US 20200188223A1

(19) United States
(12) Patent Application Publication
(10) Pub. No.: US 2020/0188223 A1
(43) Pub. Date: Jun. 18, 2020
Nguyen

(54) **TREMOR REDUCTION DEVICE**

(71) Applicant: **5IVE MICRONS**, Fresno, CA (US)

(72) Inventor: **The Nguyen**, Fresno, CA (US)

(21) Appl. No.: **16/795,560**

(22) Filed: **Feb. 19, 2020**

Related U.S. Application Data

(63) Continuation-in-part of application No. 16/172,829, filed on Oct. 28, 2018, which is a continuation-in-part of application No. 15/601,201, filed on May 22, 2017.

(60) Provisional application No. 62/807,249, filed on Feb. 19, 2019, provisional application No. 62/728,368, filed on Sep. 7, 2018, provisional application No. 62/383,287, filed on Sep. 2, 2016.

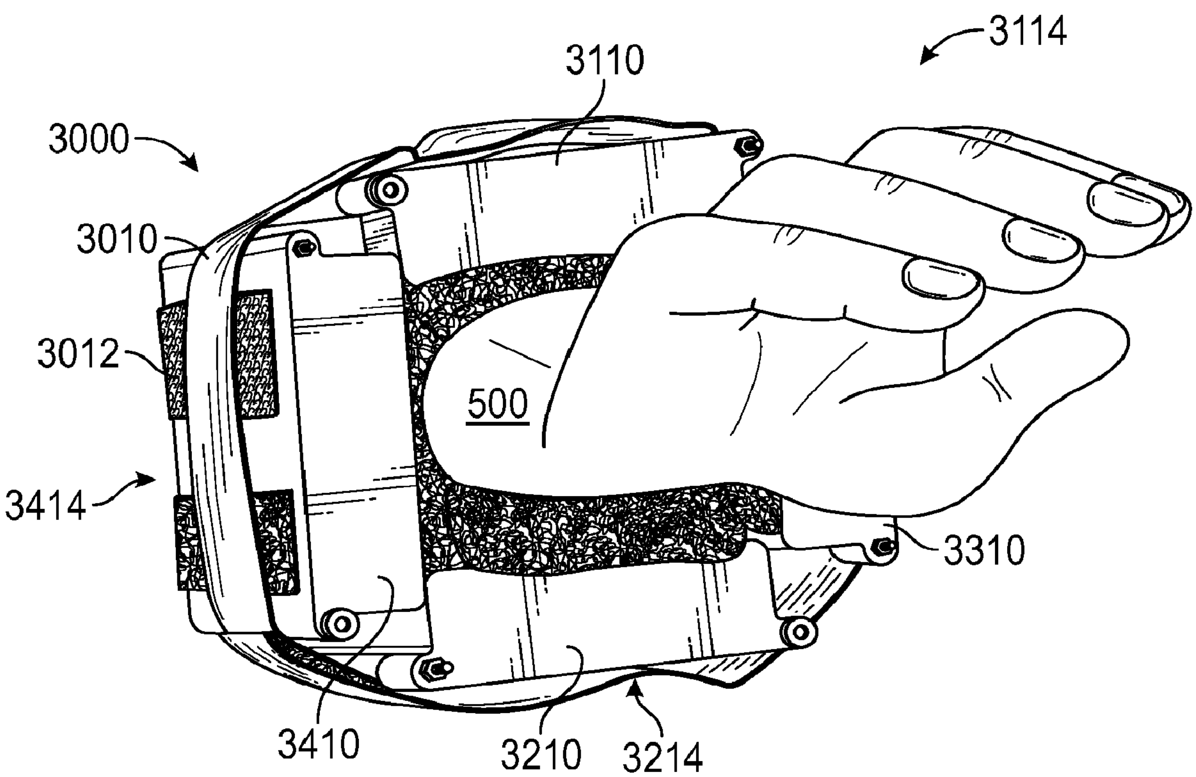
Publication Classification

(51) **Int. Cl.**
A61H 23/00 (2006.01)
A61H 11/00 (2006.01)

(52) **U.S. Cl.**
CPC ***A61H 23/004*** (2013.01); ***A61H 11/00*** (2013.01); *A61H 2201/165* (2013.01); *A61H 2201/1638* (2013.01); *A61H 2201/1253* (2013.01)

(57) **ABSTRACT**

A wearable tremor reduction device reduces tremor by internally generating forces which cancel or reduce the magnitude force of the tremor experienced by the person wearing the device. The device may be worn on a wrist, arm, ankle or leg. The device has a plurality of housing members which are connected together. Each housing member contains a mass which is translatable along an axis between a proximal limit and a distal limit, and a neutral position approximately midway between the proximal limit and the distal limit. Following imposition of a force having a component along the axis, a biasing means returns the mass to the neutral position.



