either side of vertical.

10

Preferably, the hip joint is one selected from a rose joint, universal joint or ball and socket joint, configured for facilitating the multi axis rotational capability of said upper leg structural member relative to said pelvic support member.

- 15 Preferably, the hip joint is configured for providing pivotal movement of the upper leg structural member in a medial/lateral plane and an anterior/posterior plane about said pelvic support member, while at least partially preventing pivoting movement of the upper leg structural member about its longitudinal axis.

- 20 Preferably, each hip joint is configured with its axis of rotation extending downwardly in a lateral direction at an angle of between zero and 6 degrees.

Preferably, each hip joint is configured with its axis of rotation extending downwardly in a lateral direction at an angle of about four degrees.

25

Preferably, the knee joint is offset rearwardly from the upper leg structural member to align substantially with an axis of rotation of a user's knee in operation.

Preferably, the knee joint includes a roller bearing for facilitating rotation of the knee joint.

5

Preferably, the knee joint also includes a thrust bearing for resisting axial forces on the knee joint.

Preferably, the exoskeleton comprises, for each of the first leg structure and second leg structure, a secondary foot actuator, configured for actuating rotation of said foot member in a substantially medial/lateral plane about said foot joint.

10

Preferably, the secondary foot actuator is configured for actuating rotation of said upper leg structural member in medial/lateral plane in a range of about six degrees to either side of vertical.

15

Preferably, the foot joint is a rose joint, a universal joint or ball and socket joint, configured for facilitating the multi axis rotational capability of said foot member relative said lower leg structural member.

Preferably, each foot joint is configured with its axis of rotation extending downwardly in a lateral direction at an angle of between zero and 6 degrees.

20

Preferably, each foot joint is configured with its axis of rotation extending downwardly in a lateral direction at an angle of about four degrees.

Preferably, the foot joint is configured for providing pivotal movement of the upper leg structural member in a medial/lateral plane and an anterior/posterior plane about said pelvic support member, while at least partially preventing pivoting movement of the lower leg structural member relative to the foot member about its longitudinal axis.

5

Preferably, each of said upper leg structural member and lower leg structural member include fasteners to fasten to the legs of a user.

Preferably, the fasteners comprise an orthotic device shaped to conform to part of the users legs to which it is to be engaged and a strap to hold said leg to said orthotic device.

10

Preferably, the fasteners comprises an adjustable strapping for securing at least partially about a user's leg.

15 Preferably, the adjustable strapping includes an adjustable fastening arrangement.

Preferably, the adjustable fastening arrangement comprises at least one selected from a hook and loop formation, a buckle formation, a ratchet formation and a catch formation.

20 Preferably, each said upper leg structural member has engaged thereto an upper leg orthotic device by which the upper leg of a user, in use, is rigidly held relative a respective said upper leg structural member and wherein each said lower leg structural member has engaged thereto a lower leg orthotic device by which the lower leg of a user, in use, is rigidly held relative a respective said lower leg structural member.

25

Preferably, each said upper leg orthotic includes at least one strap to secure said upper leg orthotic to the users leg and each said lower leg orthotic include at least one strap to secure said lower leg orthotic to the users leg.

- 5 Preferably, each said orthotic device is releasably engageable to the exoskeleton.

Preferably, the exoskeleton includes fasteners to releasably engage each said orthotic device to hold such in an appropriate location relative said exoskeleton.

- 10 Preferably, the fasteners allow for the orthotic devices to be engaged in a variety of positions.

Preferably, each of said foot members includes a foot member structural component for guiding the movement of a user's feet operationally.

- 15 Preferably, each of said foot members includes a shoe into which the user can place their feet.

Preferably, the shoe is removably engageable to the foot member structural component.

- 20 Preferably, the shoe member includes securing formations configured for facilitating convenient securing association between the foot member structural component and the shoe.

Preferably, the securing formation allows for a clip-on and clip-off association between the foot member structural component and the shoe.

- 25 Preferably, the position of the shoe is adjustable relative the foot member structural component.

Preferably, the foot member includes a foot engaging formation for engaging directly or indirectly with a user's foot.

- 5 Preferably, the foot engaging formation is coupled to the foot member structural component.

Preferably, the position of the foot engaging formation is adjustable relative the foot member structural component.

- 10 Preferably, the length of each upper leg structural members can be varied to vary the distance between the hip joint and knee joint.

Preferably, each of said upper leg structural member comprises at least two parts that are movable relative each other to extend and contract the effective length of the upper leg structural member.

15

Preferably, the two parts of said upper leg structural member are, by virtue of (a) a threaded relationship, (b) a telescopic relationship or (c) sliding relationship to each other, adjustable in length.

- 20 Preferably, the upper leg structural member is configured for receiving an upper leg lengthening insert for extending the effective length of the upper leg structural member.

Preferably, the upper leg lengthening insert is securable to the upper leg structural member by one or more selected from a thread formation, a bayonet-type formation, a snap fit formation, or

- 25 the like.

Preferably, the length of each lower leg structural members can be varied to vary the distance between the foot joint and knee joint.

- 5 Preferably, each of said lower leg structural member comprises at least two parts that are movable relative each other to extend and contract the effective length of the lower leg structural member.

Preferably, the two parts of said lower leg structural member are, by virtue of (a) a threaded relationship, (b) a telescopic relationship or (c) sliding relationship to each other, adjustable in
10 length.

Preferably, the lower leg structural member is configured for receiving a lower leg lengthening insert for extending the effective length of the lower leg structural member.

- 15 Preferably, the lower leg lengthening insert is securable to the lower leg structural member by one or more selected from a thread formation, a bayonet-type formation, a snap fit formation, or the like.

Preferably, a user is fully supported by the user securing arrangement at or towards the pelvic
20 region of the user, so that that the legs of the user do not carry the weight of the user.

Preferably, the user securing arrangement includes one or more selected from

 a pelvic harness suitable for securing a user's pelvis to the pelvic support member;

 a packing arrangement for snugly fitting a user's hips against the pelvic support member;

- 25 and

a fastener arrangement for securing each of the user's legs to an associated leg structure.

Preferably, the exoskeleton includes a torso harness that, in use engages to a user above said user securing arrangement.

5

Preferably, the exoskeleton is configurable in a sitting position, for facilitating the transfer of a user to and from the exoskeleton.

Preferably, the exoskeleton includes support surfaces configured and dimensioned to be
10 engageable by a user for facilitating transfer of the user to and/or from the exoskeleton.

Preferably, the support surfaces are handles.

Preferably, the support surfaces are presented to be engageable by a user, when the exoskeleton
15 is in the sitting position.

Preferably, the handles are configured to extend substantially horizontally when the exoskeleton is in the sitting position.

20 Preferably, the support surfaces are defined by covers that cover at least part of the exoskeleton.

Preferably, the pelvic support member is moulded.

Preferably, the pelvic support member is moulded from one selected from carbon fibre or glass
25 fibre.

Preferably, the pelvic support member is moulded as single hollow unit.

Preferably, the pelvic support member is moulded as single hollow unit including shear webs
5 across the interior hollow space of the pelvic support member.

Preferably, a plurality of sensors is provided, said sensors being configurable for providing
information to the control system for facilitating the control of movement of the exoskeleton.
Preferably, the plurality of sensors are configured for sensing a characteristic to be sensed, and
10 generating a signal indicative of that characteristic, and transmitting the signal to the control
system for facilitating the control of movement of the exoskeleton.

Preferably, the sensors include position sensors for determining the position of the actuators.

15 Preferably, the sensors include pressure sensors disposed on the foot member to determine the
pressure being applied by the foot member to the ground.

Preferably, the pressure sensors are configured for determining the pressure variation applied to
the ground, across the bottom of the foot member.

20

Preferably, the sensors include distance sensors configured for determining the slope of the
ground anteriorly and posteriorly of the exoskeleton.

Preferably, the distance sensors are configured to detect the slope of the ground medially of the exoskeleton, said distance sensors allowing the controller to control the actuators to take account of the slope of the ground surrounding the exoskeleton.

- 5 Preferably, the sensors include an accelerometer to measure the acceleration of at least one or more selected from said pelvic support member, the upper leg structural members, the lower leg structural members and the foot members.

- 10 Preferably, the sensors include an inclinometer to measure the inclination of at least one or more selected from said pelvic support member, the upper leg structural members, the lower leg structural members and the foot members.

Preferably, the controller includes a gyroscope configured for defining a reference frame for the purposes of positional control of the or part of the exoskeleton.

15

Preferably, the exoskeleton includes a human interface device. Preferably, the human interface device includes a joystick. Preferably, the human interface device includes a keypad.

- 20 Preferably, the human interface device is pivotable on a swing arm for convenient moving to a vertical position during transfer of a user to the walking aid.

According to a further aspect, there is provided an exoskeleton suitable for use in a walking aid, said exoskeleton comprising:

- 25 a rigid pelvic support member suitable for snug engagement with a user's hips operationally

a user securing arrangement for fastening to a user to fully support said user operationally,
a first leg structure and a second leg structure, each of the first leg structure and the
second leg structure being coupled to and extending from said pelvic support member for
operational location adjacent a respective leg of a user, each of the first leg structure and second
5 leg structure comprising

an upper leg structural member for engagement with the upper leg of the user, the upper
leg structural member being pivotally engaged at a first end thereof to the pelvic support member
by a hip joint, wherein the hip joint is configured for facilitating the multi axis rotational
capability of said upper leg structural member relative to said pelvic support member in at least
10 the anterior posterior plane and the medial/lateral plane for abduction and adduction;

a lower leg structural member for engagement with the lower leg of the user, the lower
leg structural member being pivotally engaged at a first end thereof to a second end of the upper
leg structural member by a knee joint,

a foot member for engagement with the foot of a user, the foot member being pivotally
15 engaged to a second end of the lower leg member by a foot joint,

a main hip actuator configured for actuating rotation of said upper leg structural member
relative to said pelvic support member about said hip joint, to in use pivot the upper leg structural
member in an anterior/posterior plane,

a secondary hip actuator, configured for actuating rotation of said upper leg structural
20 member in a medial/lateral plane in adduction or abduction about said pelvic support member;

a knee actuator configured for actuating rotation of said lower leg structural member
relative said upper leg structural member about said knee joint, and

a main foot actuator configured for actuating rotation of said foot member relative said
lower leg structural member about said foot joint about an axis of rotation substantially parallel
25 to the axis of rotation of the knee joint.

Preferably, the user securing arrangement includes
a pelvic harness suitable for securing a user's hips to the pelvic support member; and
securing fasteners suitable for securing a user's legs to the leg structures operationally.

5 The term "anterior" as used in this specification relates to a direction corresponding to the front
or in front of a human user, and the term "anteriorly" is to be construed accordingly. The term
"posterior" as used in this specification relates to a direction corresponding to the back of or
behind a human user, and the term "posteriorly" is to be construed accordingly. The term
"anterior/posterior plane" as used in this specification relates to a plane extending anteriorly
10 and/or posteriorly from a user. The term "medial" as used in this specification relates to a
direction extending inwardly towards a user's body from the user's inner arm, and the term
"medially" is to be construed accordingly. The term "movement in the medial/lateral plane" as
used in this specification relates to movement in an adduction/abduction direction. The term
"lateral" as used in this specification relates to a direction extending outwardly sideways from a
15 user's body, and the term "laterally" is to be construed accordingly. The term "medial/lateral
plane" as used in this specification relates to a plane extending medially and/or laterally from a
user.

This invention may also be said broadly to consist in the parts, elements and features referred to
20 or indicated in the specification of the application, individually or collectively, and any or all
combinations of any two or more of said parts, elements or features, and where specific integers
are mentioned herein which have known equivalents in the art to which this invention relates,
such known equivalents are deemed to be incorporated herein as if individually set forth.

As used herein the term “and/or” means “and” or “or”, or both. As used herein “(s)” following a noun means the plural and/or singular forms of the noun.

5 The term “comprising” as used in this specification means “consisting at least in part of”. When interpreting statements in this specification which include that term, the features, prefaced by that term in each statement, all need to be present but other features can also be present. Related terms such as “comprise” and “comprised” are to be interpreted in the same manner.

10 In this specification where reference has been made to patent specifications, other external documents, or other sources of information, this is generally for the purpose of providing a context for discussing the features of the invention. Unless specifically stated otherwise, reference to such external documents is not to be construed as an admission that such documents, or such sources of information, in any jurisdiction, are prior art, or form part of the common general knowledge in the art.

15

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a side view of the exoskeleton forming part of the WA of the present invention
20 with orthotics provided, shown in this embodiment without a secondary hip actuator;

Figure 2 is a cutaway front view of part of the exoskeleton and orthotics that is shown in Figure
1;

25 Figure 3 is a front view of the exoskeleton and orthotics shown in Figure 1;

Figure 4 is a front view of the WA of Figure 1 supporting a user;

Figure 5 is a cutaway side view of part of the exoskeleton of Figure 1 in the region of the foot
5 member;

Figure 6 is a rear view of Figure 5;

Figure 7 is a cutaway front view of part of an exoskeleton including a secondary hip actuator in
10 the region of the hip joint;

Figure 8 is the side view of Figure 7;

Figure 8a shows schematic layout of the lateral movement actuators of the exoskeleton seen from
15 the front;

Figure 9 shows a side view of a foot member;

Figure 10 shows a bottom view of a foot member;

20

Figure 10a shows a perspective view of a foot member;

25

Figure 11 shows a schematic side view of part of the exoskeleton showing sensors placement and
their intended sensing of the surrounding environment,

Figure 12 shows a side view of the knee joint in schematic form showing the offset of the knee joint,

Figure 13 is a side view of a person being supported by an embodiment of the WA including a
5 secondary hip actuator,

Figure 14 shows a side view of a person supported by a WA with covers attached to it,

Figure 15 shows a perspective cutaway rear view of the foot member and lower leg structural
10 member of the exoskeleton,

Figure 16 shows a side view of an upper region of the exoskeleton including an upper body control extension for supporting upper body movement relative to the pelvic brace;

15 Figure 17 shows a side view of a WA in a stepping forward position;

Figure 18 shows a rear view of a WA including a secondary hip actuator;

Figure 19 shows a front view showing in more detail the bracing and support that is provided to
20 secure the user by the exoskeleton,

Figure 20 shows a cutaway right side view of the knee region of the exoskeleton showing a knee pivot offset,

25 Figure 21 shows a cutaway right rear view of the preferred knee pivot off set

Figure 22 shows a cutaway right front view of the knee pivot offset,

Figure 23 shows a side view of a WA with covers on,

5

Figure 24 shows a rear view of a WA with covers on,

Figure 25 shows a front view of a WA with covers included and supporting the user,

10 Figure 26 shows a perspective front view of a third embodiment of a WA in a stepping position;

Figure 27 shows a perspective front view of a third embodiment of a WA supporting a user in a standing position;

15 Figure 28 shows a side view of a third embodiment of a WA supporting a user in a standing position;

Figure 29 shows a front view of a third embodiment of a WA;

20 Figure 30 shows a rear view of a region near the hip joint of figure 26,;

Figure 31 shows a side view of a region near the hip joint of figure 26;

Figure 32 shows a rear view of a region near the knee joint of figure 26;

25

Figure 33 shows a perspective front view of a knee joint of figure 26;

Figure 34 shows a perspective front view of a region near the hip joint of figure 26;

5 Figure 35 shows a side view of a region near the knee joint of figure 26;

Figure 36 shows a side view of a third embodiment of a WA in a standing position without covers on;

10 Figure 37 shows a side view of a third embodiment of a WA in a stepping position without covers on;

Figure 38 shows a side view of a third embodiment of a WA in a stepping position with covers on;

15

Figure 39 shows a front perspective view of a third embodiment of a WA in a sitting position without covers on;

Figure 40 shows a front view of a third embodiment of a WA in a sitting position without covers
20 on;

Figure 41 shows a front perspective view of a region near the foot joint of a WA;

Figure 42 shows a front view of a region near the foot joint of a WA;

25

Figure 43 shows a schematic diagram illustrating the movement of centre of mass of the WA and user between steps during a walking movement; and

Figure 44 shows a wedge shaped foam packing arrangement.

5

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

With reference to the above drawings, in which similar features are generally indicated by similar numerals, a device that may in one form be a walking aid according to a first aspect of the invention is generally indicated by the numeral 100, and an exoskeleton suitable for use in a controllable walking aid is generally indicated by the numeral 500. The device may also in another form be considered a medical device that can assist in reducing adverse effects of immobility of the leg or legs of a mobility impaired disabled user, where the device also is able to move the user in a walking or stepping manner or not.

According to a first aspect there is provided a walking aid (WA) 100 suitable for supporting a mobility impaired disabled user while moving through a set of movements correlating to a walking motion. The WA 100 comprises an exoskeleton 500, a power source in the form of a battery pack or other similar onboard power pack (not shown) together with its associated power supply cables (not shown), and a control system (not shown).

The exoskeleton 500 comprises a rigid pelvic support member or hip frame 15 including a pelvic harness 96, and a pair of leg structures 50 (a first leg structure and second leg structure).

25

The hip frame 15 is required to be of a relatively low weight, while having a high rigidity and low amounts of flexing in operation. For this reason, the hip frame 15 is moulded from carbon fibre as a single unit having an interior hollow space (not shown). It is envisaged that the hip frame 15 could also be moulded from glass fibre. The hip frame 15 further includes transverse
5 shear webs extending across its interior hollow space.

Each of the leg structures 50 comprise an upper leg structural member 10, a lower leg structural member 11, a foot member 18, a main hip actuator 16, a knee actuator 13 and a main foot actuator 19.
10

The upper leg structural member 10 is for securing with an upper leg 610 of a user 600, the upper leg structural member 10 being pivotally engaged at a first end 10a thereof to the hip frame 15 by the hip joint 14.

15 The lower leg structural member 11 is for securing with the lower leg 620 of the user 600, the lower leg structural member 11 being pivotally engaged at a first end 11a thereof to a second end 10b of the upper leg structural member 10 by a knee joint 12.

In one embodiment, it is envisaged that the knee joint 12 will only allow relative pivotal
20 movement between the upper leg structural member 10 and the lower leg structural member 11 along a single plane. It will preferably use a roller bearing arrangement (not shown) to accomplish this. However, the knee joint 12 may be subject to large twisting forces or sideways forces, causing axial forces on the roller bearing arrangement. For this reason, it is envisaged that the knee joint will also include a thrust bearing arrangement (not shown) configured for resisting
25 axial forces on the knee joint 12.

- Each of said upper leg structural member 10 and lower leg structural member 11 include a fastening arrangement in the form of adjustable fasteners 46 for fastening the respective leg structures 50 the associated legs of a user 600 in use. It is envisaged that the fasteners 46 may be comprised of flexible webbing or straps, and can include an adjustable fastening arrangement 47, which could be in the form of straps having a hook and loop fastening system such as Velcro® which pass through a buckle. Alternately, the adjustable fastening arrangement can include a typical buckle, ratchet buckle or catch formation.
- 10 The foot member 18 is for securing to the foot 630 of a user 600, the foot member 18 being pivotally engaged to a second end 11b of the lower leg structural member 11 by a foot joint 17. Each of said foot members 18 includes a foot member structural component 126 for guiding the movement of a user's feet 630 operationally.
- 15 In one embodiment, each of said foot members 18 includes a shoe 31 which is conveniently removably engageable with the foot member structural component 126, and into which the user 600 can place their feet. The shoe 31 is conveniently removably engageable with the foot member structural component 126 by means of a securing formation, such as a clip-type formation, a snap-fit type formation, a bayonet-type formation or any other suitable formation. The position of the shoe 31 relative to the foot member structural component 126 is envisaged as being adjustable, to allow the alignment of a user's ankle with the axis of rotation 17A of the foot joint 17.
- 20

In another embodiment, each of the foot members 18 include a foot engaging formation 34 for engaging indirectly (i.e. the user wearing shoes) with a user's foot 630. The foot engaging

formation 34 is coupled to the foot member structural component 126 in an adjustable manner, to again allow for positioning of the user's 600 ankle.

