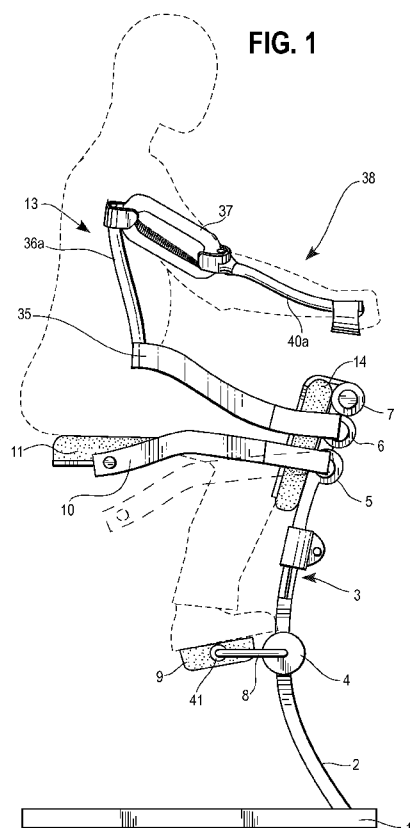




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[Continued on next page]

(54) Title: HUMAN SUPPORT SYSTEM



(57) Abstract: Adjustable support systems are provided for holding human arms in fixed or moving positions, and providing support for other portions of the body that may be subjected to strain. The support systems are configurable for use in a variety of postures including sitting, standing and crouching. Dynamic support components are incorporated into the system to counter forces on a user created by a user's posture or objects a user is lifting or working with. The pivoting joints can be compliant within a settable range of motion, and the torsional forces produced at the pivoting joints can be variable by use of an elastic element acting across the fixed and movable sides of the rotary joints.



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HUMAN SUPPORT SYSTEM

[0001] This application is based on and claims priority to United States Provisional Patent Application Serial No. 61/502,562, filed June 29, 2011.

BACKGROUND OF THE INVENTION

[0002] The practice of surgery, dentistry and other clinical procedures often requires long periods of standing while focused on a critical task at hand. This can cause strain associated with leaning, bending, holding one's arms extended and even standing in one place unsupported for several hours at a time without periods of rest or the opportunity to change positions without impairment of access, reach or vantage. Similar worker strain occurs in other situations, such as exists in laboratory or manufacturing settings. Accordingly, there is a need to reduce the strain on individuals performing repetitive or strenuous tasks or other activities that preclude proper ergonomic postures or rest periods.

SUMMARY OF THE INVENTION

[0003] Support systems are provided that deploy mechanical, electrical or electro-mechanical support equipment for holding human arms in fixed or moving positions, and provide support for other portions of the body that may be subjected to strain from a task at hand. Exemplary embodiments of the invention provide adjustable, ergonomic body support systems that are useful in a variety of modes and multiple postures. Embodiments of the invention can include dynamic support devices, such as the Equipois, Inc. X-ar™ arm support device. "Dynamic support" devices or segments as used herein are devices that provide a

weight-counteracting force, and include devices providing uniform counteracting force throughout the excursion of the weight and those providing varying forces.

[0004] The support system integrates dynamic arm rest supports with supports for various other portions of the body. The support structure is generally configurable to support a user in a standing position, sitting position or crouching position. Embodiments of the invention include a support frame to which one or more support rests are pivotably connected at adjustable pivot connection locations that may be adjustable. The support frame can include a main frame with various sub-frame components attached thereto. The sub-frame components can include fixed length or adjustable arms, gimbals and pivot connections to provide desired degrees of freedom and various sizing and positioning adjustments. The adjustable configuration can allow for use of the support system for a variety of tasks. Adjustment mechanisms may be remotely controlled or hands-free controllable.

[0005] The support rests may include for example, one or more first support rests configured to support a user's arm, a second support rest configured to support a user's body along a portion of an area extending from the user's upper thigh to the user's buttocks, a third support rest configured to support a user's chest when the user is in a leaning position, a fourth support rest positioned and configured to support a user's body along a portion of the user's lower legs (which includes the feet), and a fifth support rest configured to support a user's head including in a forward lean position. The terms "first," "second," "third," etc. are used to simplify the description and do not denote any particular sequence of use or inclusion in the support system.

[0006] The support rests may be adjustable to a plurality of positions, either manually or electronically, and may be lockable into various positions. Mechanisms, such as markings can be used to allow a user to readily reproduce desired settings when deployed as a manual mechanical system. In the case of an electromechanically controlled system, the user's

preferred, or other selected settings, can be stored in the controller memory as a recallable reference point.

[0007] One or more output force adjustment components, which may be tuned to the user's weight, and positioned at support rest joints and configured to adjust the resistance to motion about the joint to accommodate movement by the user and maintain substantially contact between the user and the support rest while substantially maintaining the supporting force.

DESCRIPTION OF THE DRAWINGS

[0008] Illustrative embodiments of the invention are best understood from the following detailed description when read with the accompanying drawings.

[0009] Figure 1 depicts a human support system with a user in a sitting mode according to an illustrative embodiment of the invention.

[00010] Figure 2 depicts a human support system with a user in a partially crouching mode according to an illustrative embodiment of the invention.

[00011] Figure 3 depicts a human support system with a user in a standing mode according to an illustrative embodiment of the invention.

[00012] Figure 4 depicts a human support system according to an illustrative embodiment of the invention.

[00013] Figure 5 depicts a human support system with a head support rest system according to an illustrative embodiment of the invention.