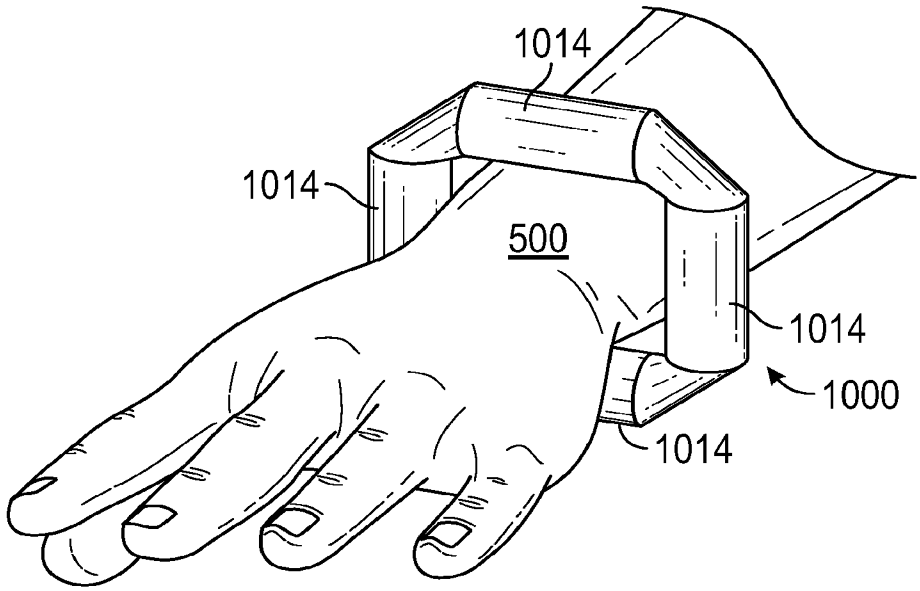

1014
1014
500
1014
1000
1014

FIG. 1

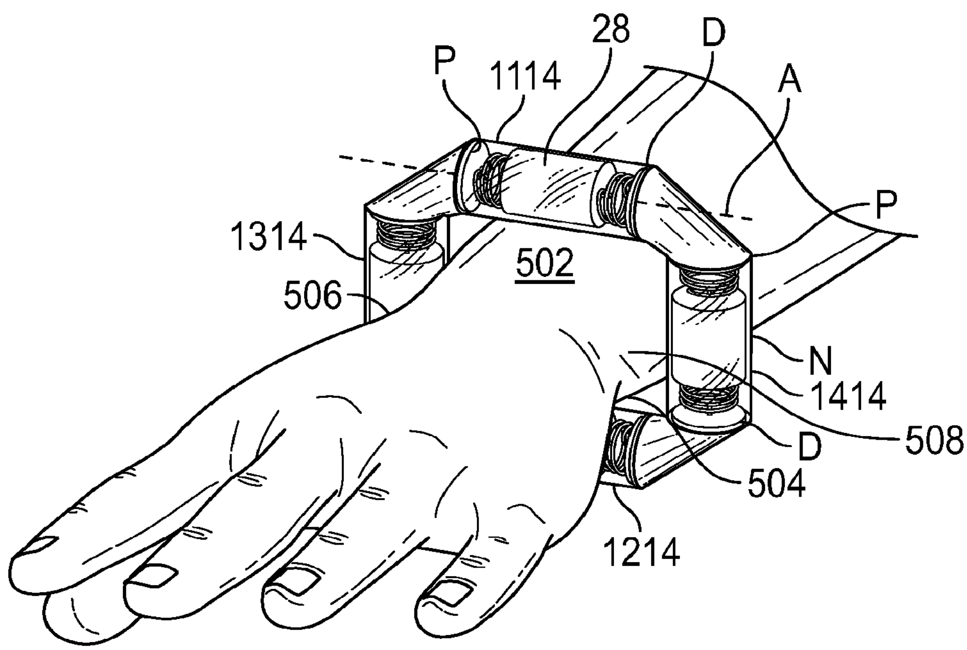

28
D
P
1114
A
P
1314
502
506
N
1414
508
D