The main hip actuator 16 is configured for actuating rotation of said upper leg structural member 10 relative to said hip frame 15 about said hip joint 14, to thereby (in use) pivot the upper leg structural member 10 in an anterior/posterior plane of the user 600.

The exoskeleton 500 further includes, for each of the leg structures 50, a secondary hip actuator 38. The secondary hip actuator 38 is configured for actuating rotation of the upper leg structural member 10 in a medial/lateral plane about the hip frame 15 and relative to the user 600 in use. In a preferred embodiment, the secondary hip actuator 38 is configured for actuating rotation of said upper leg structural member 10 in a medial/lateral plane in a range of about twelve degrees, and more preferably about six degrees, to either side of vertical.

The knee actuator 13 is configured for actuating rotation of said lower leg structural member 11 relative said upper leg structural member 10 about said knee joint 12.

The main foot actuator 19 is configured for actuating rotation of said foot member 18 relative said lower leg structural member 11 about said foot joint 17 about an axis of rotation 17A substantially parallel to the axis of rotation 12A of the knee joint 12.

Further, the exoskeleton 500 includes, for each of the leg structures 50, a secondary foot actuator 39. The secondary foot actuator 39 is configured for actuating rotation of said foot member 18 in a substantially medial/lateral plane about said foot joint 17. Each secondary foot actuator 39 is configured for actuating rotation of its associated upper leg structural members 10 in

medial/lateral plane in a range of about ten degrees, and more preferably about six degrees to either side of vertical.

The power source is configurable for providing power to the actuators 16, 13, 19, 38, 39.

5

The control system is configurable for controlling movement of the main hip actuators, secondary hip actuators, knee actuators, main foot actuators, and secondary foot actuators. This will cause movement of the exoskeleton 500 relative to the ground on which the walking aid is positioned. It is envisaged that when controlled to actuate the actuators in the correct sequence, a walking
10 motion may be obtained by the exoskeleton. When a mobility impaired disabled user 600 is secured to the WA, the user 600 is caused to move their joints and muscles through the motions of walking, thereby assisting in the prevention of deterioration of a user's 600 physiology.

It is important to note that mobility impaired disabled users need to be supported to the extent
15 that they are not able to stand by themselves. In this context, a mobility impaired disabled user may be said to be "fully" supported. However, an important aspect of the current WA is its ability to support the mobility impaired disabled user in a position so that their own legs are weight bearing, so that their bones are being subjected to stress. Typically, mobility impaired disabled user's leg and pelvic bones deteriorate over time. This is caused by the removal or leeching of
20 minerals from their bones where their bones are not subjected to regular stress. In addition to the weakening of their bones, mobility impaired disabled users can suffer from downstream complications from this mineral removal, in that these minerals may build up in other parts of their bodies, for instance in, such as kidney stones or the like.

In subjecting a mobility impaired disabled user's bones to stress where they would otherwise not be, this helps prevent deterioration of a user's bones, and subsequent complications where minerals removed from the user's bones builds up elsewhere in the user's system. Further, causing movement of the user's legs assists in stimulating blood flow through their system, which
5 allows associated physiological benefits.

With reference to the figures, in figures 1 and 3 there is generally shown a walking aid (WA) 100. The WA 100 includes a moveable mechanical frame or exoskeleton 500 that a user 600 is effectively supported by. It can support and carry the user 600
10

The WA 100 includes an exoskeleton 500 that is a skeletal structure worn externally by a user 600. It may be powered by an onboard power pack (not shown) that is preferably chargeable from a power source such as a car or at any domestic power socket.

15 The user is strapped to and supported by the exoskeleton 500. It is envisaged that the WA 100 is a self supporting structure that is capable of moving the user 600. The WA 100 includes a user securing arrangement in the form of a pelvic harness 96 including braces, tethers, strapping, a harness or webbing to hold the user's 600 hips snugly to the hip frame 15, and either orthotics or adjustable fasteners to secure the user's legs and/or feet to the leg structures 50. In one
20 embodiment the braces include orthotics 4 positioned, configured and designed to ensure correct alignment of the users limbs and joints and can also include straps or webbing.

The WA is controlled by the user by way of a joystick 2 and keypad 3 normally positioned at waist height. The keypad 3 and joystick 2 may be supported by an arm 5. This may be able to

pivot to move between at least one operational position (eg in use extending horizontally or pointing down vertically) and a retired position (eg extending vertically)

With reference to Figures 1-3, the exoskeleton 500 includes an upper leg structural member 10 and a lower leg structural member 11. These are connected by a knee joint 12 that defines a pivot axis 12A to allow the upper leg member 10 and lower leg structural member 11 to pivot relative to each other. The pivot axis 12A ensures the upper leg member and lower leg member can rotate relative to each other but only about one pivot axis.

Movement about the knee axis 12A of the upper leg member and lower leg member can be actuated by the knee actuator 13. The knee actuator 13 extends between parts of the upper leg member and lower leg member for the purposes of actuating relative rotational movement between the upper leg member 10 and lower leg structural member 11.

The knee joint 12 is preferably located at a distal first end 10b of the upper leg member 10. At a first end 10a of the upper leg member 10 is a hip joint 14 that pivotally engages the upper leg member 10 with the hip frame 15. The hip joint 14 defines a hip axis 14A that in use is located relative to the user 600 at or approximate to the natural axis of hip rotation in an anterior/posterior direction of movement. In a preferred embodiment, each hip joint 14 is configured relative to the hip frame 15 with its axis of rotation 14A extending downwardly in a lateral direction at an angle of between zero and ten degrees, and more preferably of about four degrees. This inclination of the axis of rotation 14A mimics a human beings upper leg alignment and is illustrated as angle α in figure 30. The inclination means that the foot members of the WA 100 are closer together, which allows for more natural transfer of the centre of mass (generally located about the middle of the pelvis) to a point within the support area provided by the foot members 18 during when

the WA 100 is controlled in to move through a walking motion. This is further illustrated in Figure 43, showing how the movement of the combined centre of mass (illustrated as point C) of the WA 100 and the user moves in a reduced side to side movement between the individual steps in a walking movement, compared to a WA not having such an inclination of the axis of rotation
 5 of the hip joint(shown in broken lines).

The hip joint 14 allows for a relative rotation between the upper leg member 10 and the hip frame 15. Such rotation is preferably primarily about an axis that is parallel to the knee axis 12A. However the hip joint 14 also allows for a rotation of the upper leg member 10 relative the hip
 10 frame 15 in a medial/lateral plane direction, which will in operation result in a movement of a user's 600 leg along a medial/lateral plane (e.g. the leg splaying outwardly). This multi axis pivoting capability can be facilitated by the use of a rose joint to define the hip joint 14. It is envisaged that the hip joint 14 (in the form of a rose joint) may be limited in its movement by a pair of horizontally aligned plastic, and preferably acetyl, bushes (not shown) disposed on either
 15 side of the rose joint. A vertically aligned flange (not shown) connected to the upper leg structural member 10 will be prevented from pivotal movement in a horizontal plane in this way, at least partially preventing pivoting movement of the upper leg structural member 10 about its longitudinal axis.

20 Rotation of the hip frame, or also herein referred to as the pelvis harness 15 relative the upper leg member 10 about an axis parallel to the knee axis 12A, at the hip joint 14 can be achieved by the use of the main hip actuator 16.

Disposed at a second distal end 11b (the end away from the knee joint) of the lower leg structural
 25 member 11, is a foot member 18. The foot member 18 is capable to rotating relative the lower

leg structural member 11 by virtue of the foot joint 17. The foot joint 17 preferably defines a pivot axis 17a that extends parallel with the knee axis 12A. Pivotal movement of foot member 18 about the foot joint 17 relative to the lower structural support member 11 in the anterior/posterior plane can be effected by the foot actuator 19. The foot joint 17 may, like the
5 hip joint, be a rose joint to facilitate its multi-axis pivoting capability. The foot joint 17 can allow for the foot member 18 to have multiple degrees of rotational movement relative the lower leg structural member 11. In a preferred embodiment, it is envisaged that the foot joint 17 is configured for providing pivotal movement of the lower leg structural member 11 in a medial/lateral plane and an anterior/posterior plane about said foot member 18, while at least
10 partially preventing pivoting movement of the lower leg structural member 11 relative to the foot member 18 about its longitudinal axis. This limitation on pivoting or twisting movement is accomplished in a similar manner to that of the hip joint 14, that is by the insertion of acetyl bushes on either side of the rose joint. It is envisaged that in a preferred embodiment, each foot joint 17 is configured with its axis of rotation 17A extending downwardly in a lateral direction at
15 an angle of between zero and 6 degrees, and more preferably at about four degrees.

A secondary foot actuator 39 may be provided, and coupled to the foot member 18 to control a rotational movement of the foot member in a direction substantially transverse to the direction in which the main foot actuator 19 can control rotational movement and substantially along a
20 medial/lateral plane. The secondary foot actuator 39 may be engaged to an axle or lever arm 40 of the foot member 18 to facilitate this pivoting movement.

With reference to Figures 5-6, in Figure 5 there is shown a close up view of the foot member 18, foot joint 17 and lower leg structural member 11 of the device, wherein it can be seen that a

secondary axis 17b is provided about which the foot member 18 can rotate as a result of operation of the secondary actuator 39.

With reference to Figures 7-8, it can be seen a primary axis of rotation is about axis 14a and a
5 secondary axis is defined by axis 14b, movement about which can be controlled by the secondary hip actuator 38.

To allow for the WA 100 to be fitted to a user to allow the user to operate the device in a safe manner, it is important to ensure that the spacing between hip joint 14, knee joint 12 and foot
10 joint 17 is appropriate. Appropriate positioning should be where such joints are, as close as possible, aligned with the corresponding natural joints of a user.

The exoskeleton 500, when worn by a user will sit relative a user 600 in a position defined by a combination of factors. The user is preferably held to the exoskeleton by the use of orthotics
15 (which shall be described in more detail hereinafter) that are engaged to the exoskeleton. Adjustment of the position of the hip joint, knee joint and foot joint is achieved by virtue of an adjustability in the effective length of the upper leg member 10 and the lower leg structural member 11. Such adjustment may be achieved by a turn buckle style adjustment means 20 that may be located at the second distal end of the lower leg structural member 11 and a turn buckle
20 21 at the first distal end of the upper leg member 10. The turn buckle 21 can allow for the distance between the hip joint 14 and knee joint 12 to be varied and the turn buckle 20 can allow for the distance between the knee joint and the foot joint 17 to be varied. In an alternate embodiment, the length adjustment may be accomplished by the insertion of lengthening inserts, which may be screwed into the upper and lower leg structural members 10, 11. It will be appreciated that
25 adjustment features can be provided elsewhere and may also come in different forms such as in

the form of a snap fit arrangement, bayonet type arrangement, telescopic or other means of setting the distance between the joints. This adjustment can allow for the one device to be used by different users that may be of differing body shape or size.

5 With reference to Figure 12, there is shown a view of the knee joint 12 from the side. As may be seen, in a preferred embodiment, the upper leg member 10 in its elongated direction is offset from the pivot axis 12a of the knee joint 12. The lower leg structural member 11 does project through the axis 12a. This correctly aligns the knee pivot joint with the user's knee joints and prevents knee damage to the user 600. The axis 12a is in a location behind (in a forward direction of travel
10 of the user) the location at where the upper leg member 10 projects. This offset of the WA knee joint replicates and aligns to the form of the human skeleton, therefore avoiding any stress or damage to the users knee joint.

Whilst in Figure 2, only part of the exoskeleton is shown, with reference to Figure 3, the full
15 exoskeleton is shown wherein two leg structures 50a and 50b are shown. The leg structures 50 are held together by the hip frame 15. The hip frame 15 holds part of the hip joints 14 thereby setting a fixed spacing of the hip joints 14 relative each other. The hip frame 15 is preferably a rigid member that can sit about part of the waist of a user. Preferably the hip frame 15 extends substantially about the posterior of the hip region of a user 600. The hip frame 15 may also
20 extend about part of the waist of the user.

The user is supported at the hip frame by a pelvic harness 96 which may include adjustable straps or webbing which extend about the legs of a user and are fastened and released as appropriate by the user. Such webbing may be adjustable in length. It may include the likes of a hook and loop
25 fastening system such as Velcro® for facilitating easy entry and exit from the WA by the user.

With reference to Figure 4 it can be seen that the harness can include webbing 23. A user 600 can be strapped to the hip frame 15 by webbing 23 around their waist to ensure that the user remains firmly held to the hip frame 15. Further, a packing arrangement 101 composed of a material such as wedge shaped foam or foamed plastic may be used to ensure a snug fit by the user in the hip frame 15. It is also envisaged that the packing arrangement 101 could be an inflatable thin walled pressure vessel (not shown)

Further support to the user is provided by orthotics as an alternative or in addition to the adjustable fasteners 46 described above. The orthotics are orthotic designed braces that help ensure the user 600 is not only supported but is also correctly aligned within the exoskeleton so as not to damage the user's 600 limbs or joints. They may include webbing or straps to hold the user in position relative the formed portion of the orthotics. The webbing 23 may also facilitate an easy and adjustable fitting and release of the user from the WA 100.

The orthotic braces are preferably engaged and/or capable of being releasably engaged to the exoskeleton. With reference to Figure 3, the orthotics may include an upper leg orthotic 26 and a lower leg orthotic 27. These may be directly joined to each or indirectly joined to each other by the exoskeleton. For example with reference to Figure 3, the upper leg orthotic 26 and lower leg orthotic 27 may be joined at the joints 28. The orthotics are engageable to the exoskeleton 500 via connectors 29.

The connectors 29 rigidly hold the orthotics to the exoskeleton. The connectors 29 may facilitate a releasable engagement of the orthotics to the exoskeleton 500. This can be beneficial to a user 600 who normally wears orthotics. This allows for such a person to more rapidly associate themselves with the exoskeleton 500. It also allows for such a person to associate with the

exoskeleton 500 in a more comfortable manner because the orthotics 4 are already engaged to the person in an appropriate location. So, the user 600 may use the adjustable fasteners 46 supplied with the WA 100 or may use their own braces by the use of a supplied interface that the user's orthotic specialist can fit onto the users braces. It is necessary for users to be able to interface
5 with the WA 100 bearing in mind that many users 600 have specific orthotic requirements and can not wear generic braces.

Being able to release the orthotic brace from the WA 100 and wear the brace as a normal use brace allows users to transfer out of and into the device quickly without having to change braces.
10

The connectors 29 are of a shape and configuration so that a correct alignment of the upper and lower leg of the person is achieved once engaged to the exoskeleton. The connectors 29 may be of a dove tail configuration or snap lock configuration or other to facilitate a rapid engagement and disengagement of the orthotics with the exoskeleton.

15

The user 100 may engage with the exoskeleton, wearing their own shoes that can be placed on platforms 30 of each foot member 18. Alternatively the exoskeleton includes footwear such as a shoe 31 into which the user 600 can place their feet 630. The footwear 31 may remain permanently engaged with the exoskeleton 500 and a user can place their feet in the footwear.

20 The shoes 31 preferably have a rigid frame on the outside edge with a precision keyway. The negative of said keyway is on the WA 100. These two parts slide one into the other causing an automatic locking pin to engage when correctly positioned. The rear portion of the fixing contains all of the electrical connections for the sensors contained within the shoe. Correct alignment of the shoe ensures a complete connection. The automatic pin can be released manually or
25 electronically. The linear actuators used are preferably low voltage DC actuators with position

feedback through a sensor in the actuator. The low voltage aspect of the actuator is important in that it is safe for use and will do no harm to the user in the case of a fault. Typically, an actuator would be caused to move by an electric motor (not shown) driving a worm gear (not shown), which in turn causes the actuator to extend or retract.

5

With reference to Figure 16 there is shown an additional aspect of the WA of the present invention making the device suitable for users with lack of upper body strength and or function.

There may be provided one or more torso harnesses or upper body braces 92 that is attached to the hip frame 15. The upper body brace 92 can be provided for users 600 that have limited upper body control. This upper body brace 92 may include a frame or corset that is actuated to move the user's upper body 640 to help with their balance. In one embodiment (not shown), the torso harness 92 can be connected to the pelvic harness 96. Some or all of the components of the exoskeleton 500 may be fully or partially covered by covers 98 (as shown in fig 14, 23, 25 and 38). These covers 98 are provided for safety, waterproofing, dustproofing and aesthetic purposes and said covers 98 will be of sufficient strength and stability to allow the user 600 to transfer into and out of the WA by using the covers for support. In one embodiment, handles may be built into the covers 98, to facilitate transfer of the user 600 to and from the exoskeleton 500.

In one embodiment, the exoskeleton 500 is configurable to a seated position (as shown in figures 39 and 40). For example, when the exoskeleton 500 is in a seated position, the surfaces 99 of the covers (eg shown in figure 23, but not in the seated position) will extend substantially horizontally. The WA 100, located on a seat will then give the user a rigid surface to rely on for the purposes of their transfer into and out of the device. As such the covers 98 are preferably engaged to the exoskeleton in a rigid manner and in a manner that ensures they are stable relative

thereto. The covers 98 may also (or instead) include functional shape features that can offer hand holds to the user for similar purposes.

With the use of orthotic support, a user is very limited or prevented from movement relative to the exoskeleton structure. A person is unable to rotate their leg relative to the exoskeleton structure and prevent it from longitudinally or laterally moving their leg relative to the exoskeleton structure.

The WA 100 may include a number of inertia measurement units 55 shown in figure 11. Preferably, each of these inertia measurement units 55 consist of an accelerometer, a gyroscope and an inclinometer. These inertia measurement units 55 measure and provide feedback on the attitude and rate of change of attitude and momentum of the WA 100 in operation and provide input variables to the controller.

It is envisaged that in one embodiment, the WA 100 can include distance sensors such as ultrasonic, laser or infrared sensors 56. These sensors can measure the distance between a set-point on the device to the surface of the ground. There may also be six ultrasonic sensors (not shown) to achieve this, one to the left, one to the right, one to the left side, one to the right side one at the back and one at the front of the device.

20

The WA 100 can also include two position sensors 58, 59 (ultrasonic, infrared or laser) at the front and two 60, 61 at the back of the device for detecting objects which could act as an obstacle to movement of the WA 100. The WA further includes a distance sensor on each leg measuring distance downwardly in front of each leg to potentially measure the distance from the lowest level of each foot to the ground or top of a step.

25

In one embodiment, the foot member 18 () can include contact/pressure sensors 67, 68, 69 (shown in figure 11) that can detect contact of the foot member 18 with a surface and/or the degree of pressure being applied by part of the foot member 18 to the surface, or even the pressure variation applied to the ground across the bottom of the foot member 18. It is envisaged that in a preferred embodiment, the sensors on the foot member 18 are sealed by a waterproof cover (not shown).

It is envisaged that any of these sensors are configurable for providing information to the control system for facilitating the control of movement of the exoskeleton 500. They will typically do this by sensing a particular characteristic to be sensed and generating a signal indicative of that characteristic, and transmitting the signal to the control system for facilitating the control of movement of the exoskeleton 500.

The device may also include seat sensors (not shown) for detecting forces applied by a user to the WA. It is envisaged that these could be in the form of a strain gauge (not shown) or the like. Two of these may exist at the rear of the WA 100, one in each “thigh” region.

The WA can further include pressure sensors 65 and 66 in the front and rear of the foot. These can detect any obstacles in front of the foot members 18.

It is envisaged that the WA control system (not shown) is configured to receive user input via a human interface device 1601 through which a human interface with the control system and may input information and receive information through sensory signals such as sound, light or vibration. Some examples of such a human interface device are a control pad (not shown), a keypad 3, a joystick 2, a touch screen or the like.

The control system includes a human interface device 1601. As described, various sensors, including sensors in the actuators are configurable to provide feedback signals which can be used by the control system for facilitating the control of the actuators.

5

In the preferred embodiment a control pad 4 will be used for human-machine interfacing. The control pad will be pivotable on a swing arm 5. It is envisaged that in one preferred embodiment, the control pad 7 contains a membrane keypad (3), light emitting diode (LED) lights (not shown), a joystick 2 and a battery meter (not shown). Other suitable human machine interfacing controls
10 may be used. For example a touch screen (not shown) may replace the control pad.