[00014] Figure 6 depicts a portion of a head support rest system according to an illustrative embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[00015] The illustrative embodiments of the invention include a human support system that supports various parts or regions of the human body during performance of tasks. The system is intended to counter, offset or eliminate stress on the user's body. Adjustable components allow the system to be used by people of various sizes, and support a user in a variety of poses.

[00016] FIGS. 1, 2 and 3 depict a user in various poses utilizing a support system. FIG. 1 shows a user in a sitting position. FIG. 2 shows a user in a standing position, with the user leaning forward so as to be in a partially crouched position. FIG. 3 depicts a user in a more upright standing position. A support system can be configured so the user has no or little support or contact with system components at times while at other times the system is engaged with the user to provide support desired for execution of a task. In this manner the system can be in place and ready for use with little or no interference with typical unsupported activities.

[00017] The seated position depicted in FIG.1 shows the user's arm or arms supported by an arm support rest system and with his/her feet elevated and positioned on a foot support rest 9. FIG. 2 shows the user in a semi-crouched position wherein the user is supported by a chest support rest 14, upper thigh support rest 11 and a lower leg rest 9. FIG. 3 depicts the user standing with his arm supported by arm support rest system 13. Upper thigh support rest 11 is in position should the user require support to counter strain on the upper thighs.

[00018] FIG. 1 depicts the support system with a frame that includes base 1 upon which other support frame components are disposed. Base 1 may have glides or castors. When not in use, castors are in contact with floor to provide ease of movement. When a user's weight is applied, the castors retract and slip resistant feet engage the floor.

[00019] Height support post 2 is secured to base 1. Post 2 may be anterior or posterior to the user and need not be exactly vertical. Shown in FIG. 1 is an anterior method of deploying all support members, such as various support rests, which will be described in more detail below.

[00020] The terms “height” and “vertical” are used broadly. A height or vertical adjustment does not necessarily mean a completely vertical adjustment. Height and vertical adjustments may be entirely vertical or include a lesser horizontal component.

[00021] Post 2 has a primary height adjustment 3 for adapting the apparatus to various users' overall height and position, such as shown by arrow 3a in FIG. 2. In this illustrative embodiment, height adjustment 3 is a telescoping mechanism, with the ability to lock post 2 at a desired height, a locking mechanism. Locking and height adjustment mechanisms may be for example, ratchet mechanisms, pin and hole devices or pneumatic mechanisms. Height adjustments may also be accomplished by substitution or insertion of additional frame connecting members. The adjustment mechanisms and devices described with respect to the height of the system can also be applied to other frame components. Vertical system height travel may be established to cover a particular height range, such as an anthropometric range of 10 percentile female and 90 percentile male heights.

[00022] Pivot joint 4 provides a pivoting adjustment for a lower leg and foot support rest 9. Components to lock in an angle of lower leg and foot support rest 9 and adjust and lock in the height of support rest 9 can also be provided. Arm 8 connects lower leg and foot support rest 9 to post 2, and pivots at both connections to provide angular adjustments, such as shown by arrows 8a, 8b in FIG. 2. Arm 9 can also have a length adjustment.

[00023] As shown in FIG. 2, leg and foot support rest 9 can also be pivoted at each end of arm 8 to a position allowing a user to rest his/her knees against it. Leg and foot support rest may be pivotably attached two sided surface. One surface is intended for the seated position configuration shown in FIG 1, with the sole of the user's feet resting upon the surface, which

may have a suitable anti-slip frictional coating or applied gripping substrate. The obverse surface may be provided with suitable padding for contact with the leg and or knee as in the case when the system is configured as shown in FIG 2.

[00024] The opposite side can contain a non -slip or durable material on which a user can rest his/her feet. Leg and foot support rest 9 can be comprised of two rests, one for each foot, or be a single support rest on which both feet or both legs can be rested. If comprised on one support rest section it may pivot at pivot 4 through approximately a 180 degree angle. If it includes two separate support rest sections it can pivot further, such as through 360 degrees. Leg and foot support rest 9 can be pivoted roughly between the positions shown in FIGS. 1 and 2 at joint 4, and further angular freedom can be provided at joint 41.

[00025] An upper leg and seat support rest joint 5 can be provided to secure upper leg and seat support rest 11 to the frame. Joint 5 provides a pivoting and locking angle and height adjustment for upper leg and seat support rest 11. An arm 10 connects upper leg and seat support rest 11 to post 2, and pivots at both joints 5, 20 to provide angular adjustments. Arm 10 can also have a length adjustment, such as shown by arrows 10a, 10b in FIG. 2.

[00026] Upper leg and seat support rest 11 can pivot between a position to accommodate a user in a seated position, as shown in FIG. 1 and a position in which the user is standing wherein upper leg and seat support rest 11 supports the user at the upper thigh or buttocks region, such as shown in FIG. 2.

[00027] In an exemplary embodiment of the invention, arm 10 pivots through approximately a 90 degree angle, for example, from a position in which upper leg and seat support rest 11 is substantially vertical (shin or knee rest) to a position in which support rest 11 is substantially horizontal (foot rest). As with any of the support rests, upper leg and seat support rest 11 can be padded. Depending on the use of a particular support rest, padding may be used on one or both sides, or surrounding a rest if cylindrical.

[00028] An arm support rest system 13 is shown in FIGS. 1-4, for example. It includes an arm support rest frame component 35 that is attached to post 2. Frame component 35 is substantially u-shaped in this embodiment and may be constructed of a single u-shaped component or a plurality of components to enable frame 35 to partially surround the user to support additional components of arm support rest system 13 at the desired positions. Arm support rest joint 6 provides a pivot point for the system and can include a locking angle and height adjustment. An adjustment mechanism 21 permits lateral width adjustment, such as in a horizontal plane, for spacing of frame component 35, and can include an adjustment mechanism to angularly position arm support rest system 13, for example in a vertical plane as shown by arrow 35a in FIG. 2.