504
1214

FIG. 2

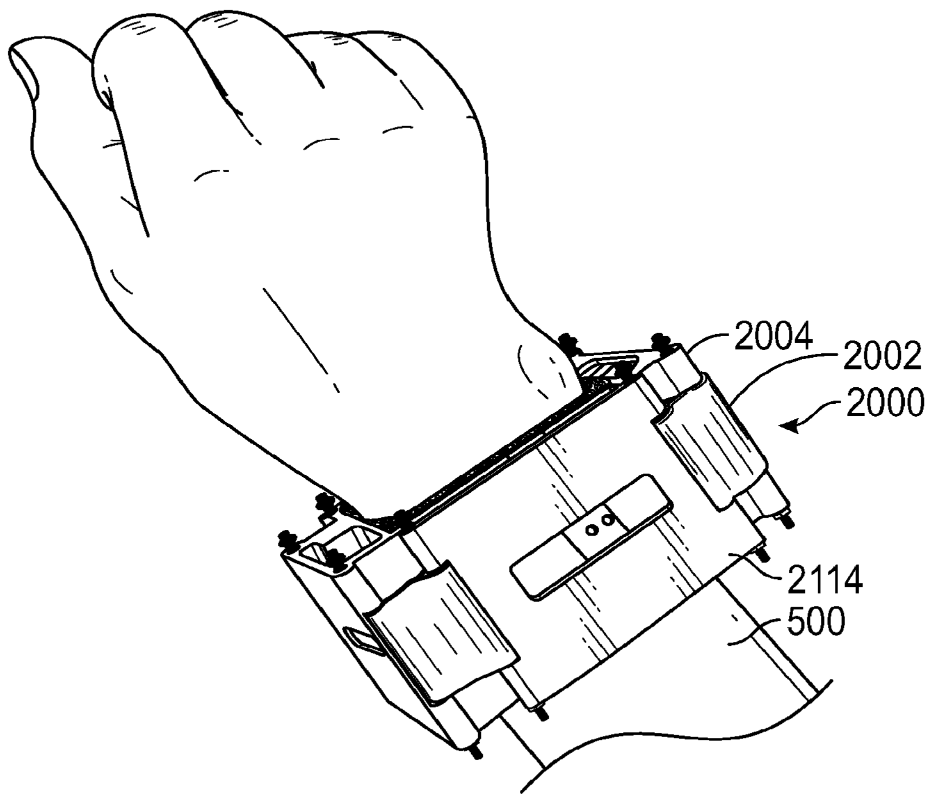

2004
2002
2000
2114
500

FIG. 3

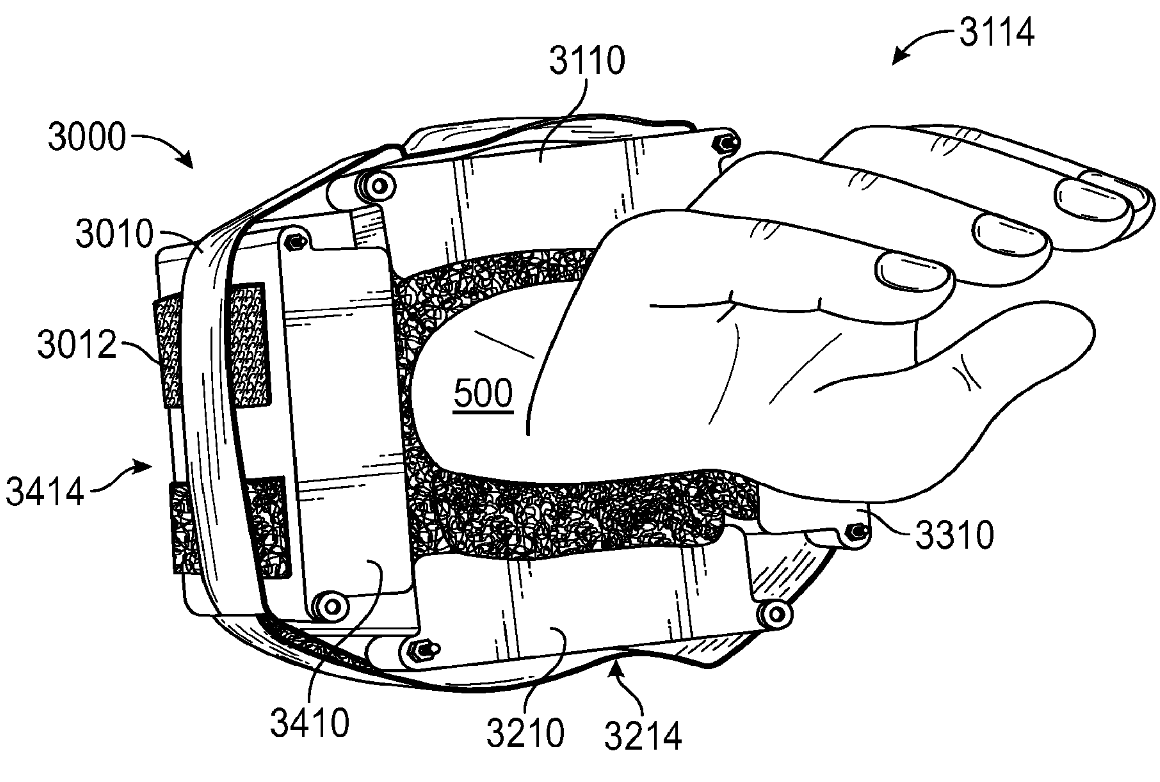

3114
3110
3000
3010
3012
500