The keypad 3 of the preferred embodiment may further include an audible buzzer to indicate warnings and the selection of inputs and/or functions of the control system.

15 It is envisaged that the LEDs can be used for a wide variety of functions, including fault indication, to indicate charging of the power supply, or to indicate that the emergency power supply (not shown) is being used.

The LED's can also be used as a battery meter to provide an indication of the available power in
20 the main battery pack, ranging from all LEDs lit up meaning the battery is fully charged to no LEDs lit up meaning the battery needs charging.

The joystick 2 will be used as a user input means to input control instructions to the control system.

25

The WA is powered by on-board battery packs (not shown). In the preferred embodiment the battery packs are located at the 'kidneys' in the hip frame and at the front of the 'shins' in the leg covers 98. The battery system is a low voltage DC system and the battery packs are rechargeable from domestic power supply or vehicle power supplies. At least the actuators require power from
5 the battery packs in order to allow them to actuate.

The battery packs are removable for quick replacement with another battery pack of similar capacity or extended capacity.

10 The battery packs can be charged on-board the WA or externally in the specifically designed charger.

Typically only a section of the battery packs will be used and in the event of these being depleted an audible alarm will sound as well as a visual battery charge indicator on the control panel will
15 alert the user of the low battery power situation, the WA will then be able to automatically switch the power over to the reserve battery portion. Alternately, and in another preferred embodiment, the control panel will merely alert the user of a low power situation, and no reserve battery packs will be provided to conserve weight. It is envisaged that the WA 100 will assist in restoring basic mobility to a disabled user.

20

The WA is self contained with on board power and control systems and can be recharged using an in car charger or domestic power supply.

CLAIMS:

1. A self-contained powered exoskeleton walker for a disabled user that at least substitutes fully disabled functions of a user required for walking, said walker comprising:

an exoskeleton comprising:

a rigid pelvic support member including a user securing arrangement for securely fastening the user to at least the pelvic support member to fully support said user operationally at or towards a pelvic region of the user, so that the user's legs do not support the weight of the user,

a first leg structure and a second leg structure, each of the first leg structure and the second leg structure being coupled to and extending from said pelvic support member for operational location adjacent a respective leg of the user, each of the first leg structure and second leg structure comprising

an upper leg structural member for engagement with the upper leg of the user, the upper leg structural member being pivotally engaged at a first end thereof to the pelvic support member by a passive hip joint, wherein the hip joint is configured to be driven and for facilitating multi axis rotational movement of said upper leg structural member relative to said pelvic support member

towards and away from a coronal plane of the user's body, and
toward and away from a sagittal plane of the user's body for
adduction and abduction,

a lower leg structural member for engagement with the lower leg of the user, the lower leg structural member being pivotally engaged at a first end thereof to a second end of the upper leg structural member by a knee joint providing an axis of rotation,

a foot member for engagement with a foot of the user, the foot member being pivotally engaged to a second end of the lower leg member by a foot joint,
a linear main hip actuator configured for actuating pivotal movement and for controlling the position of said upper leg structural member relative to said pelvic support member about said hip joint, and to pivot the upper leg structural member towards and away from the coronal plane of the body of the user, the main hip actuator connected at

- i) a proximal end to the pelvic support member at an offset distance below and posterior to a pivotal axis of the hip joint
and

- ii) a distal end to the upper leg structural member at an offset distance above the knee joint,
 a linear secondary hip actuator, configured for actuating pivotal movement and control the position of said upper leg structural member relative the pelvic support member about said hip joint towards and away from the sagittal plane of the body of the user for adduction and abduction, the secondary hip actuator connected at
 - i) a proximal end to the pelvic support member at an offset distance collinear to the pivotal axis of the hip joint and
 - ii) a distal end to the upper leg structural member at an offset distance posterior of the knee joint, a knee actuator configured for actuating pivotal movement and control the position of said lower leg structural member relative said upper leg structural member about said knee joint,
 a main foot actuator configured for actuating pivotal movement and controlling the position of said foot member relative said lower leg structural member

a power source configurable for providing power to at least one or more actuators selected from said main hip actuators, knee actuators, and main foot actuators,
 a control system configurable for controlling movement of at least one or more actuators selected from said main and secondary hip actuators, knee actuators, and main foot actuators, thereby to move the exoskeleton relative to ground on which the walker is positioned, for at least the purposes of effecting a walking motion to said user,
 wherein the control system is configured to receive user input via a human interface device to input control instructions to the control system, and wherein the human interface device is one of a control pad, a keypad, a joystick, or a touch screen; and
 wherein said control system includes a gyroscope configured for defining a reference frame for purposes of positional control of the exoskeleton or part of the exoskeleton.

2. The walker as claimed in claim 1 wherein said secondary hip actuator is configured for actuating said pivotal movement of said upper leg structural member to either side of a plane parallel to the sagittal plane and passing through said hip joint.

3. The walker as claimed in claim 1 wherein said hip joint is one selected from a rose joint, universal joint or ball and socket joint, configured for facilitating a multi axis rotational capability of said upper leg structural member relative to said pelvic support member.

4. The walker as claimed in claim 1 wherein pivotal movement of the upper leg structural member by the main hip actuator is about an axis of rotation extending laterally from said sagittal plane and downwardly at an angle of between 1 and 6 degrees to the transverse plane.
5. The walker as claimed in claim 1, wherein the knee joint is offset rearwardly from the upper leg structural member to align substantially with an axis of rotation of the user's knee in operation.
6. The walker as claimed in claim 1 wherein the knee joint is a polycentric knee joint.
7. The walker as claimed in claim 1 wherein said foot joint is a rose joint, a universal joint or ball and socket joint, configured for facilitating multi axis rotational capability of said foot member relative said lower leg structural member.
8. The walker as claimed in claim 1, wherein said exoskeleton comprises, for each of the first leg structure and second leg structure, a secondary foot actuator, configured for actuating rotation of said foot member about an axis of rotation extending parallel to said sagittal plane.
9. The walker as claimed in claim 1, wherein each foot joint is configured for pivotal movement of the foot member by the main foot actuator with the axis of the foot joint extending laterally of the sagittal plane and downwardly at an angle of between zero and 6 degrees to the transverse plane.
10. The walker as claimed in claim 8, wherein the foot joint is configured for pivotal movement of the foot member by the secondary foot actuator in a range of about six degrees to either side of a vertical plane.
11. The walker as claimed in claim 1 wherein a plurality of sensors are provided for providing information to the control system for facilitating control of movement of the exoskeleton.
12. The walker as claimed in claim 11 wherein the plurality of sensors are configured for sensing a characteristic to be sensed, and generating a signal indicative of that characteristic, and transmitting the signal to the control system for facilitating the control of movement of the exoskeleton.
13. The walker as claimed in claim 11 wherein said sensors are selected from at least one of:
 - an accelerometer to measure an acceleration of at least one or more selected from said pelvic support member, the upper leg structural members, the lower leg structural members and the foot members,

an inclinometer to measure an inclination of at least one or more selected from said pelvic support member, the upper leg structural members, the lower leg structural members and the foot members,
 distance sensors configured for determining a slope of the ground anteriorly, posteriorly and laterally of the walker,
 pressure sensors disposed on the foot member to determine pressure being applied by the foot member to the ground, and
 position sensors for determining position and velocity of the actuators.

14. An exoskeleton device worn by a paraplegic user for device controlled walking of the user, said exoskeleton device comprising:

a rigid pelvic support member including a user securing arrangement for engaging with the user at or towards the pelvis of the user to support said user operationally, so that the user's legs do not support the weight of the user,
 a first leg structure and a second leg structure, each of the first leg structure and the second leg structure being coupled to and extending from said pelvic support member for operational location adjacent a respective leg of a user, each of the first leg structure and second leg structure comprising

an upper leg structural member for engagement with the upper leg of the user, the upper leg structural member being pivotally engaged at a first end thereof to the pelvic support member by a hip joint, wherein the hip joint is configured for facilitating multi axis rotational movement of said upper leg structural member relative to said pelvic support member towards and away from the user's coronal plane in operation;
 a lower leg structural member for engagement with the lower leg of the user, the lower leg structural member being pivotally engaged at a first end thereof to a second end of the upper leg structural member by a knee joint,
 a foot member for engagement with the foot of a user, the foot member being pivotally engaged to a second end of the lower leg member by a passive foot joint configured to be driven and for facilitating multi axis rotational movement of said foot member relative to said lower leg member
 towards and away from a transverse plane of the user's body for dorsiflexion and plantar flexion of the foot member, and
 towards and away from a sagittal plane of the user's body for inversion and eversion of the foot member,
 a main hip actuator configured for actuating pivotal movement and control the position of said upper leg structural member relative to said pelvic

support member about said hip joint, and to pivot the upper leg structural member towards and away from the coronal plane of the body of the user, a knee actuator configured for actuating pivotal movement and control the position of said lower leg structural member relative said upper leg structural member about said knee joint,

a linear main foot actuator configured for actuating pivotal movement and controlling the position of said foot member relative said lower leg structural member for dorsiflexion and plantar flexion about said foot joint, the main foot actuator connected at

i) a proximal end to the foot member at an offset distance below and posterior to the pivotal axis the foot joint and

ii) a distal end to the lower leg structural member at an offset distance below and posterior to the knee joint; and

a linear secondary foot actuator configured for actuating pivotal movement and control the position of said foot member relative said lower leg structural member for inversion and eversion of the foot member about said foot joint, the secondary foot actuator connected at

i) a proximal end to the foot member at an offset distance below and posterior to the pivotal axis of the foot joint and

ii) a distal end to the lower leg structural member at an offset distance below and posterior to the knee joint; and

a control system configurable for controlling movement of at least one or more actuators selected from said main hip actuator, knee actuator, and main and secondary foot actuators, thereby to move the exoskeleton relative to ground on which the exoskeleton is positioned, for at least the purposes of effecting a walking motion to said user,

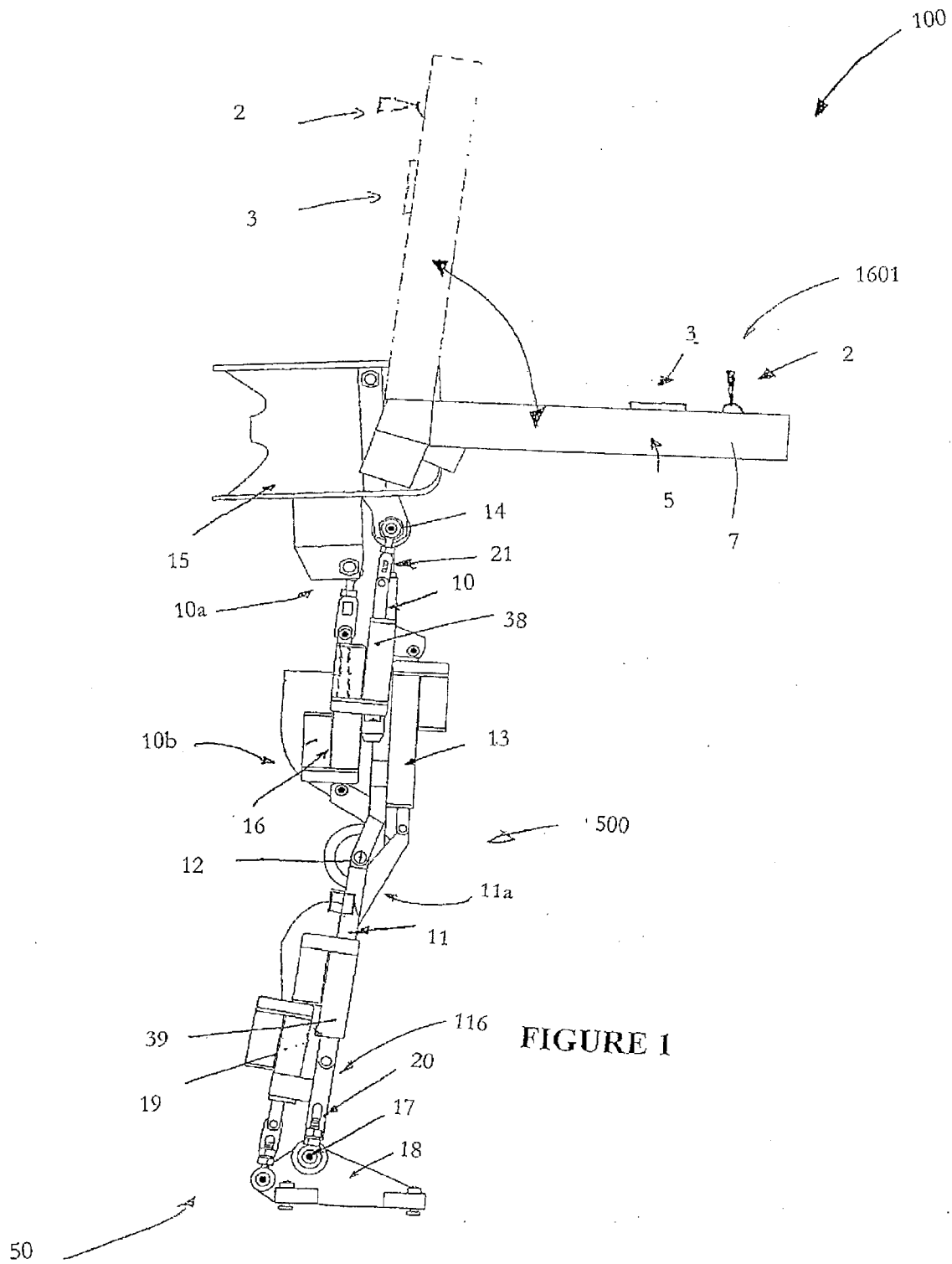
wherein the control system is configured to receive user input via a human interface device to input control instructions to the control system, and wherein the human interface device is one of a control pad, a keypad, a joystick, or a touch screen; and

wherein said control system includes a gyroscope configured for defining a reference frame for purposes of positional control of the exoskeleton or part of the exoskeleton.

15. The exoskeleton device as claimed in claim 14 wherein said exoskeleton comprises a power source configurable for providing power to at least one or more selected from said main hip actuators, knee actuators, and main foot actuators.

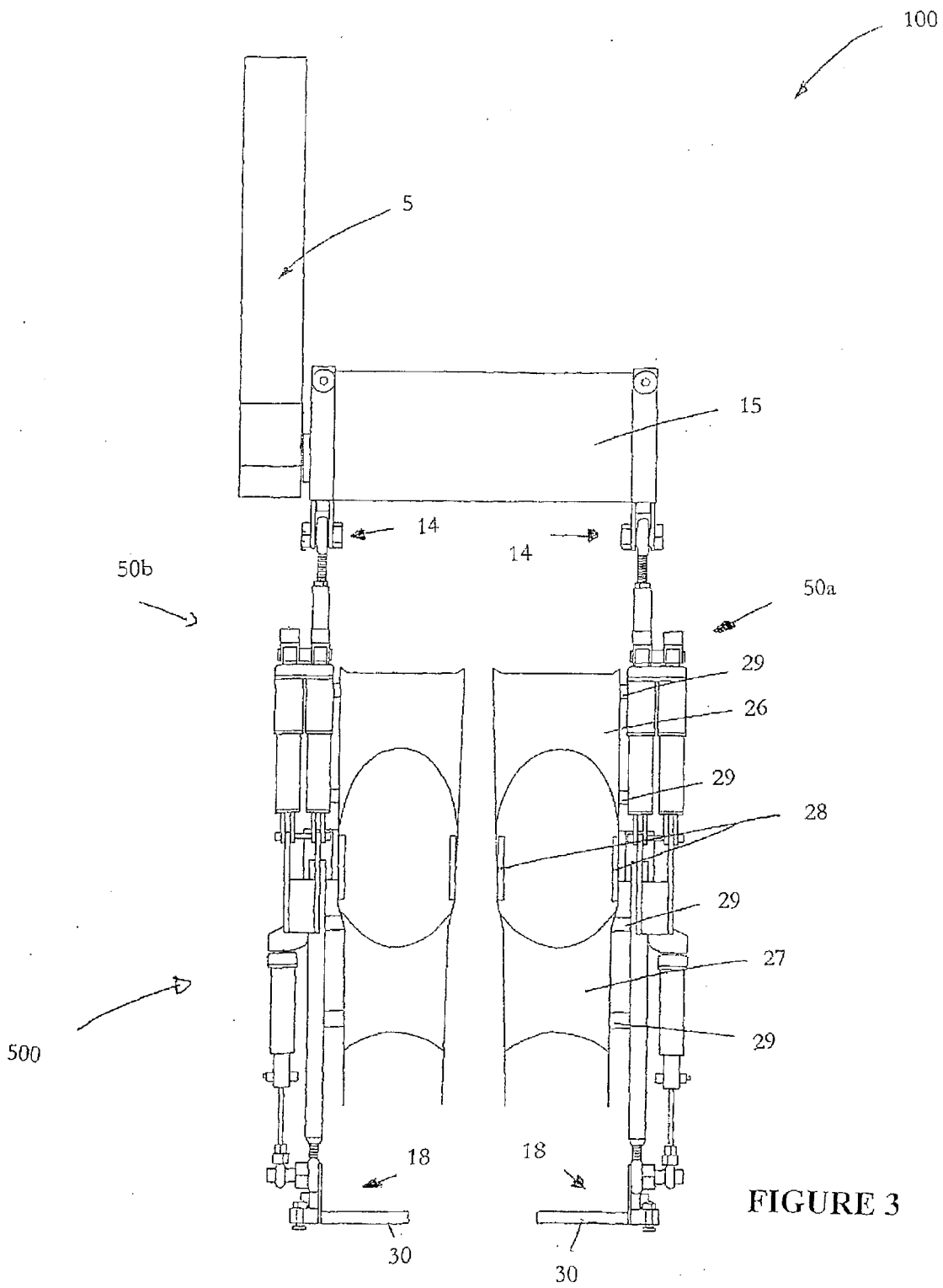
16. The exoskeleton device as claimed in claim 14 wherein the actuators are electric actuators.
17. The exoskeleton device as claimed in claim 14 wherein the foot joint is a rose joint.