[00029] FIGS. 1-4 show additional frame components 36a, 36b, that extend toward a user's shoulders. Frame components 36a, 36b may be pivotably attached to frame component 35 and further attached to a first end of dynamic support segment 37. This latter attachment may also include a pivot point. Dynamic support segment 37 provides dynamic lift support to the human arm. A second end of dynamic support segment 37 is connected, preferably pivotably, to a lower arm component 38 that supports a user's wrist, upper arm, elbow and/or forearm, such as by cuff 39. In the illustrative embodiment shown in FIG. 4 for example, a frame component 40a connects cuff 39 to dynamic support segment 37. Each of these connection points can be pivotable. Arm rest support system 13 can also or alternatively support a user's upper arm. Dynamic support segment 37 can be disposed at different locations, which may depend on which part of a user's arm is being supported by arm support rest system 13. For example, if support system 13 has a component that is attached to or provides a rest for the upper arm, dynamic support segment 37 may be disposed below it, such as in the position shown for frame component 40a. In general, arm support rest system 13 will contain various components connected to one another to mimic the range of motion of the human arm and provide the support needed for the task, including countering forces provided by one or more dynamic support segments.

[00030] FIG. 2 depicts the support system with a chest support rest 14 rotated upward at joint 7 to support a user leaning forward. The chest support 14 may be deployed in a range of positions both rotationally and linearly along the sagittal plane as shown by arrow 15 in FIG. 2. Chest support rest 14 can be rotated downward to a position that provides a rest for a user's knees, such as shown in FIG. 1 wherein the user is in a sitting position. The downward position may also serve to rest a user's knees when in a standing position, or may be needed to remove it from obstructing a task at hand.

[00031] Chest support rest 14 pivots through an angle, such as shown by arrow 14a in FIG. 2. If the desired range of angular adjustment at pivot 7 is from a chest support position to a knee level position, then a pivot angle at pivot 7 of approximately 180 degrees may be sufficient. Chest support rest 14 may also serve as an arm support if it is rotated further to the other side of post 2. To move chest support rest 14 out of the way from the user side of the apparatus and stow it, it can be rotated further. Accordingly, various ranges of rotation may be suitable for different uses. Illustrative ranges include approximately 90 degrees, 180 degrees, 270 degrees and 360 degrees. Chest support rest 14 may also be adjustable with respect to height, such as by having it slidable along its base. Providing a hinged base, such as mechanism 15, can serve to bring chest support rest 14 closer to the user, in addition to raising or lowering it. Chest support rest joint 7 can have a lockable angle adjustment and position adjustment.

[00032] FIGS. 5-6 depict a head support rest system 42 according to an illustrative embodiment of the invention. Head support rest system 42 can be attached to the system frame such as by arm 23, which in FIG. 5 is shown further attached to arm support rest frame component 35. Other points of attachment are possible and can depend for example on the particular components making up the system and the use of the system. Arm 23 is attached to frame component 35 at joint 24. Joint 24 can provide adjustment capabilities, such as along frame component 35 to bring the head support rest into the position of the user's head. When attached to a frame component such as arm rest support frame component 35 with right and left sides, the head support rest system 42 can be removably attachable to either side.

[00033] Head support rest system 42 can be configured to provide support for a user's head in various positions and may be particularly useful when the forward lean angle is excessive or the use of head mounted optical or lighting equipment is required.

[00034] An illustrative head support rest system has four degrees of freedom and is dynamically adjustable. Dynamic adjustability is provided by a dynamic support segment 25. Dynamic support segment 25 may also be non-adjustable. In an exemplary embodiment of the invention, dynamic support segment 25 is deployed in a generally vertical manner so that its equipoising or dynamic force compensates for, or offsets, the stress on a user's neck and shoulders created by the user tilting his/her head. The compensating force and positioning of dynamic support segment 25 is preferably such that there is little or no restriction in movement or range of motion.

[00035] Dynamic support segment 25 can be further attached to a connecting member 26, which in turn is connected either directly or indirectly to head support rest 27.

[00036] Head support rest 27 may include a support area 27a against which a user's forehead or rear opposing head area can rest, and an upper support section 27b against which the top of a user's head can rest. Depending on the use of the support system, the head support rest 27 can include support in other areas of the head or neck.

[00037] In an exemplary embodiment of the invention, head support rest system 42 has attachment points for mounting of optical, lighting, shielding or other devices worn by users. The accessory option for a head support can provide a means of bearing the weight of the users head while leaning either in conjunction with the upper torso chest support, arm, thigh and leg supports or independently. Attachment points for mounting equipment can also be incorporated into other parts of the support system.

[00038] Possible fore and aft travel is shown by arrow 28. A variably adjustable equipoising force created by dynamic support segment 25 can be implemented that would affect travel in the direction of arrow 28.

[00039] FIG. 6 depicts a multi-axis gimbal assembly 30 incorporated into the head support rest system 42. Gimbal assembly 30 can provide at least three angular degrees of freedom, which correspond to the rotational and tilting motions of the head as provided by the neck. Arrows 30a-d depict motion of head support rest system 42. Arrow 30a shows forward and aft translation as provided by the dynamic support segment 25. Arrow 30b represents tilt rotation as would be incurred by inclining one's head out of the sagittal plane towards the shoulder. Arrow 30c depicts tilt rotation out of the coronal plane as would be incurred by nodding ones head as if in the affirmative, made possible at joint pivot 43. Arrow 30d represents side to side rotation as would be incurred by shaking one's head in the negative, facilitated by joint pivot 44.