3414
3310
3410
3210
3214

FIG. 4

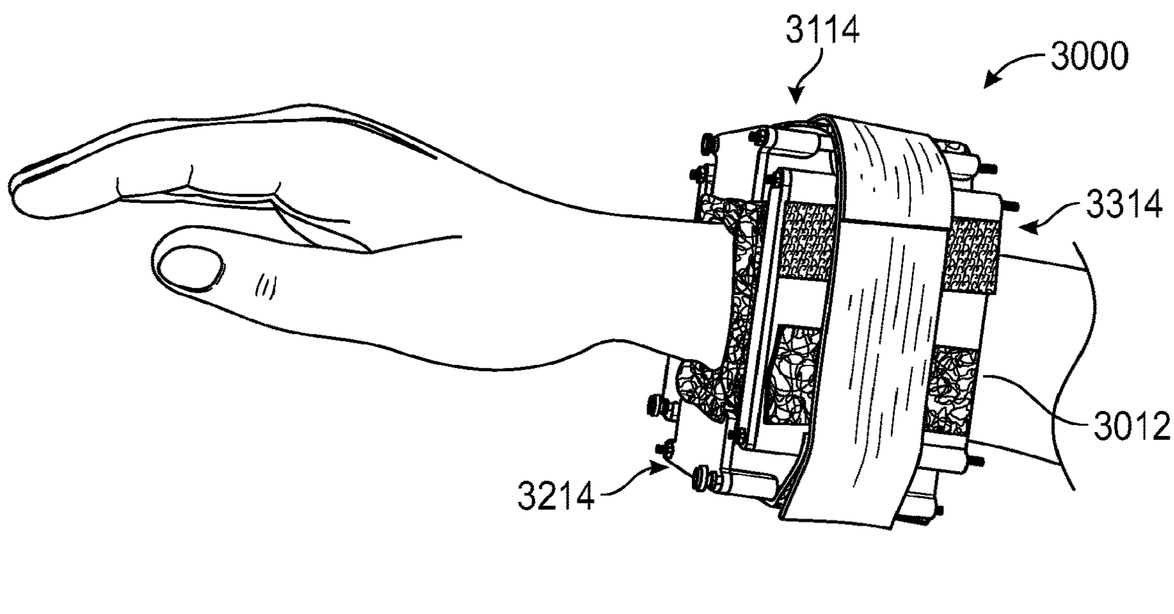

3114
3000
3314
3012
3214

FIG. 5

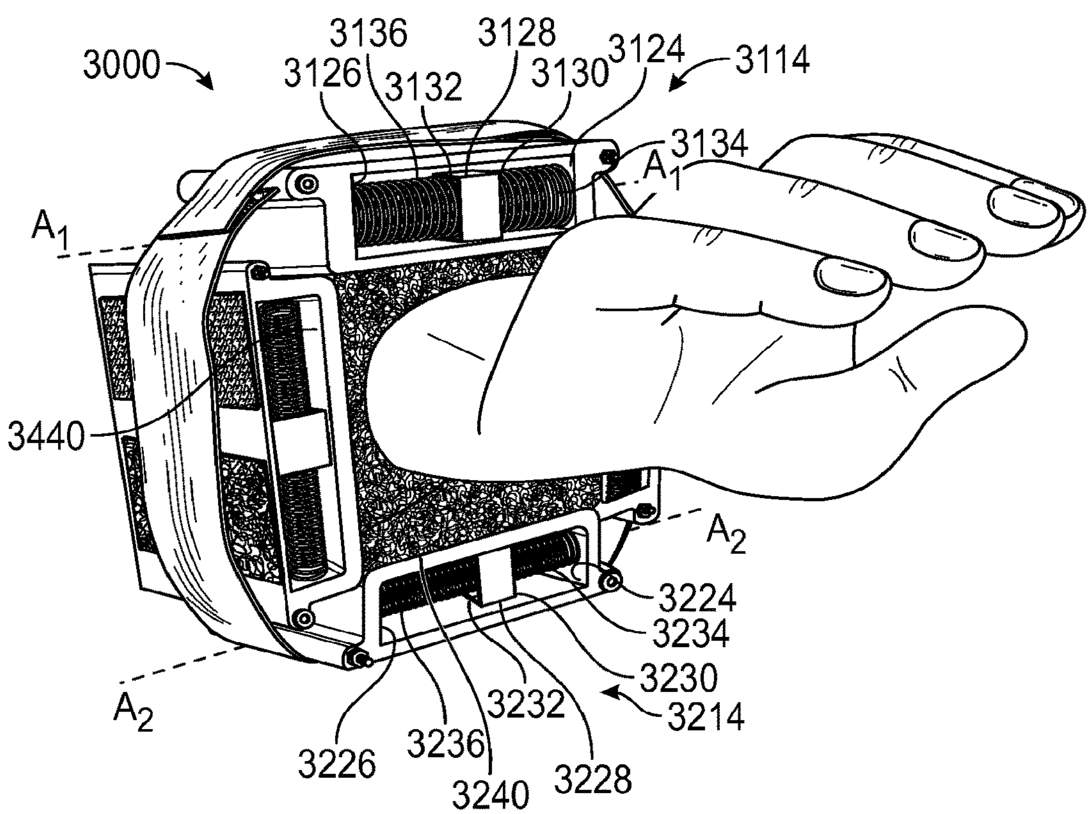

3000
3136
3128