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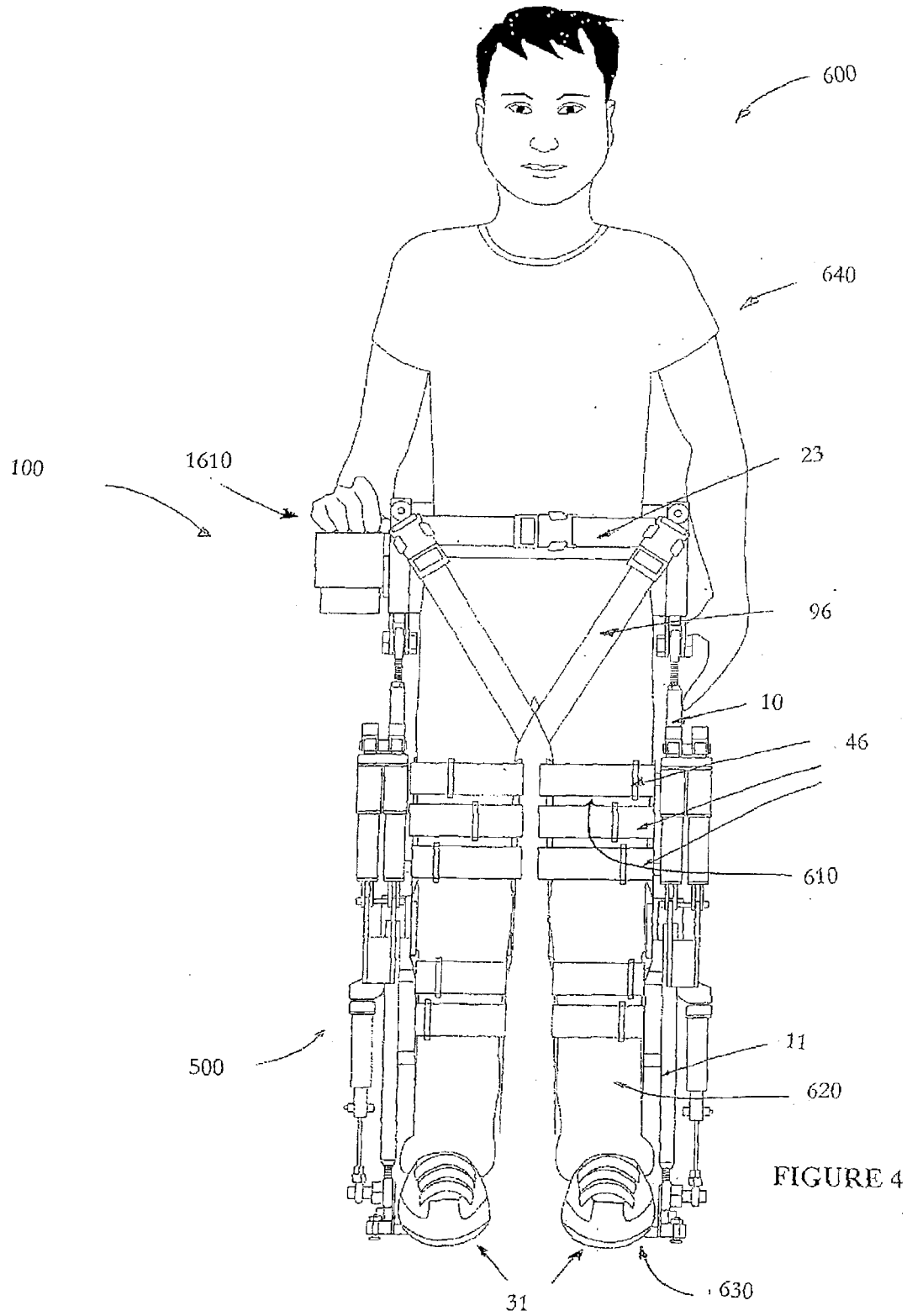


FIGURE 4

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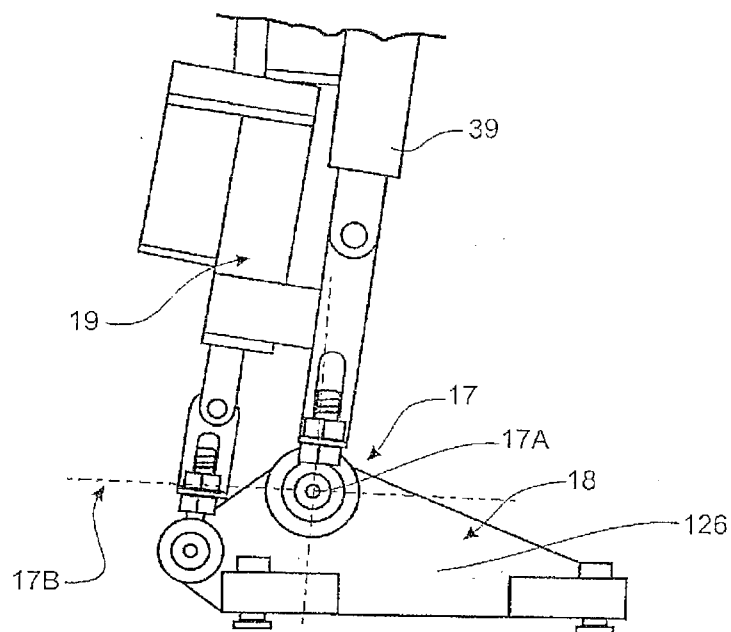


FIGURE 5

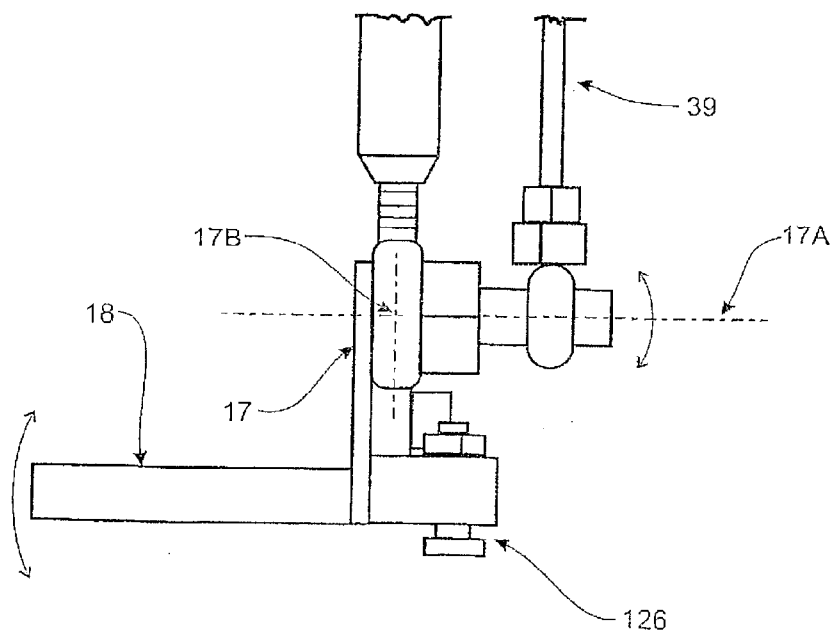


FIGURE 6

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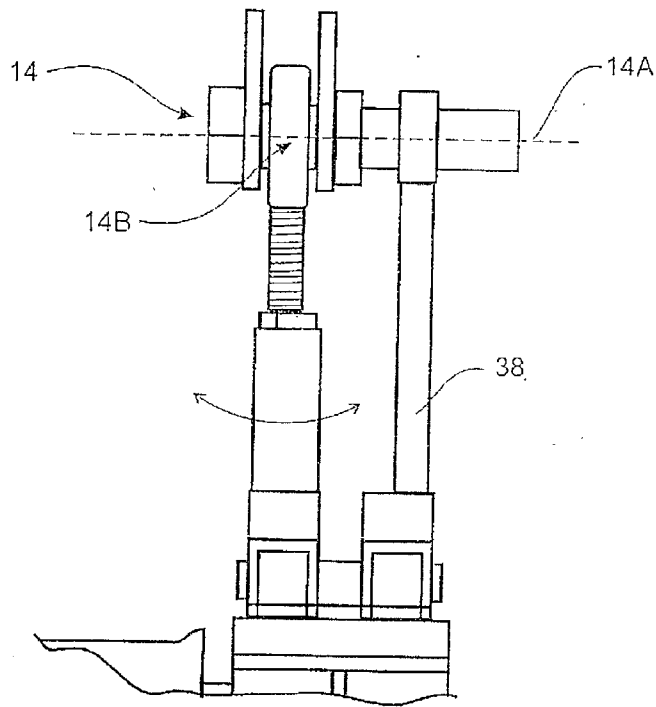


FIGURE 7

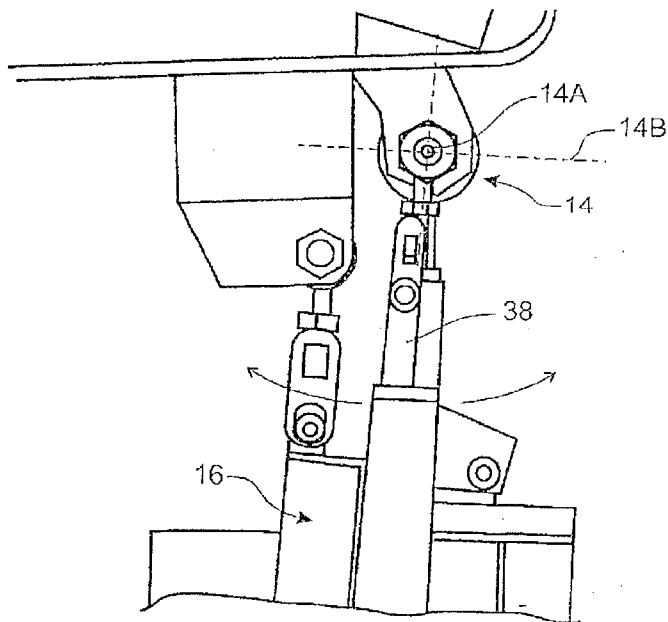


FIGURE 8

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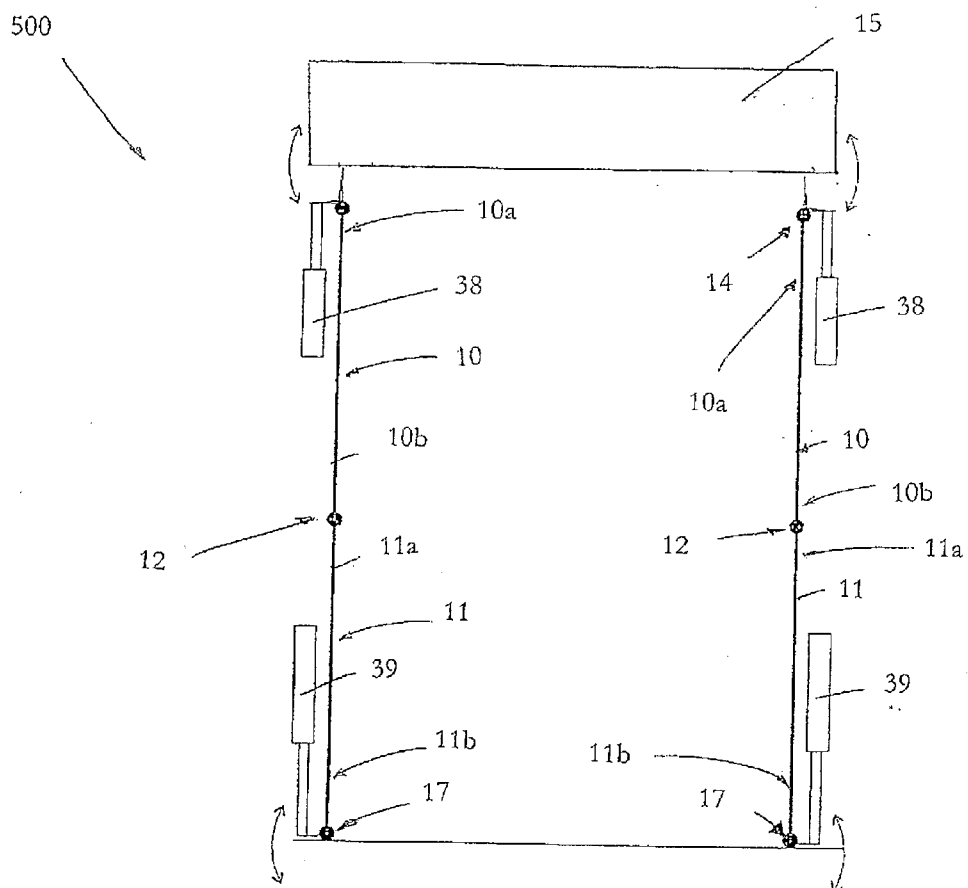


FIGURE 8a

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FIGURE 9

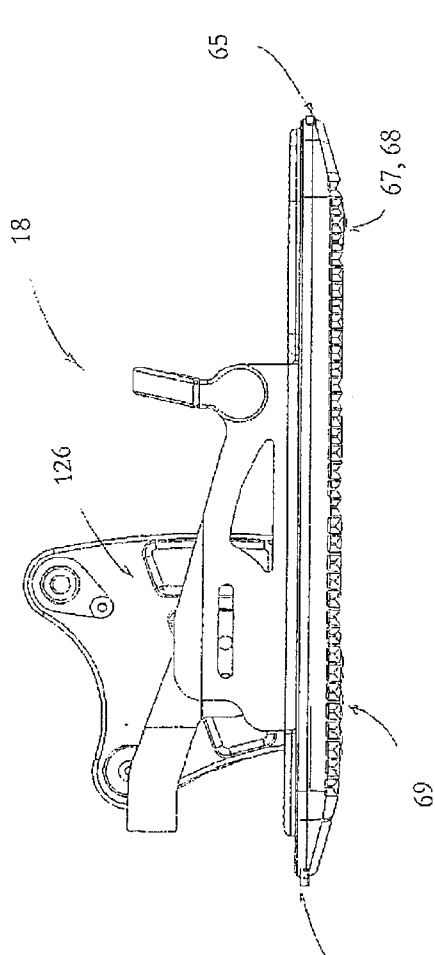


FIGURE 10a

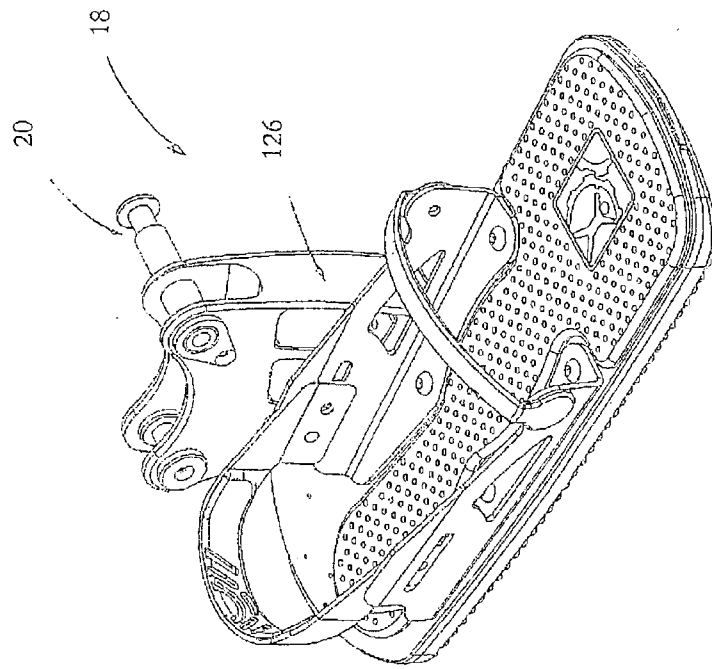
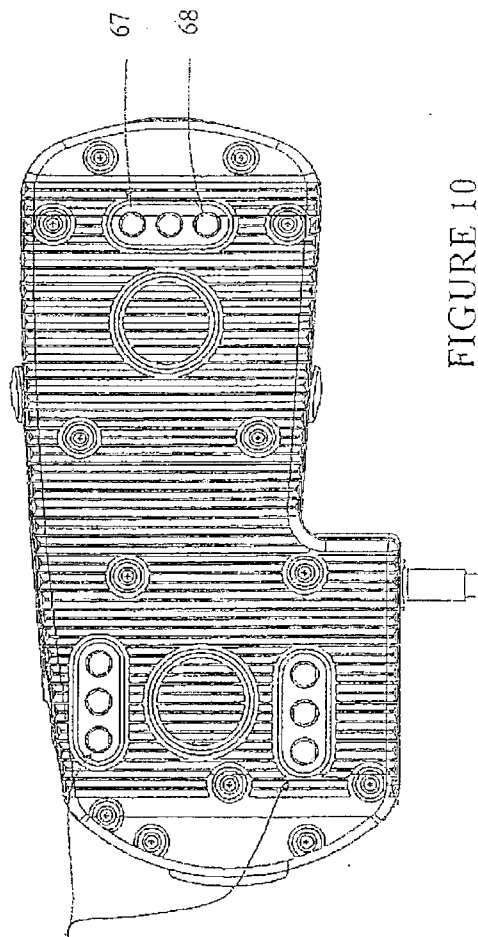


FIGURE 10



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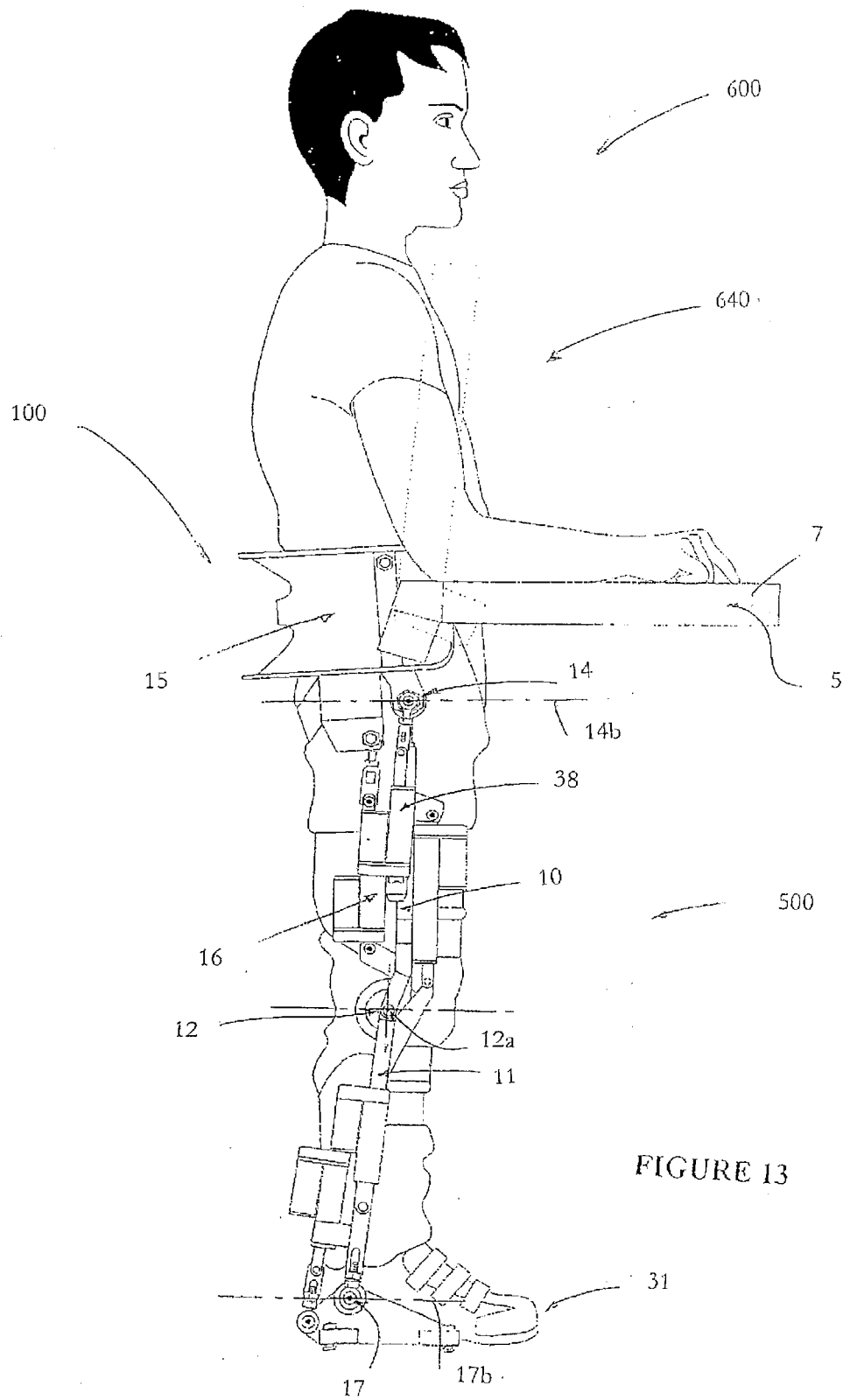