[00040] Joints in the support system can be configured so the output force exerted on the user by the components they join is adjustable, and can be set, for example to adjust the resistance to motion about the joint to accommodate slight movement by the user and maintain substantially full contact between the user and the support without changing the supporting force. The benefit thereof being that the support structures can then be tuned to the user's weight and provide a range of motion for even minor positional adjustments while still in contact with the support and consistently providing said support and stabilization. An output force adjustment component may be for example, a pin joint with a torsion spring deployed at each of the pivots to provide points of supported contact, which has an absolute and settable minimum and maximum range of motion (+/- X degrees from the "middle"), and a "spring" force adjustment, which can be set by a user. The adjustable joints of the supporting structures may utilize rotary or linear series elastic actuators such as at the pin joints to facilitate a compliant means of positioning and preloading the support. The pivoting joints can be compliant within a settable or fixed range of motion. The torsional forces produced at the pivot

joints can be made variable by means of manual or motorized actuation of the elastic element acting across the fixed and movable sides of the rotary joints.

[00041] A locking mechanism can be provided for the joints so they can be locked in positions at desired discrete intervals or along a continuous spectrum. A mechanism can be included by which the user's preferred setting or settings for a particular posture mode can be restored easily by either a visual index mark or a tactile detent or mechanical feature, for example. Such as markings can be used to allow a user to readily reproduce desired settings when deployed as a manual mechanical system. In the case of an electromechanically controlled system, the user's preferred settings can be stored in the controller memory as a recallable reference point. These and other locking mechanisms and settable position indexes described herein may be provided for any of the adjustments on the support system.

[00042] Locking, unlocking, release and activation of the joints, and adjustment of the supporting and/or output force of the dynamic arm rests and equipoising head support can be achieved manually or by remote device such as a non-hand actuated device like a foot switch or pedal, wireless device or other control device. Control can be mechanical, electromechanical, hydraulic or by any other means that facilitates operation by the user or an assistant without their hands, or by an electronically mediated control interface that includes but is not limited to voice recognition, eye scan, body gesture, brainwave pickup or other human interface device.

[00043] Structural elements may have accessory attachment points to facilitate the draping of sterile surgical field coverings. Included in this provision is the ability to attach or hang heavy radiological shielding as would typically be worn directly by the user.

[00044] Support system sections, such as support rests and frame components, can be docked or stowed in a position for ease of entry and egress and ingress. Pedal or other non-hand actuated device can be used to lock or unlock a component into or from a stowage position. A stowed position of a support rest or frame component may include for example, full down or down and slightly forward to remove or reduce obstruction.

[00045] The support system, such as on base 1, may have components to install or mount foot pedal switches and associated cabling as required by the user for operation of equipment other than the support system.

[00046] The support system, such as on post 2 or other appropriate position, may have provisions for anchoring the system to an operating room table, dental chair or other fixtures.

[00047] Various embodiments of the invention have been described, each having a different combination of elements. The invention is not limited to the specific embodiments disclosed, and may include different combinations of the elements disclosed or omission of some elements and the equivalents of such structures.

[00048] While the invention has been described by illustrative embodiments, additional advantages and modifications will occur to those skilled in the art. Therefore, the invention in its broader aspects is not limited to specific details shown and described herein. Modifications may be made without departing from the spirit and scope of the invention. Accordingly, it is intended that the invention not be limited to the specific illustrative embodiments, but be interpreted within the full spirit and scope of the appended claims and their equivalents.

Claimed is:

1. A support system comprising:

a support frame;

a plurality of support rests pivotably connected to the support frame at a pivot connection;

wherein the support structure is configurable to support a user in a standing position, sitting position and crouching position.
2. The support system of claim 1 where in the plurality of support rests include two or more of the following support rests:

one or more first support rests configured to support a user's arm;

a second support rest configured to support a user's body along a portion of an area of the user extending from the user's upper thigh to the user's buttocks;

a third support rest configured to support a user's chest when the user is in a leaning position; and

a fourth support rest positioned and configured to support a user's body along a portion of the user's lower legs.
3. The support system of claim 2 wherein the third support rest can be pivoted from a position of a user's chest height downward to a position below its pivot connection .
4. The support system of claim 2 wherein the frame has a non-rotational adjustment to change the height of one or more of the support rests.

5. The support system of claim 2 wherein the fourth support rest can be pivoted from a position at which the fourth support rest can support a user's feet to a position at which a user can rest his/her shins against the fourth support rest.
6. The support system of claim 2 further comprising a dynamic support segment having a first end and a second end wherein the first end of the dynamic support segment is attached to one of the one or more first support rests and the second end of the dynamic support segment is attached to the support frame.
7. The support system of claim 2 wherein the one or more first support rests are configured to support one or more parts selected from the user's upper arm, forearm, elbow, wrist and hand.
8. The support system of claim 2 wherein the support frame comprises:
 - a main post;
 - a first arm having a first end and a second end wherein the first end is pivotably connected to the main post and the second end is pivotably connected to a first support rest; and
 - a second arm having a first end and a second end wherein the first end is pivotably connected to the second support rest and the second end is pivotably connected to the main post.
9. The support system of claim 8 wherein the pivot connections are lockable in a plurality of discrete positions that are identified for restoring to preferred positions.
10. The support system of claim 1 wherein one or more of the pivot connections are lockable in a plurality of positions, and the support system further comprises:
 - an electromechanical control system having a controller memory;

wherein the pivot connections are reproducibly settable in a plurality of selected positions stored in the controller memory.