3124
3114
3126
3132
3130
3134
A_1
A_1
3440
A_2
3224
3234
3230
3214
A_2
3226
3236
3232
3240
3228

FIG. 6

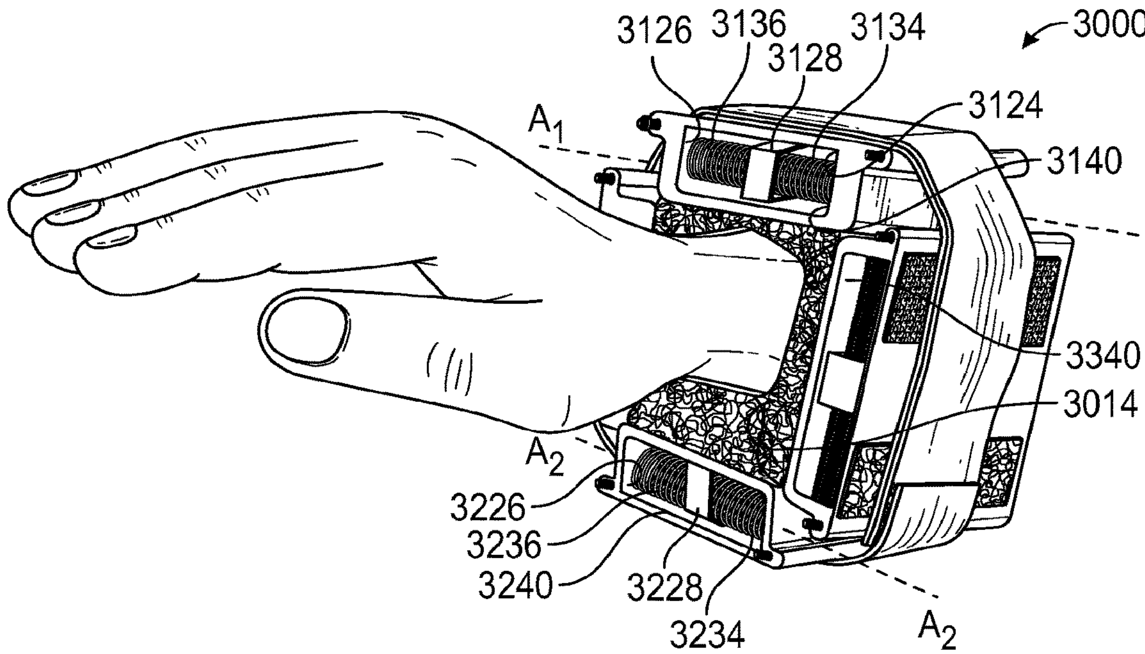

3000
3126
3136