FIGURE 13

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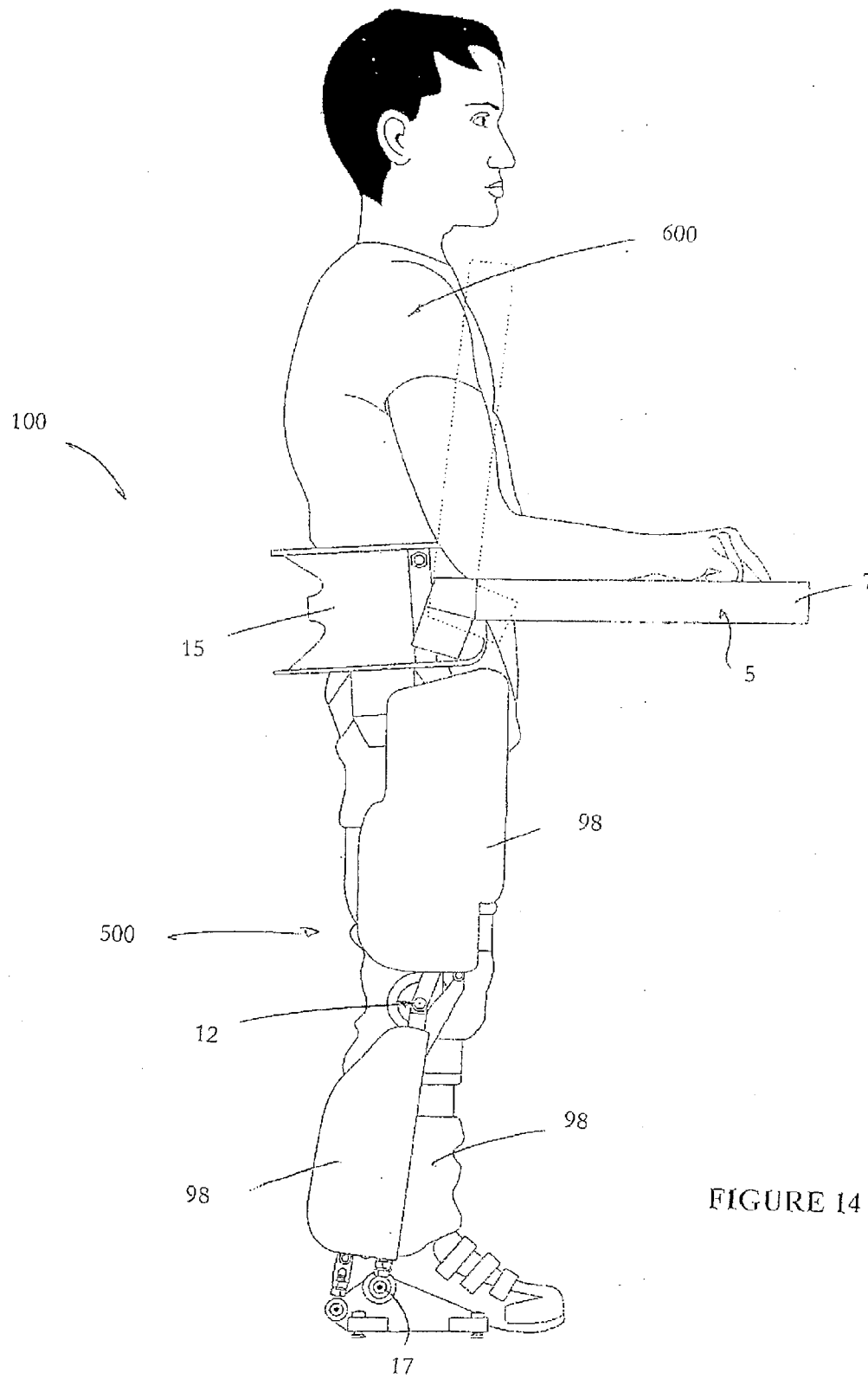


FIGURE 14

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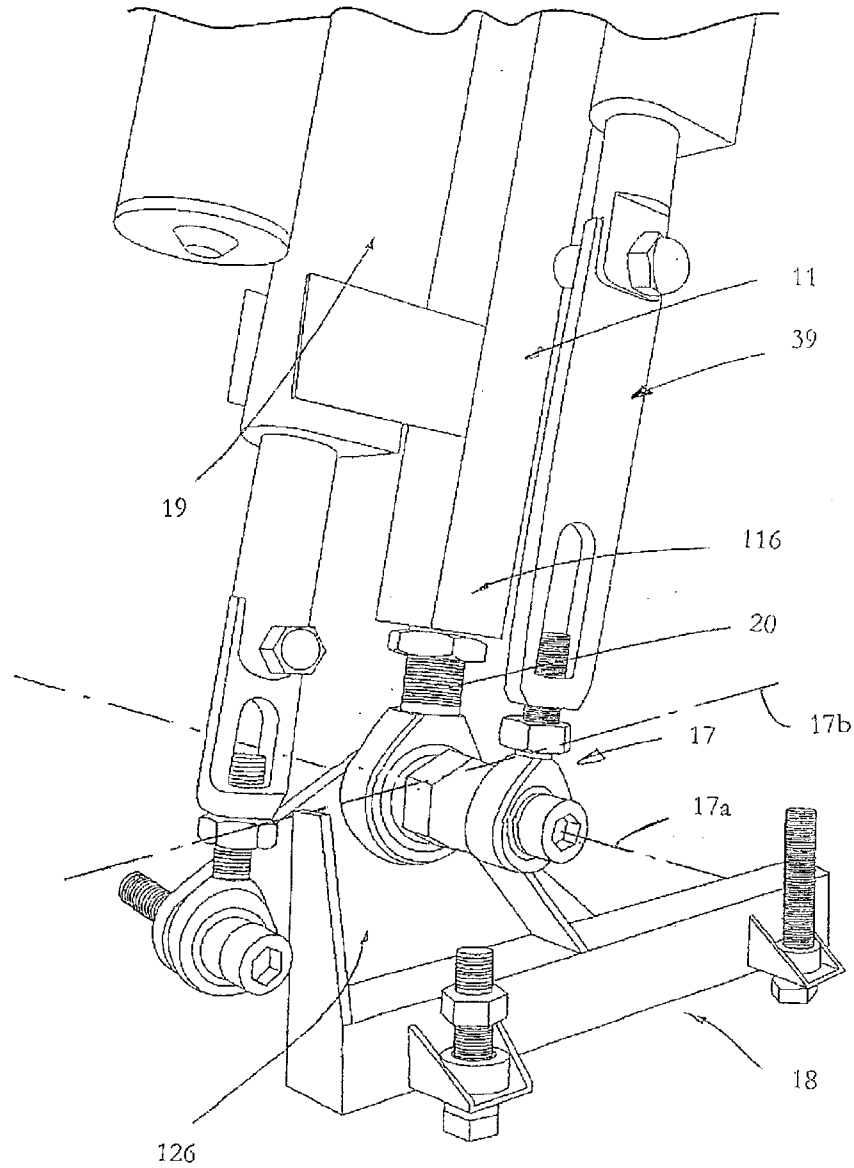


FIGURE 15

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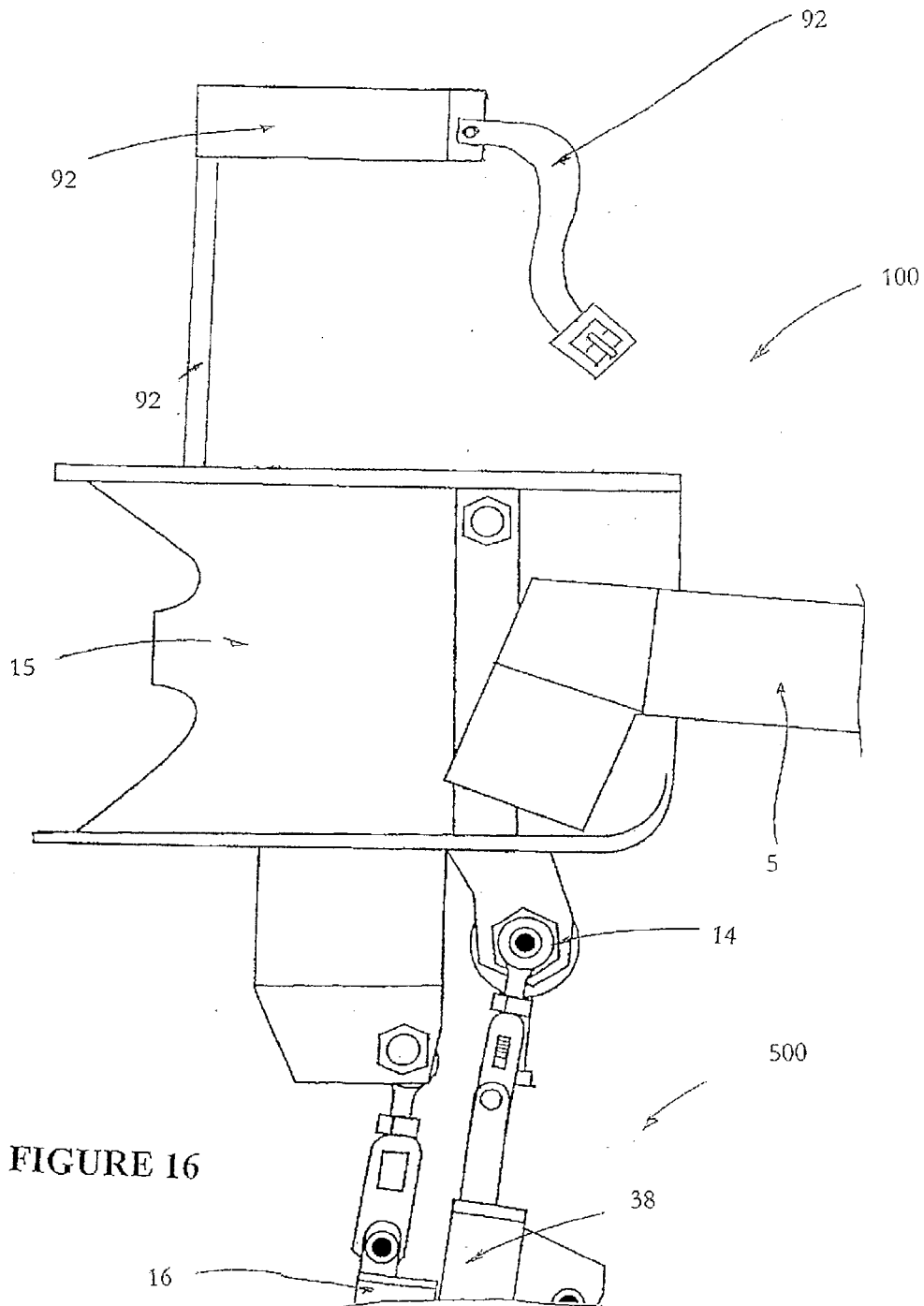
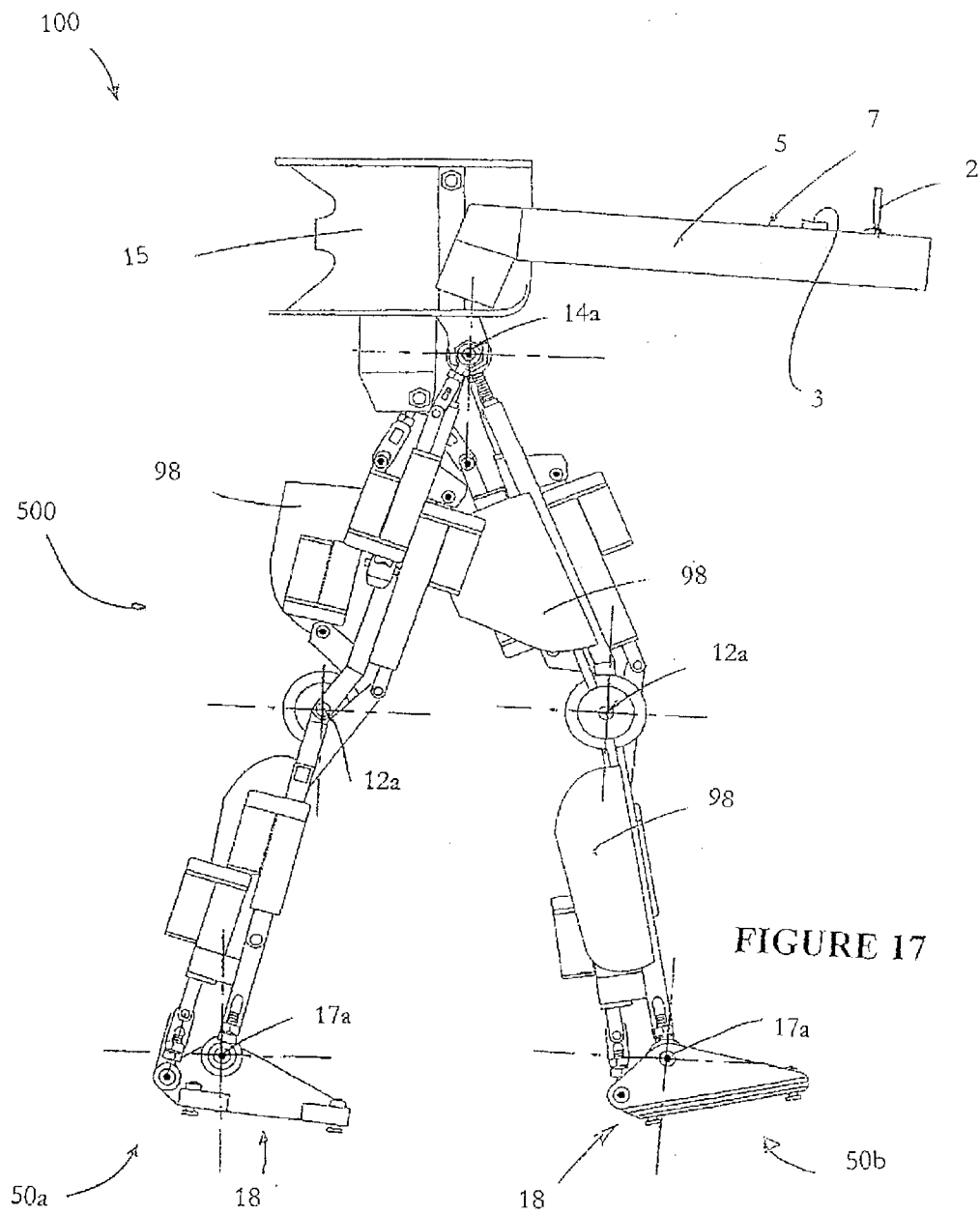


FIGURE 16

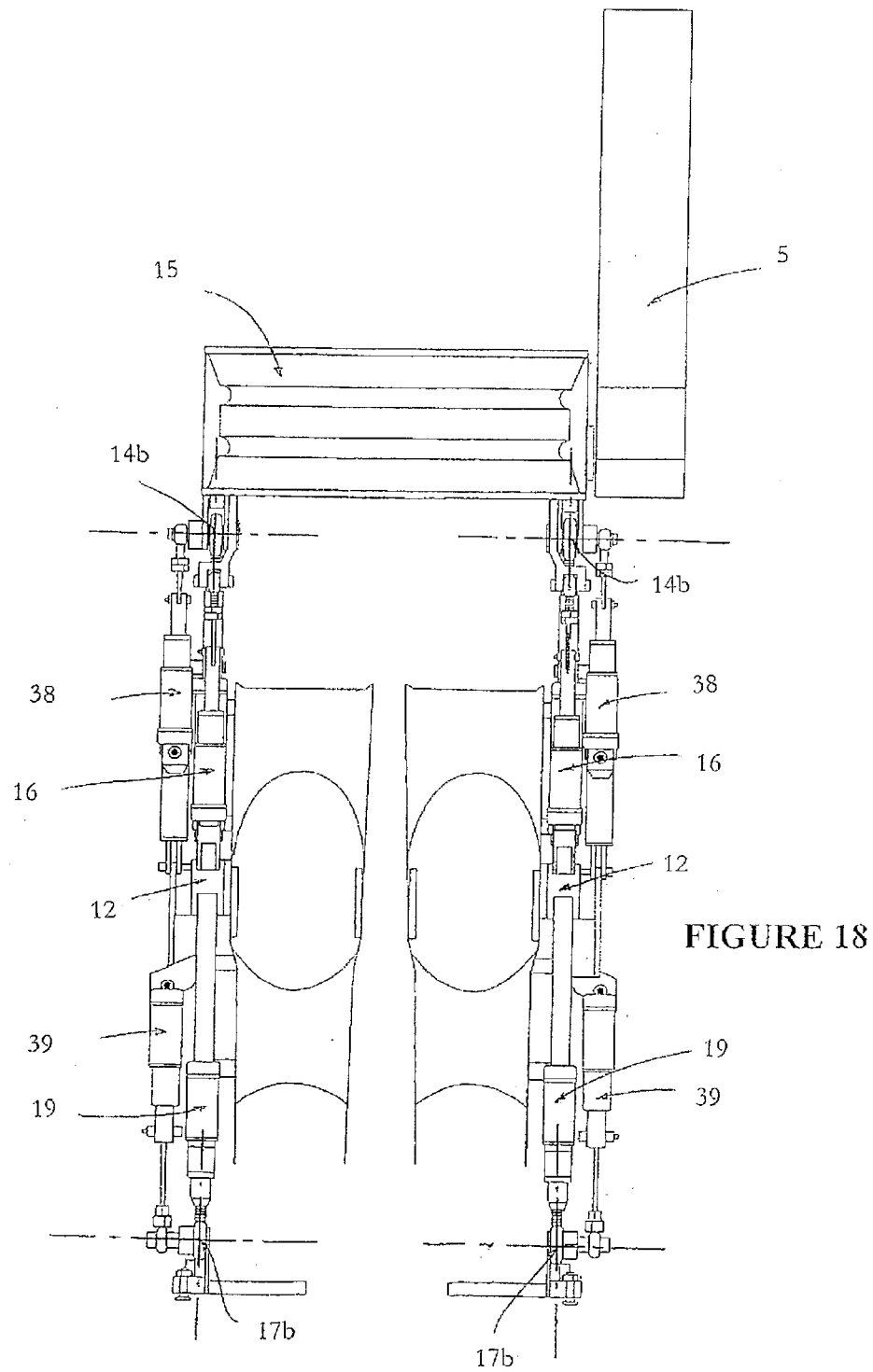
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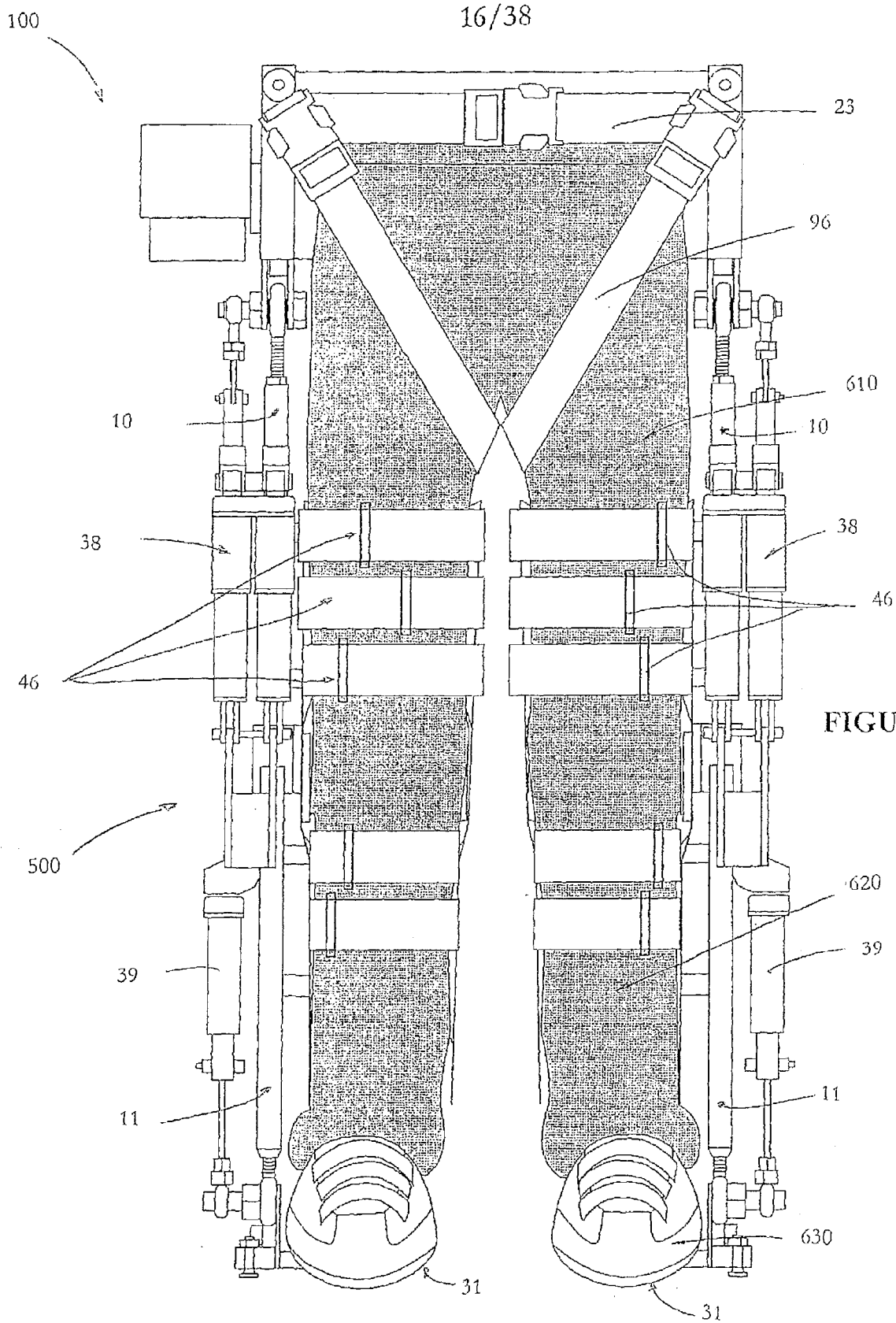