11. The support system of claim 1 comprising a motorized adjustment device to adjust the positions of one or more support rests, configured for adjustments to be made remotely.
12. The support system of claim 11 wherein control of the adjustment device is hands-free; and

wherein the hands-free adjustment device controls one or more actions selected from the group consisting of locking, unlocking, release and activation of joints, and adjustment of the supporting force of dynamic components.

13. The support system of claim 11 comprising an electronically mediated control interface.
14. The support system of claim 2 wherein the fourth support rest is adjustable along a main post.
15. The support system of claim 2 wherein the fourth support rest has a padded side and a reduced slip side opposing the padded side and the fourth support rest is rotatable so either the padded side or the reduced slip side can face the user.
16. The support system of claim 1 wherein the support frame has a telescopic main post.
17. The support system of claim 1 wherein the support frame has a main post and the main post is modular to allow addition and subtraction of lengths to vary the height of the support system.
18. The support system of claim 2 wherein the first, second, third and fourth support rests are rotatable to a stowage position.

19. The support system of claim 8 wherein the first arm is adjustable in a substantially horizontal plane and a vertical plane.
20. The support system of claim 2 further comprising:

a fifth support rest configured to support a user's head including in a forward lean position, wherein the fifth support rest is adjustable to a plurality of positions.
21. The support system of claim 20 comprising a dynamic support segment connected to the fifth support rest and providing a force to counter stress on a user created by a tilt of the user's head.
22. The support system of claim 21 wherein the dynamic support segment is disposed substantially vertically.
23. The support system of claim 1 comprising accessory attachment points on the support frame and/or the support rests.
24. The support system of claim 20 comprising:

a gimbal connected to the fifth support rest configured to provide rotational and tilting freedom of motion to the fifth support rest.
25. The support system of claim 1 comprising:

one or more support rest joints where the support rests are joined to the support frame;
and

one or more output force adjustment components tuned to the user's weight and positioned at support rest joints configured to adjust the resistance to motion about the joint to accommodate movement by the user and maintain substantially contact between the user and the support rest while substantially maintaining the supporting force.

26. The support system of claim 1 further comprising:

elastic actuators at the joints for positioning and preloading the support system components.
27. A method of performing a surgical, clinical, laboratory or manufacturing procedure comprising utilizing the support structure according to claim 1 while performing the procedure.