3128
3134
3124
3140
A1
A1
3340
3014
A2
3226
3236
3240
3228
3234
A2

FIG. 7

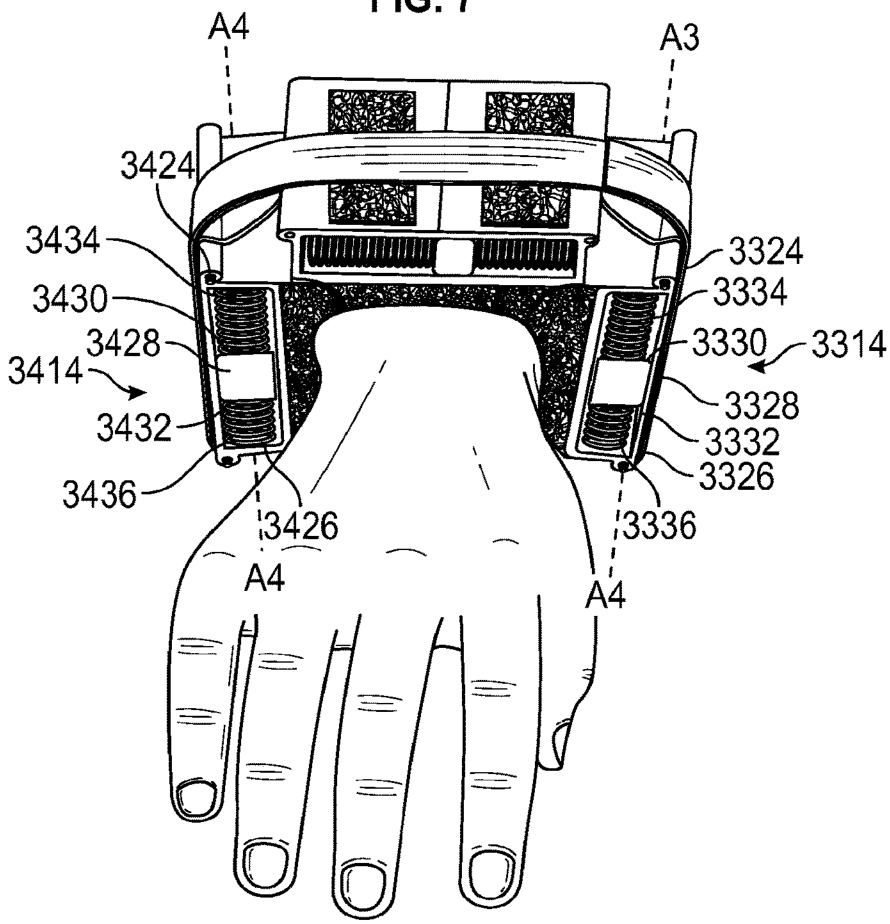

A4
A3
3424
3434
3430
3428
3414
3432
3436
3426
A4