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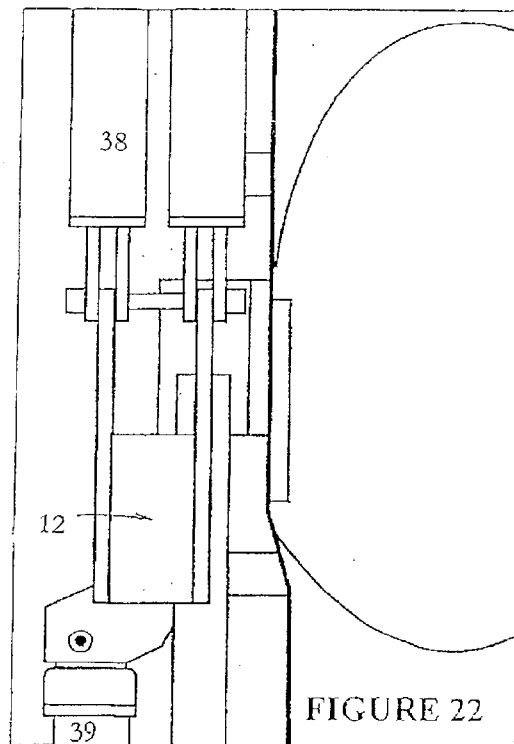
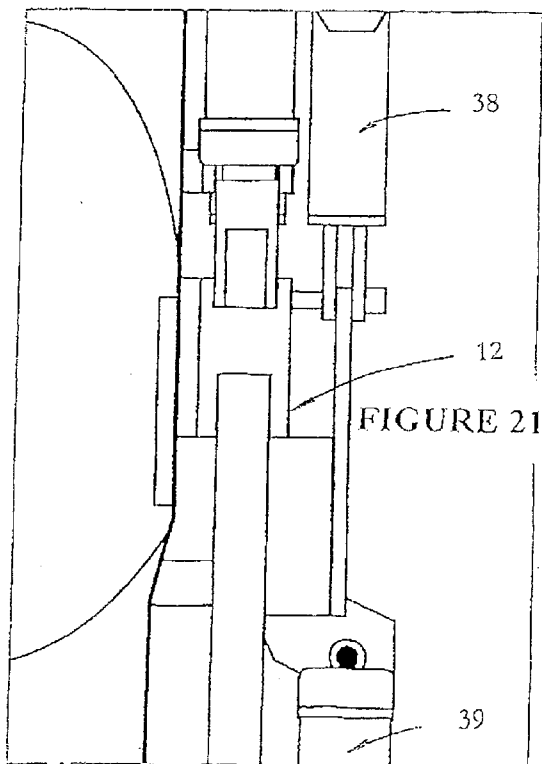
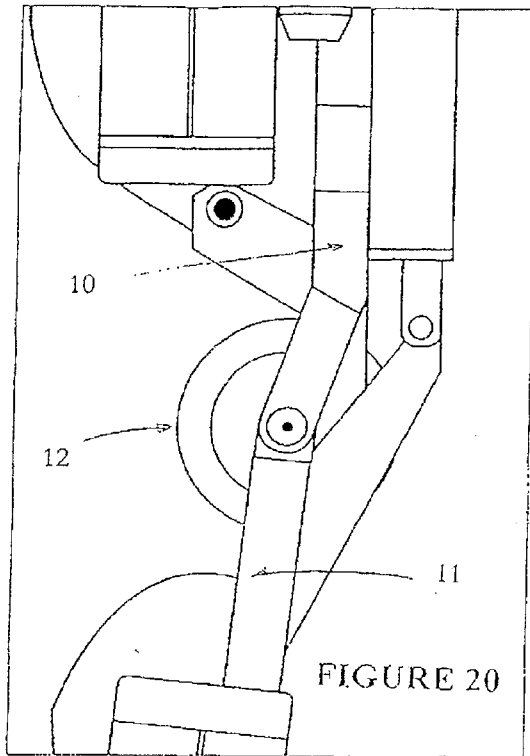


SUBSTITUTE SHEET (RULE 26)

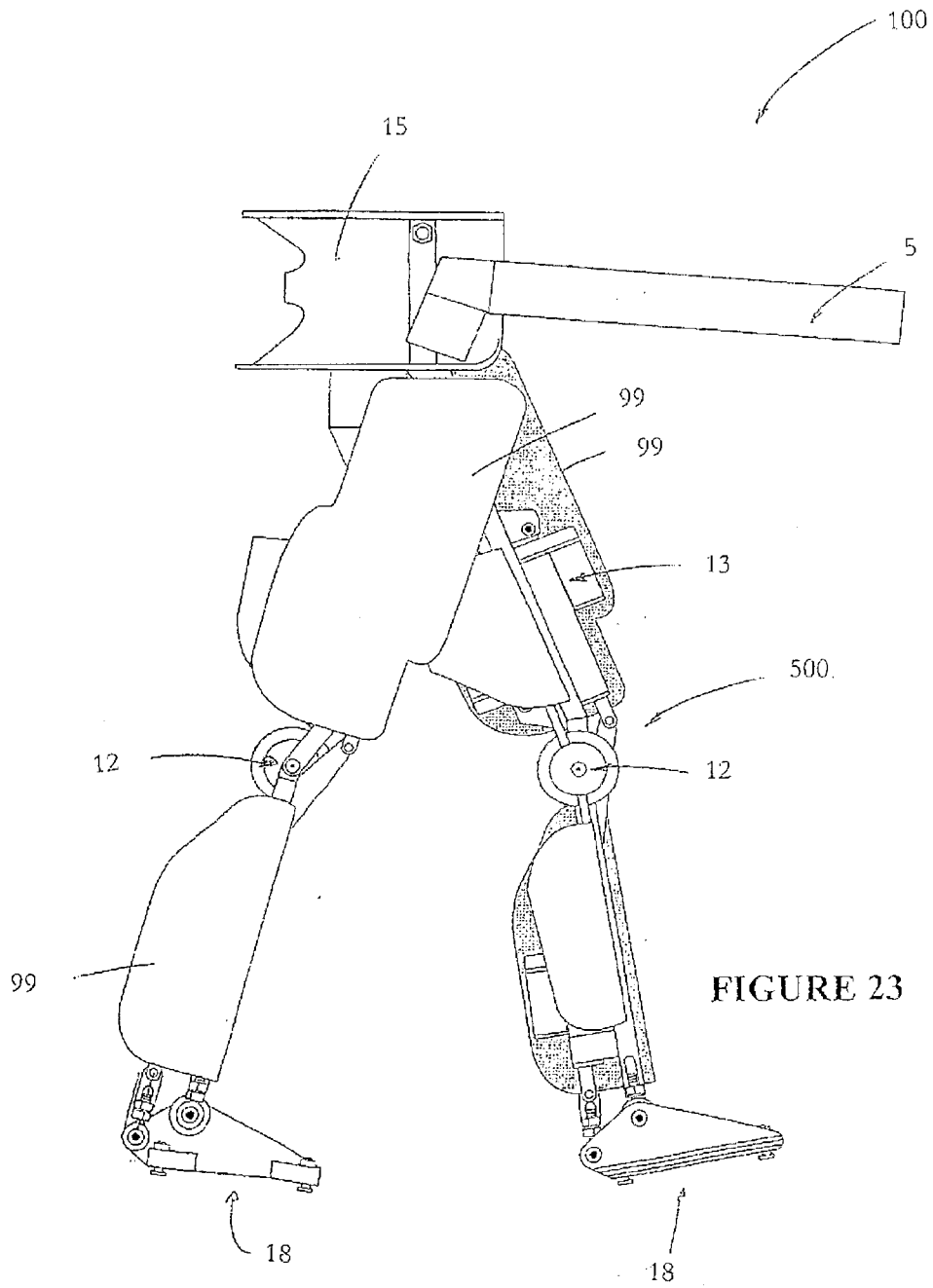


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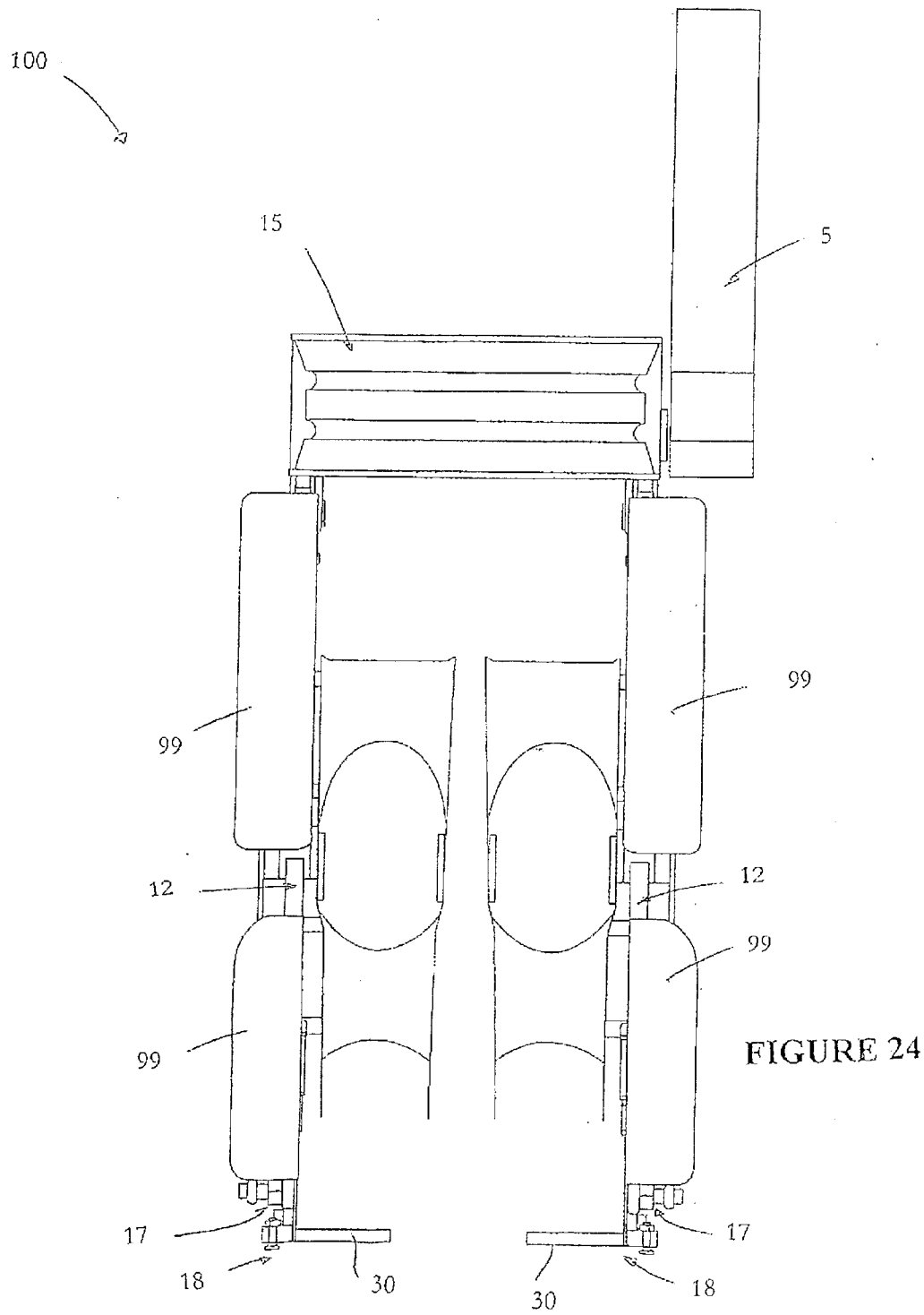


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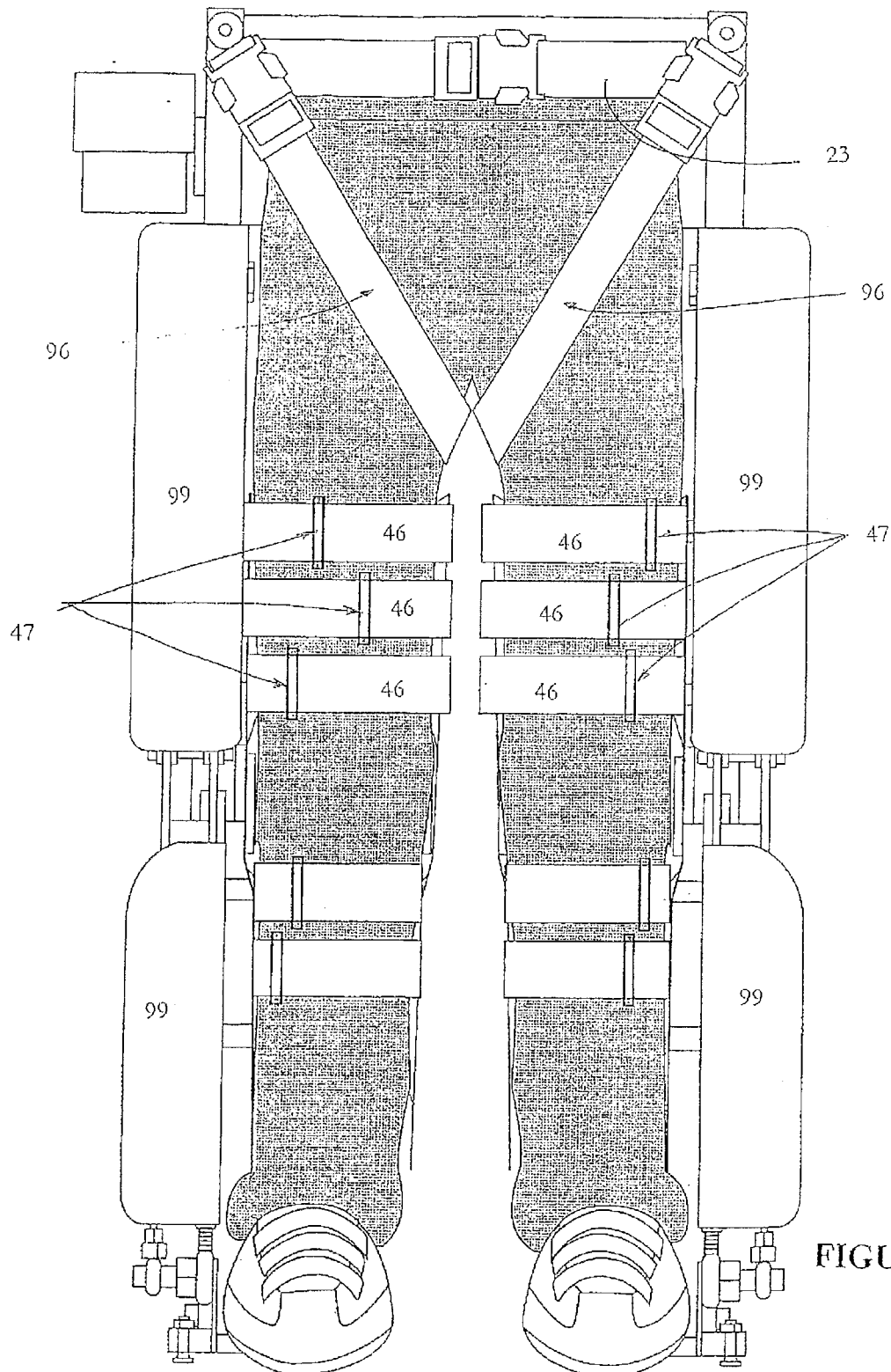


FIGURE 25

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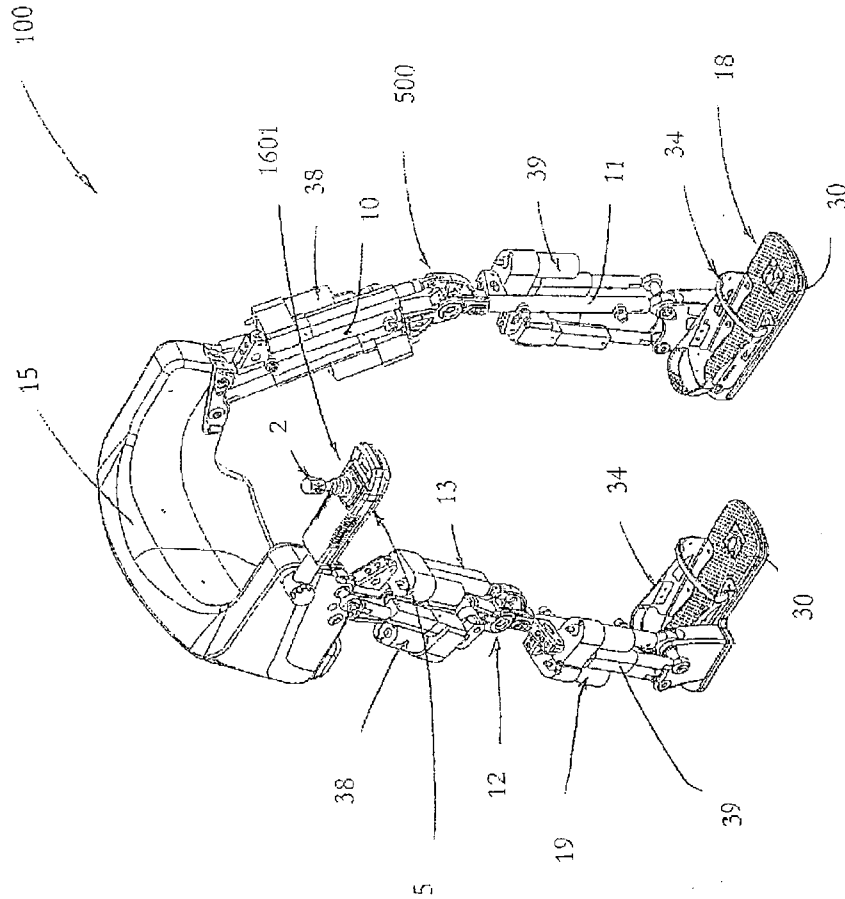