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FIG. 1

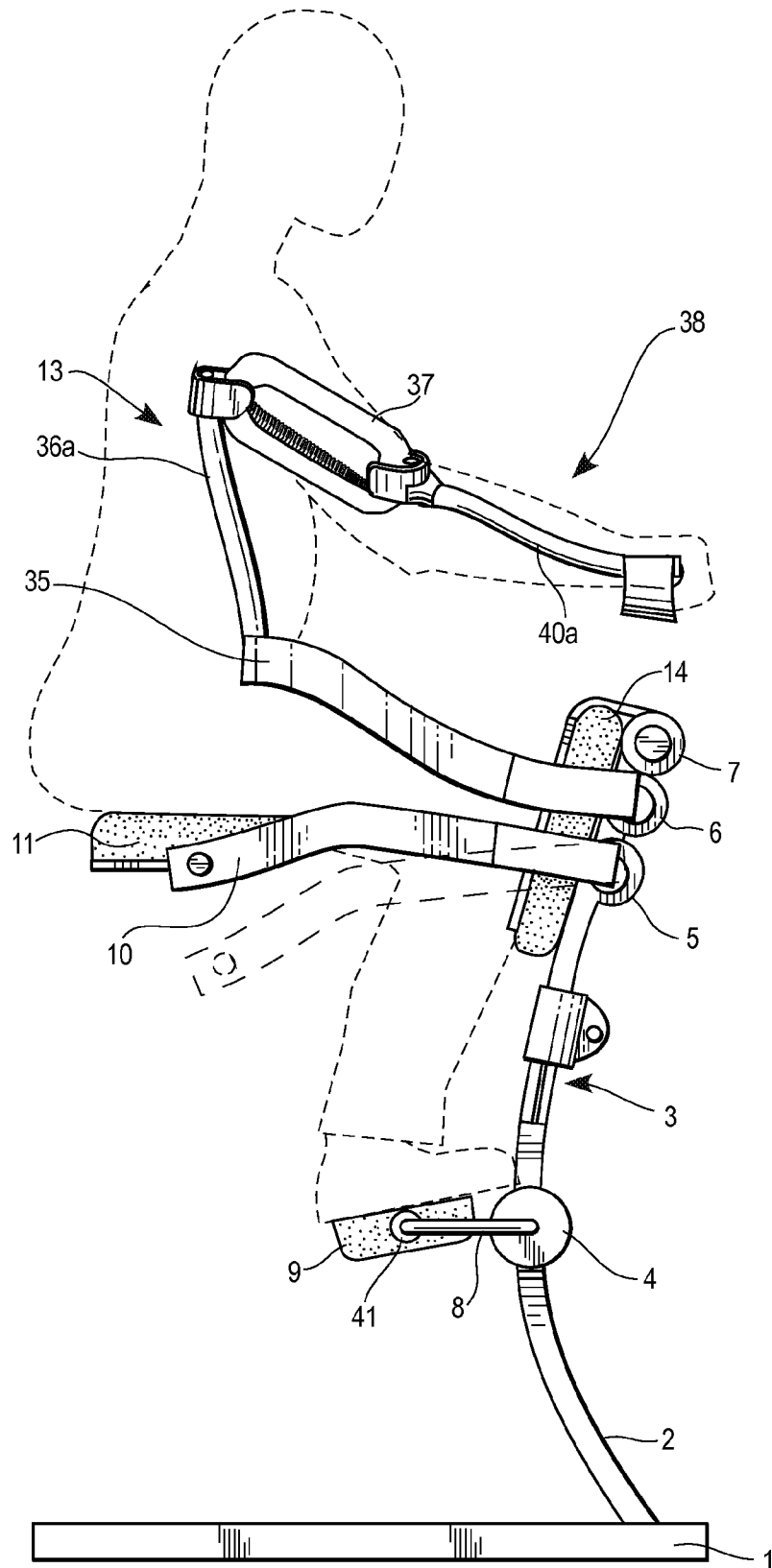
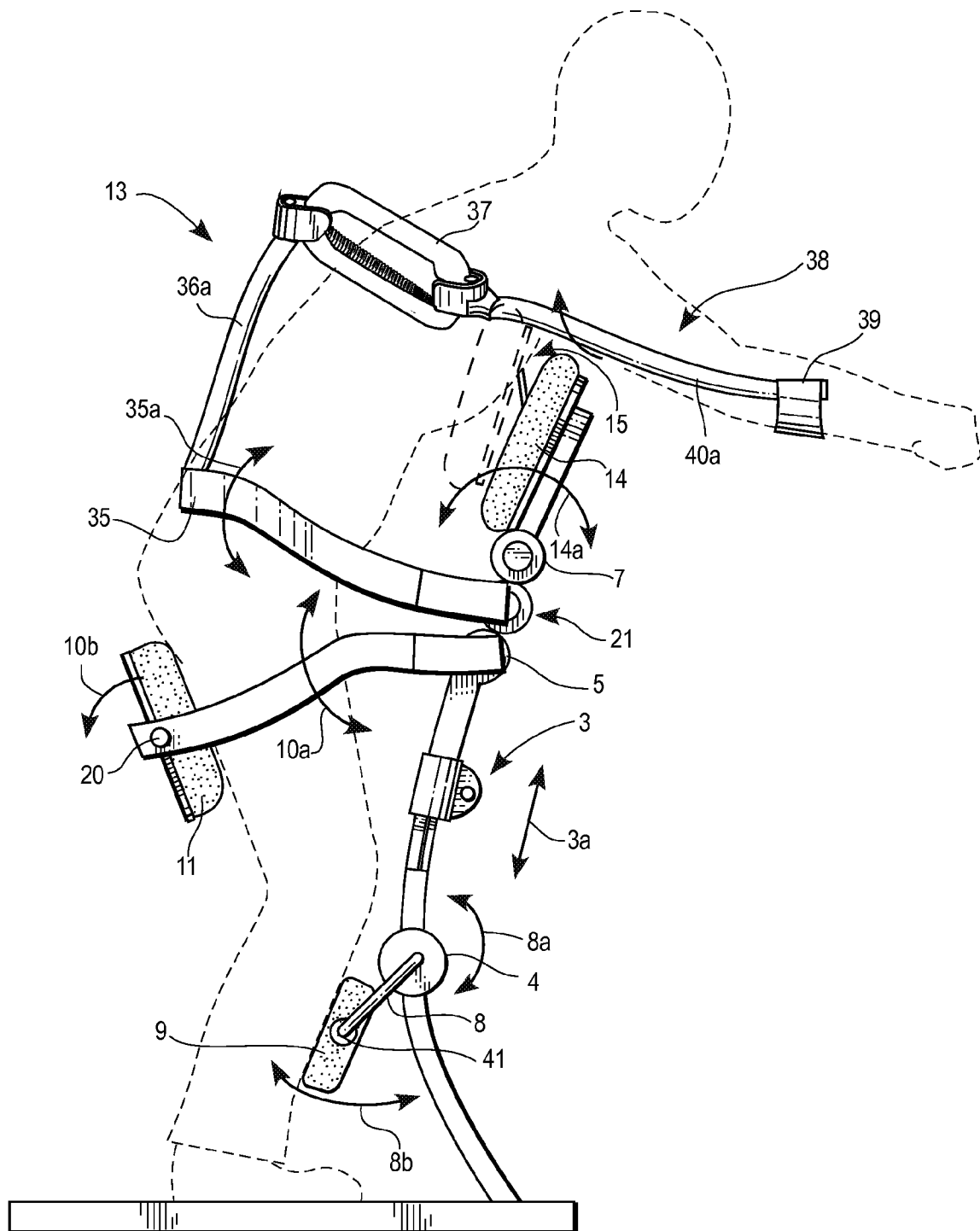
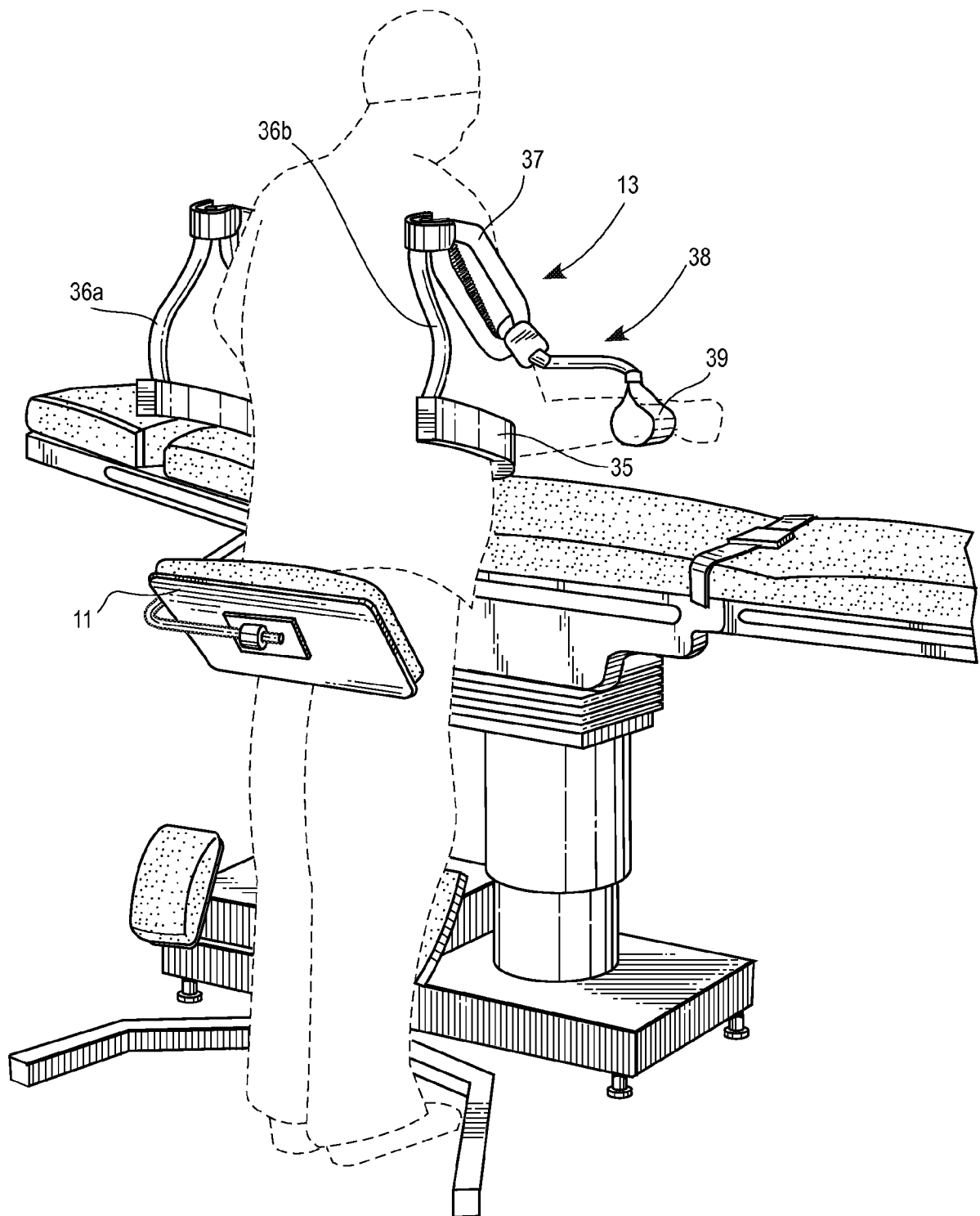