FIGURE 26

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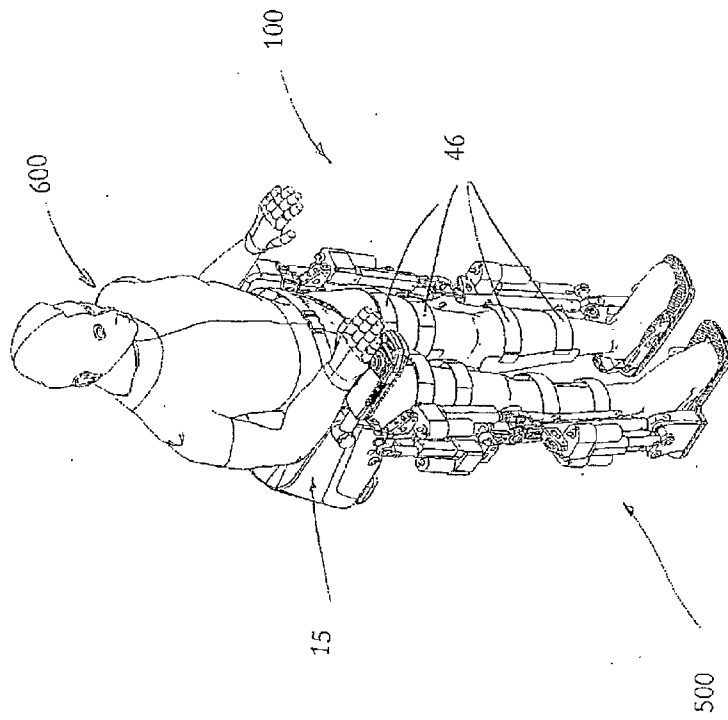


FIGURE 27

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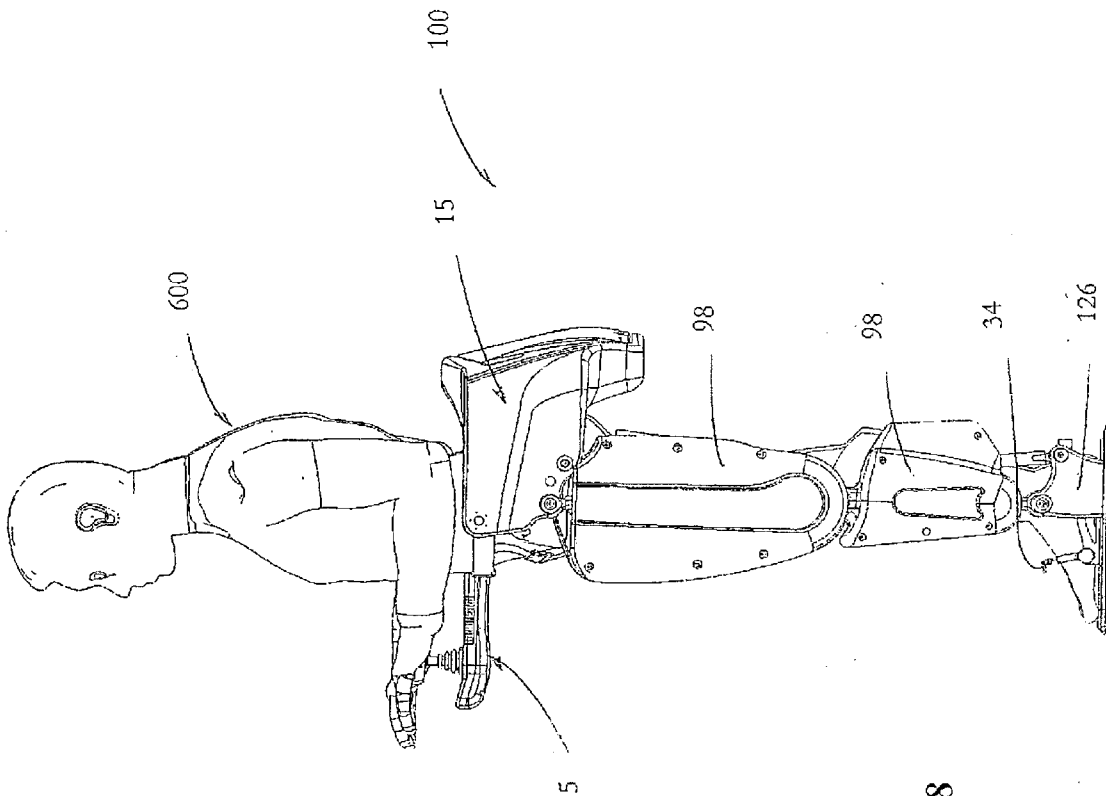


FIGURE 28

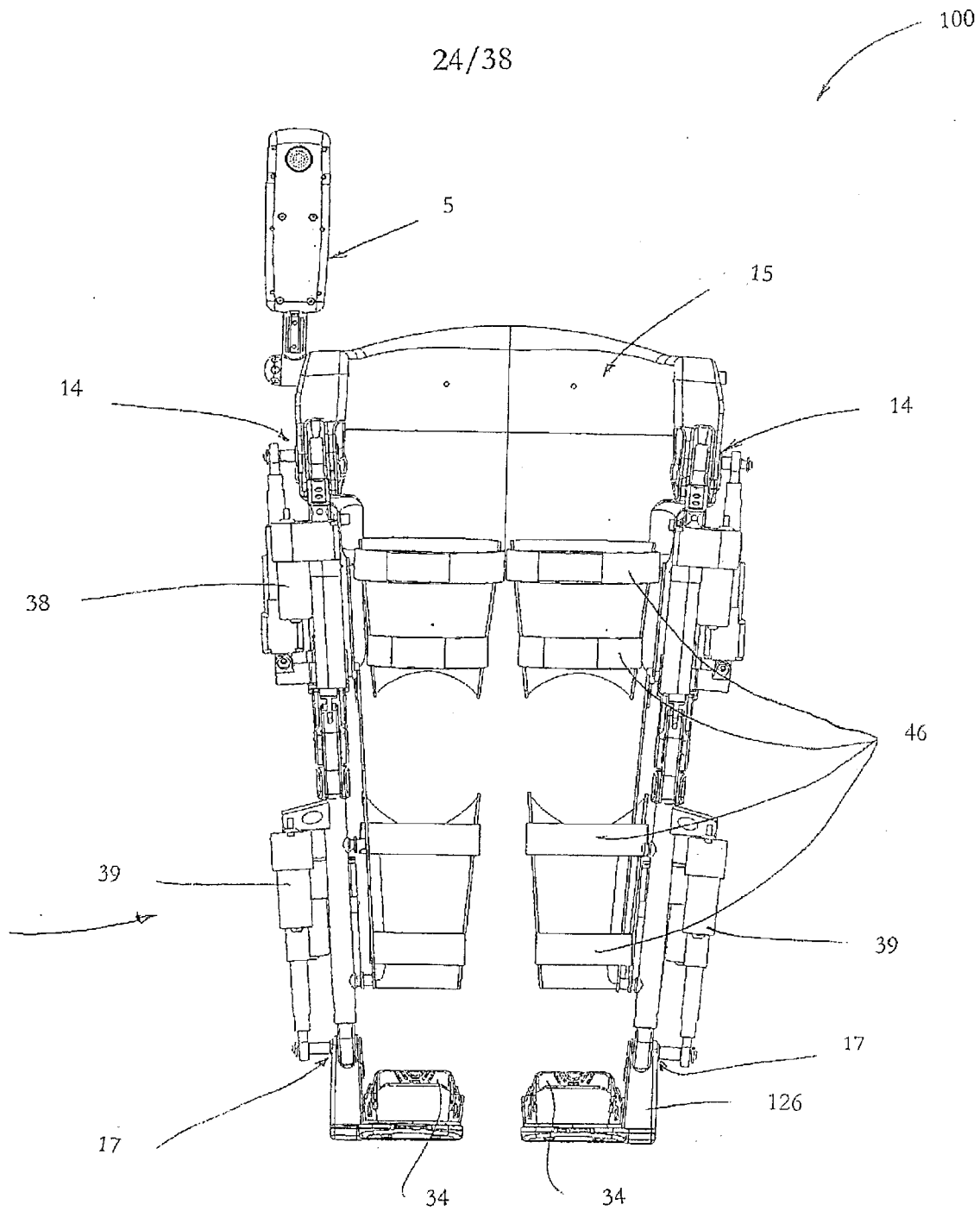


FIGURE 29

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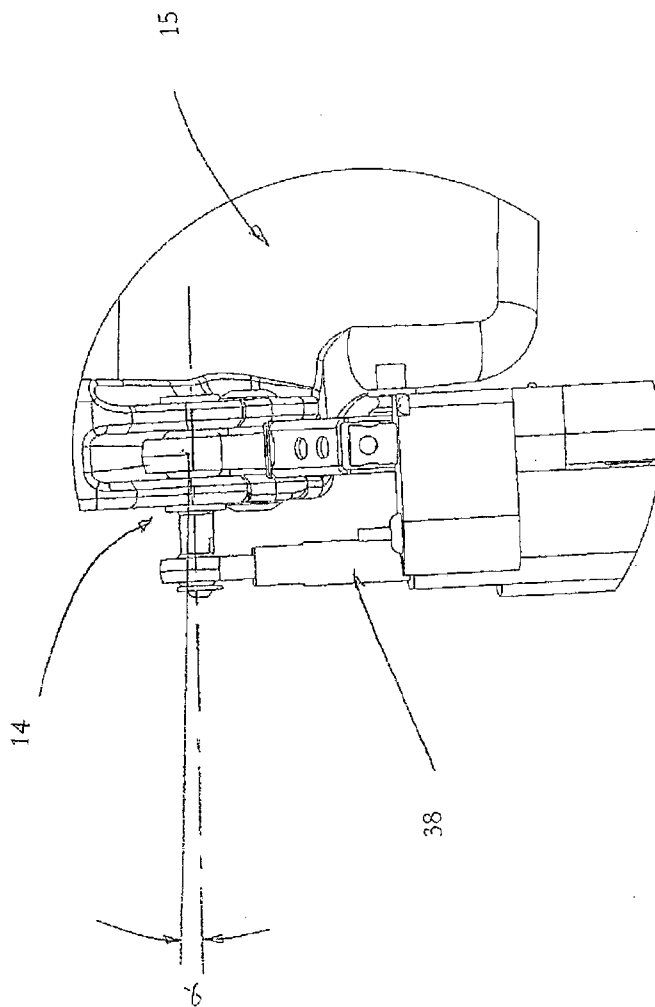


FIGURE 30

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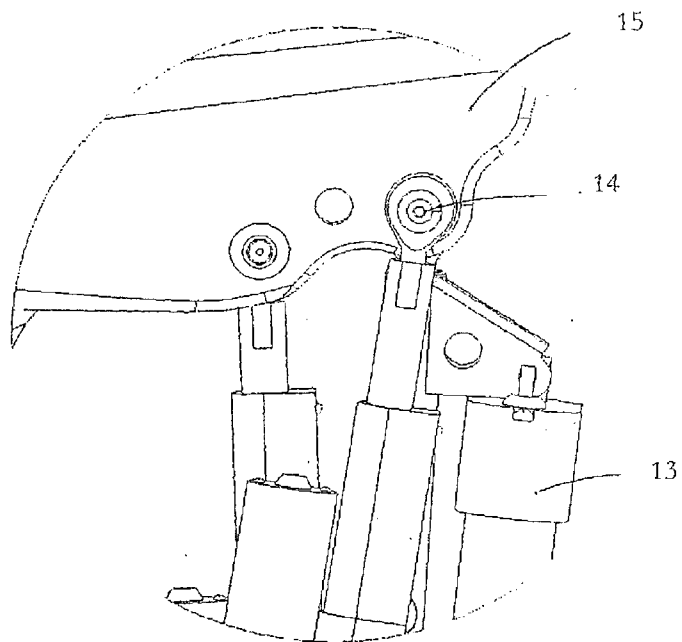


FIGURE 31

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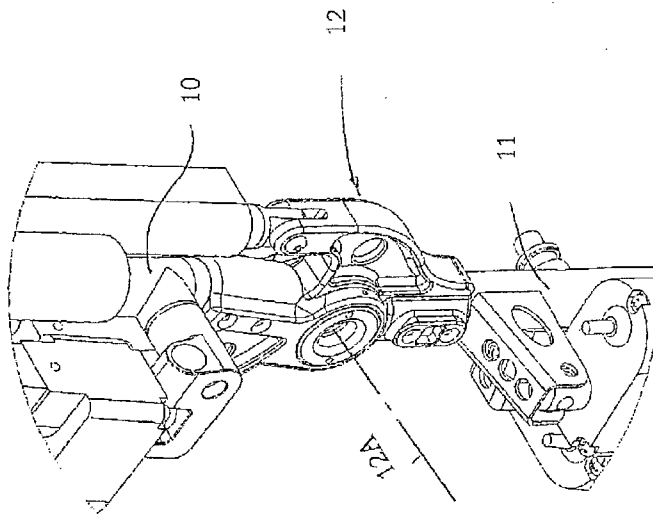


FIGURE 33

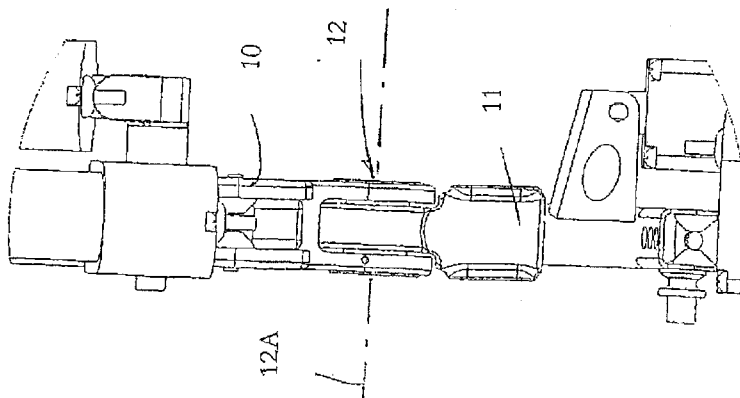


FIGURE 32

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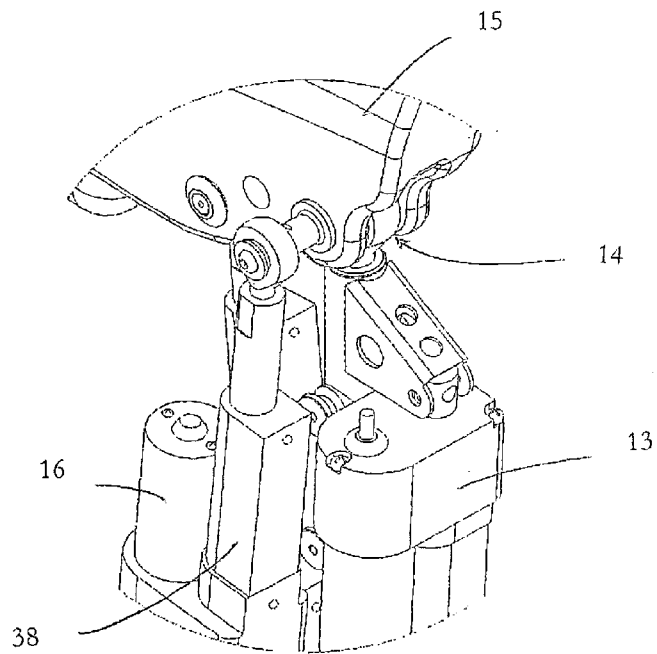


FIGURE 34

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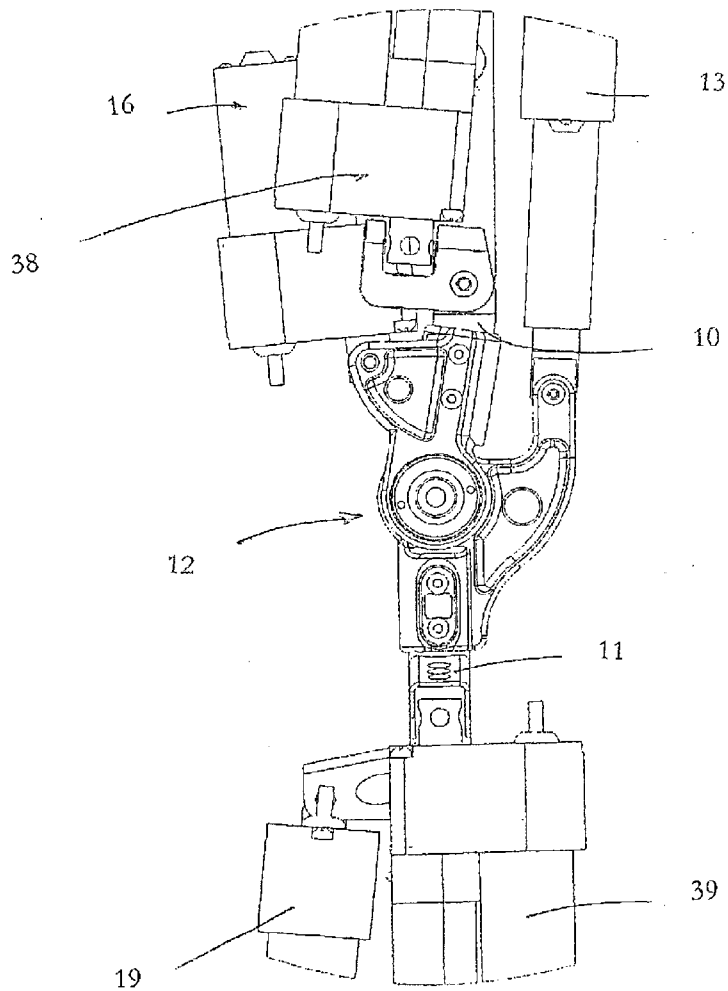


FIGURE 35

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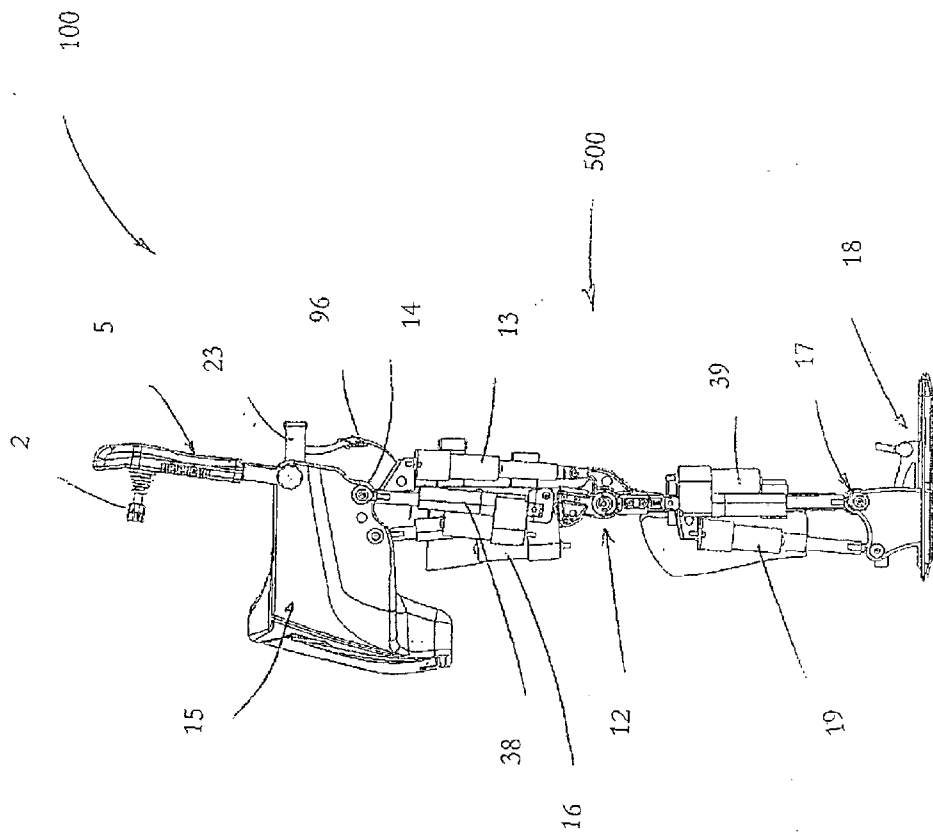