FIG. 2



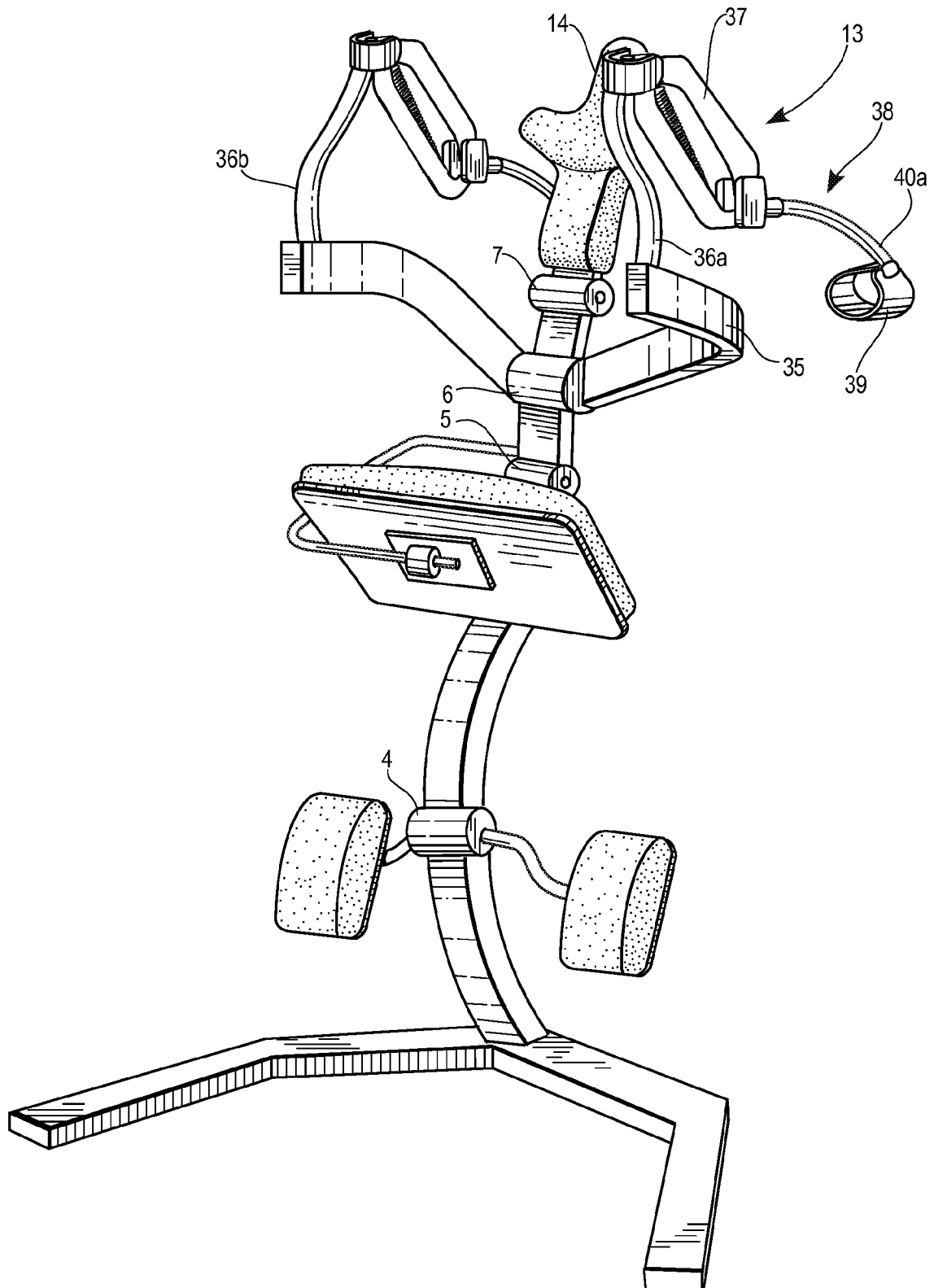
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FIG. 3



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FIG. 4



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FIG. 5

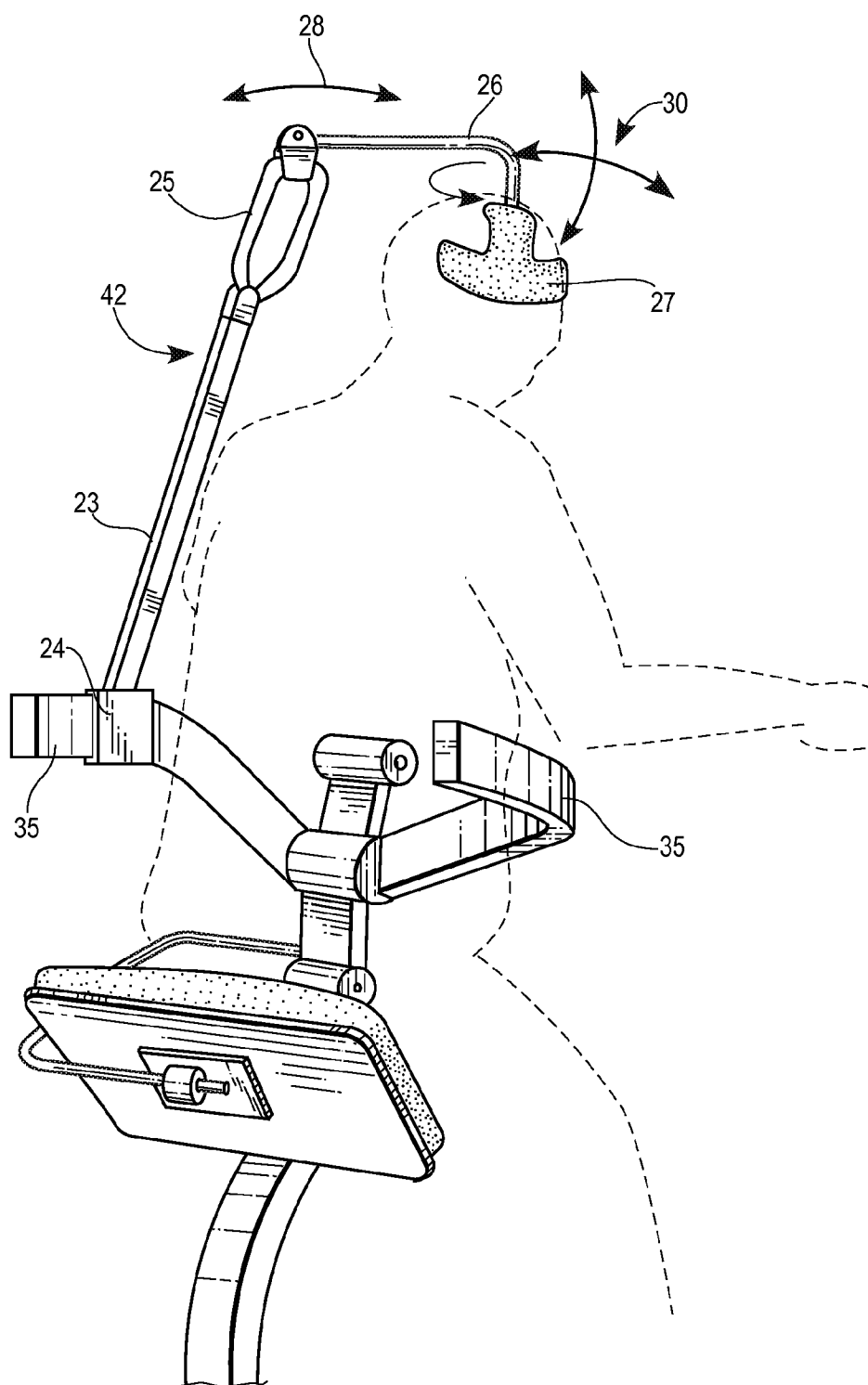


FIG. 6