FIGURE 36

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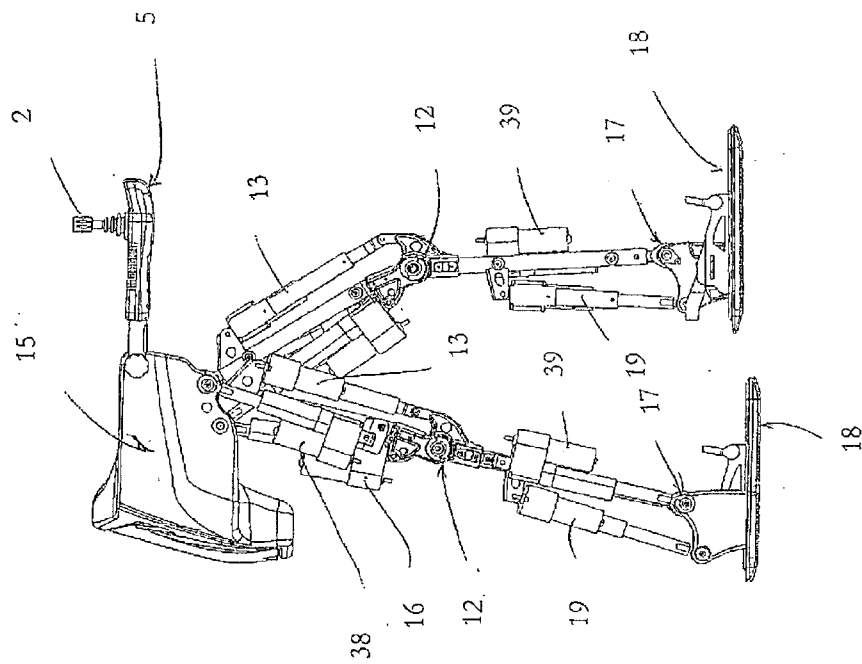


FIGURE 37

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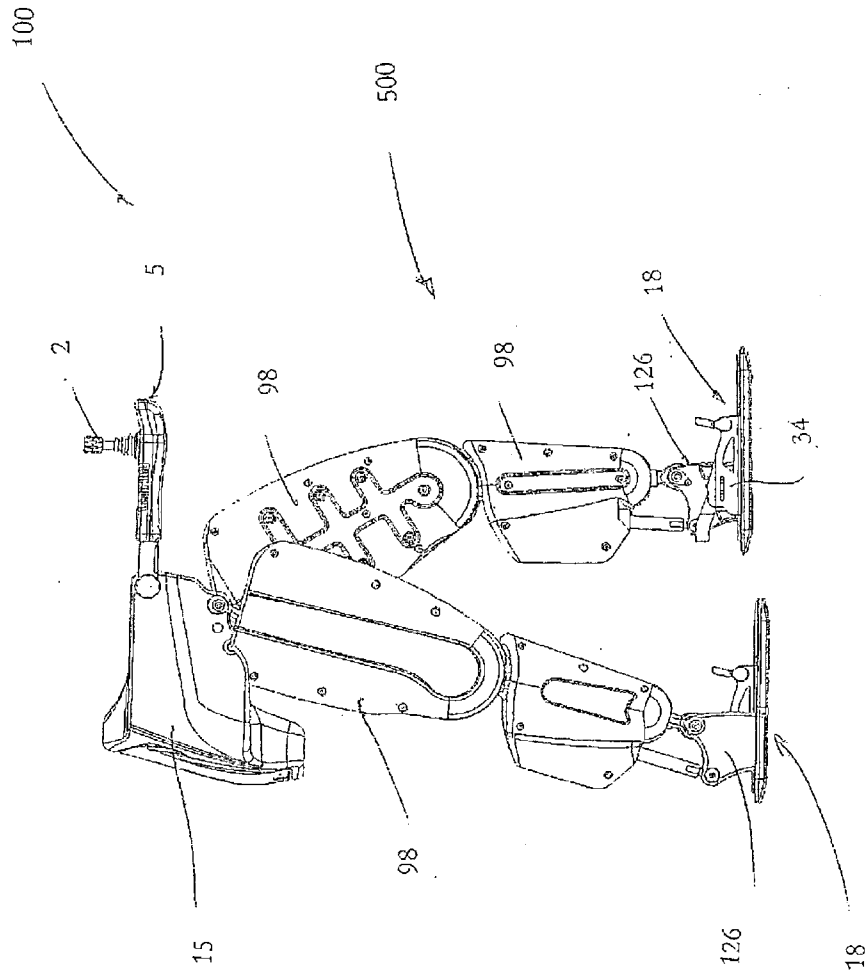


FIGURE 38

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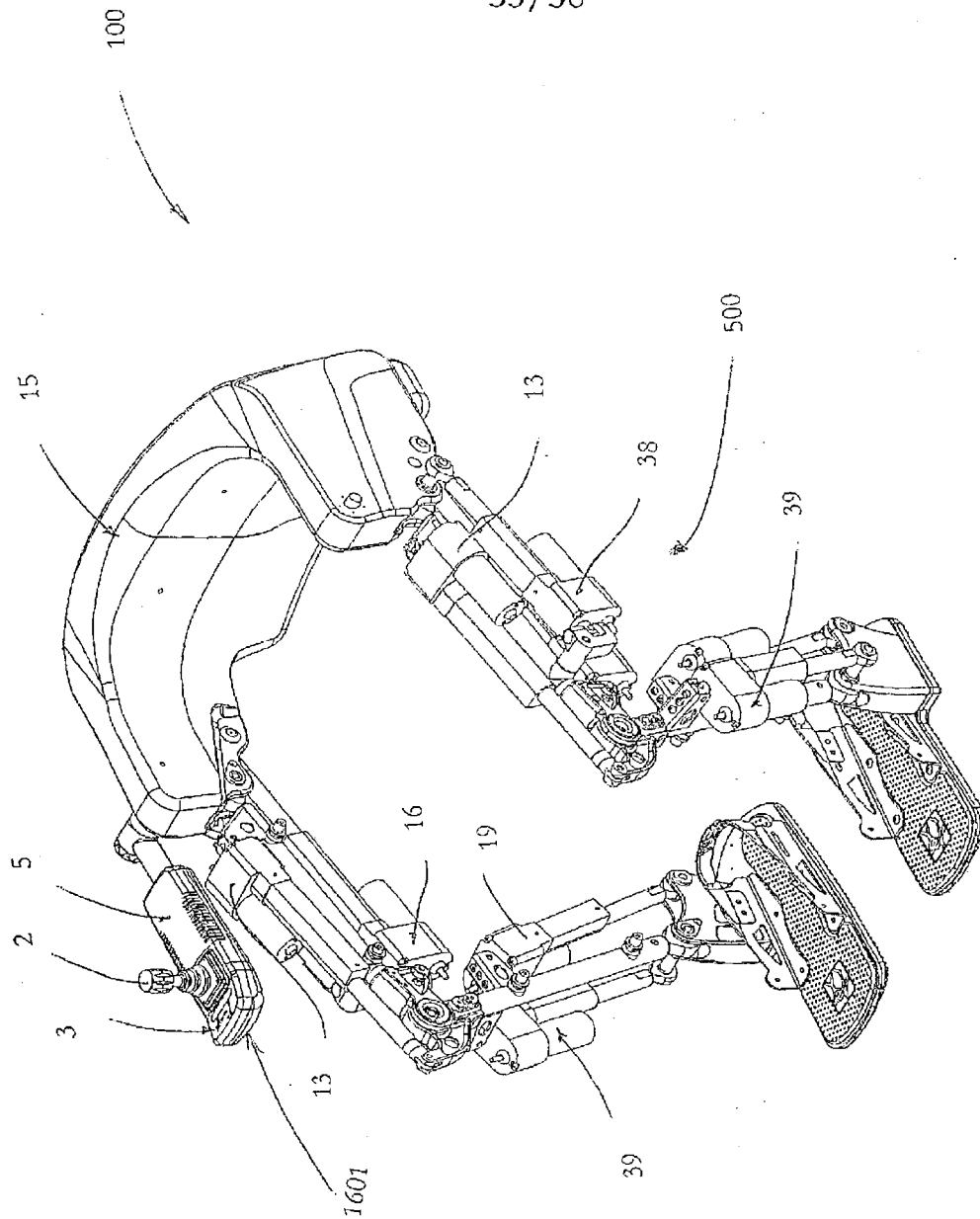


FIGURE 39

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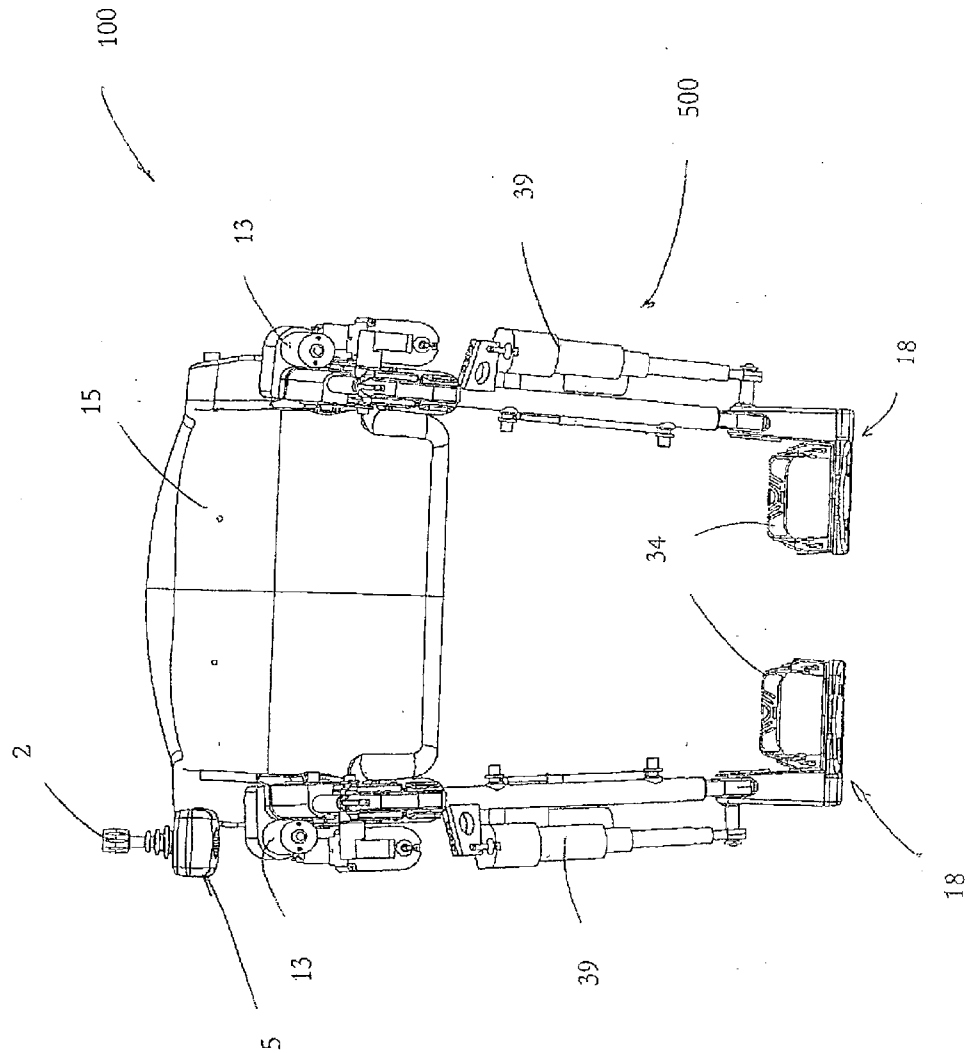
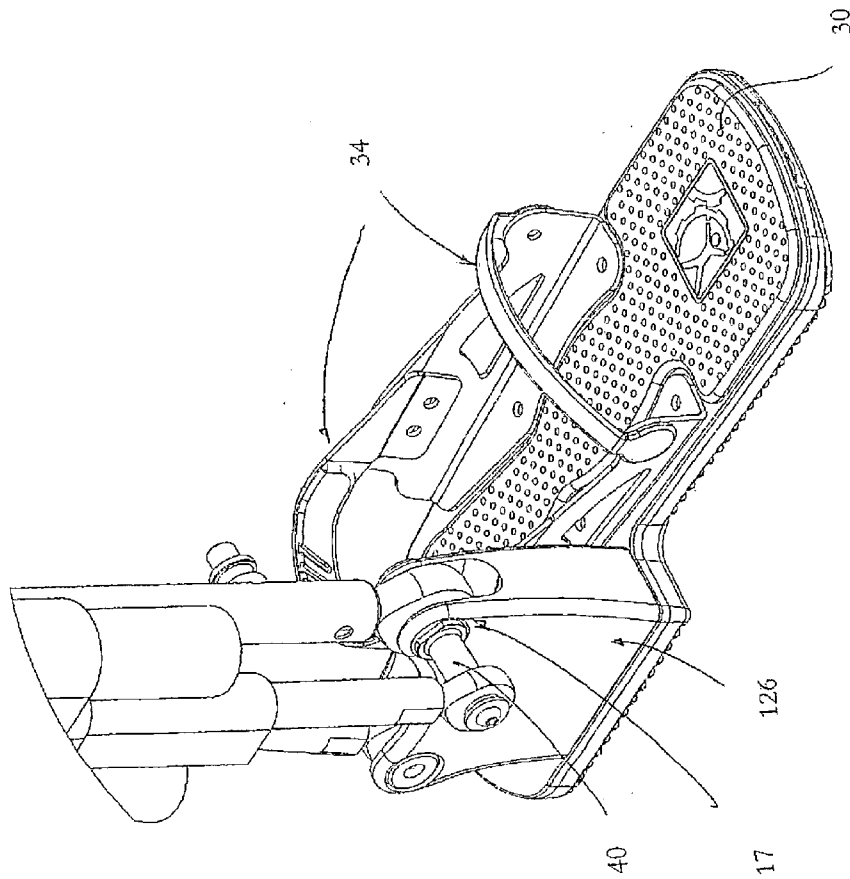


FIGURE 40

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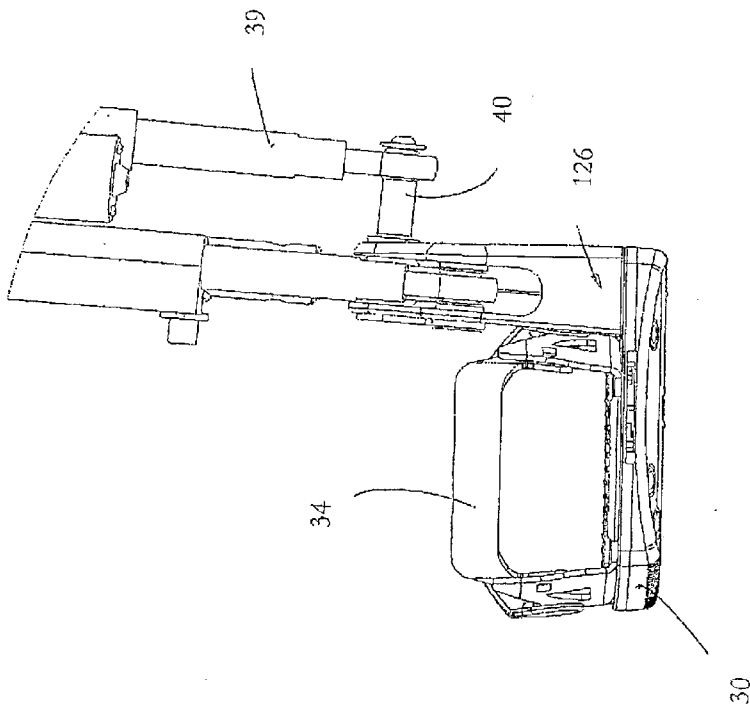
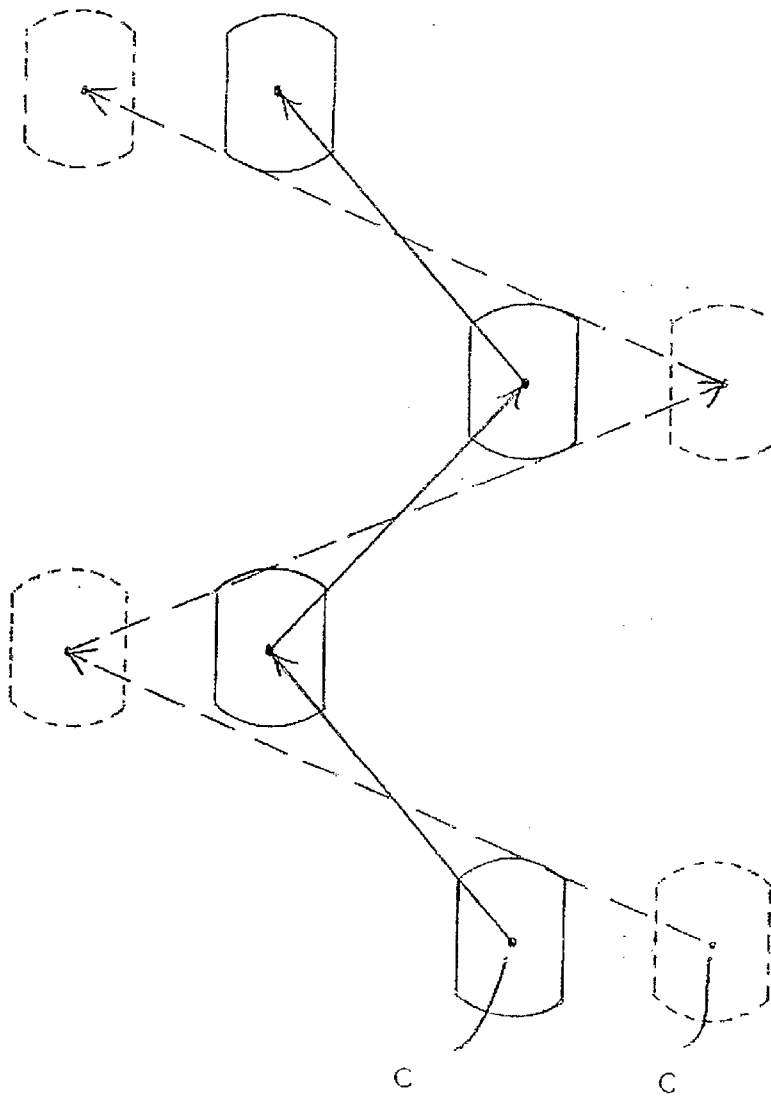


FIGURE 42

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FIGURE 43



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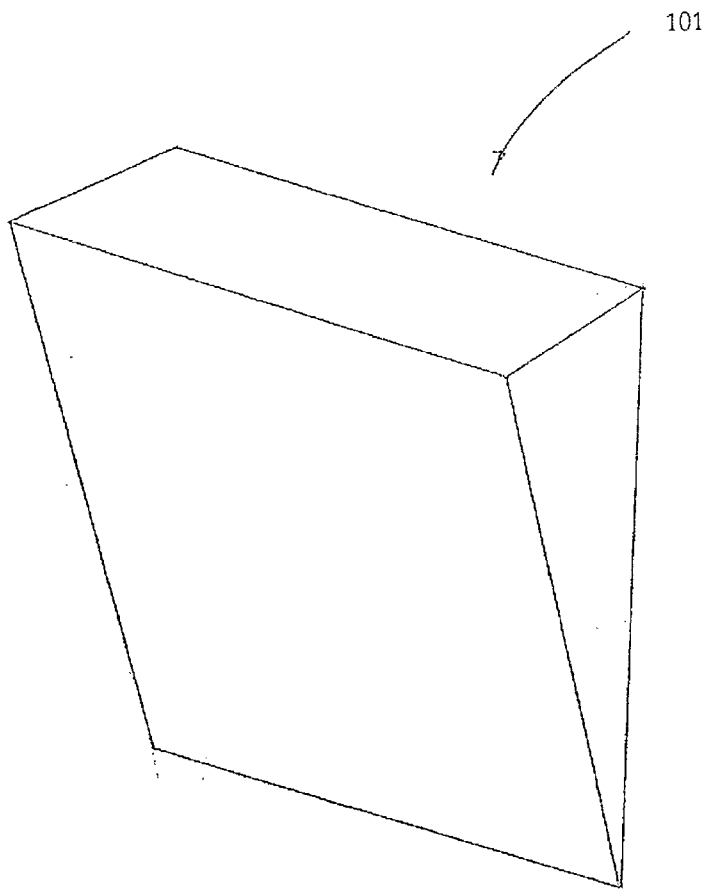


FIGURE 44