3324
3334
3330
3314
3328
3332
3326
3336
A4

FIG. 8

FIG. 9

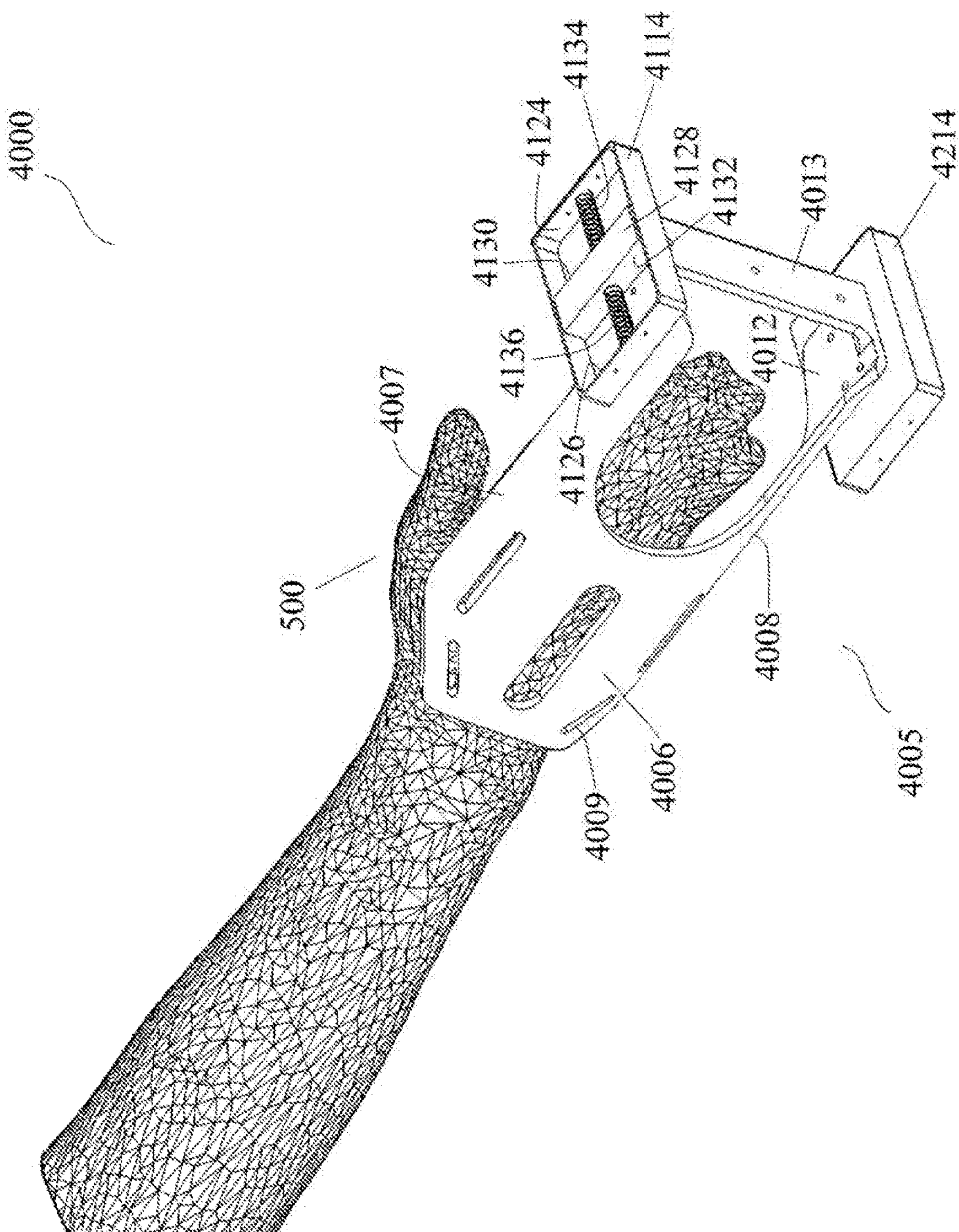
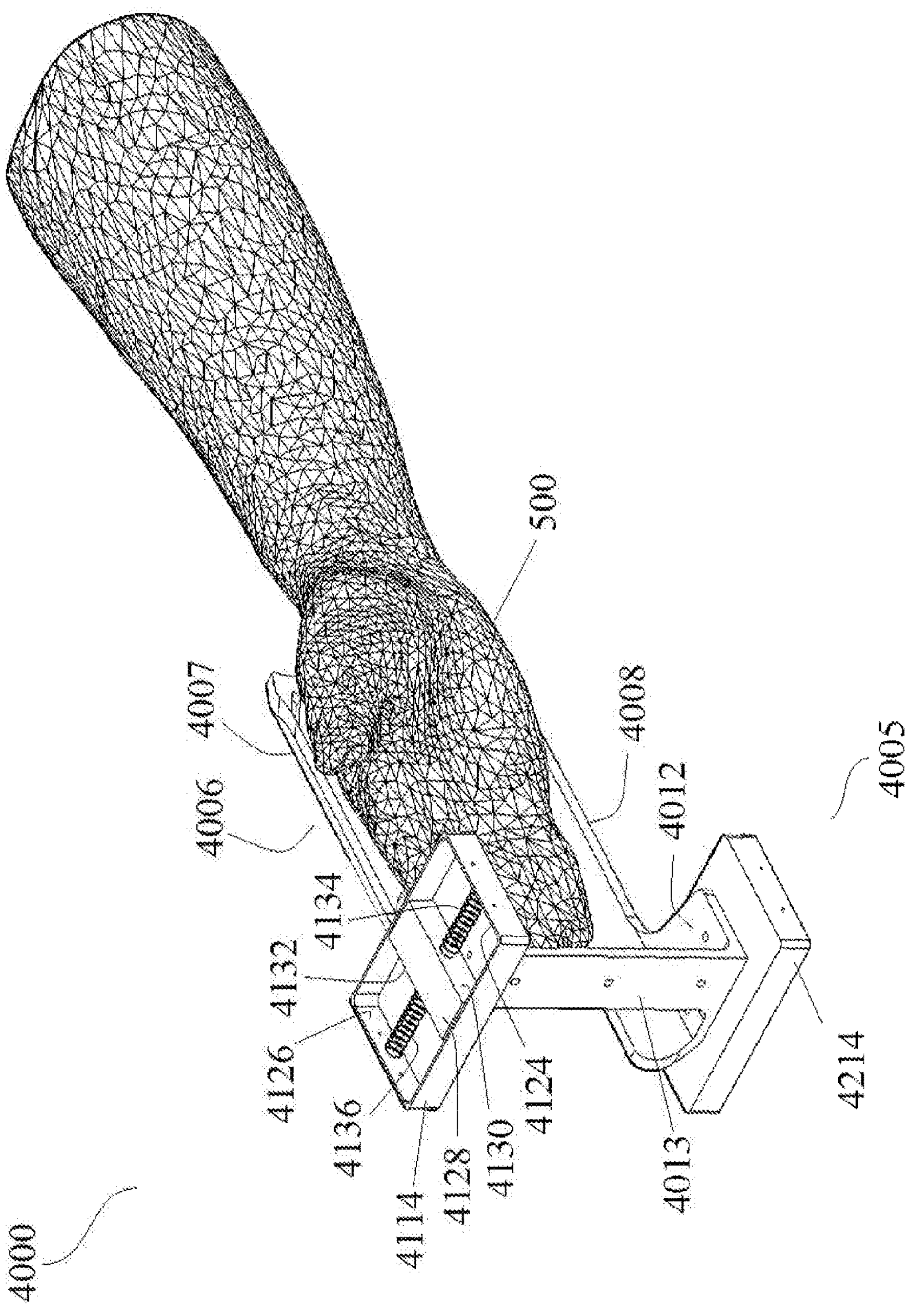

4000
4124
4134
4114
4128
4132
4130
4013
4214
4136
4007
4012
4126
500
4008
4006
4005
4009

FIG. 10


4000
500
4007
4006
4008
4005
4012
4134
4132
4126
4136
4114
4128
4130
4124
4013
4214

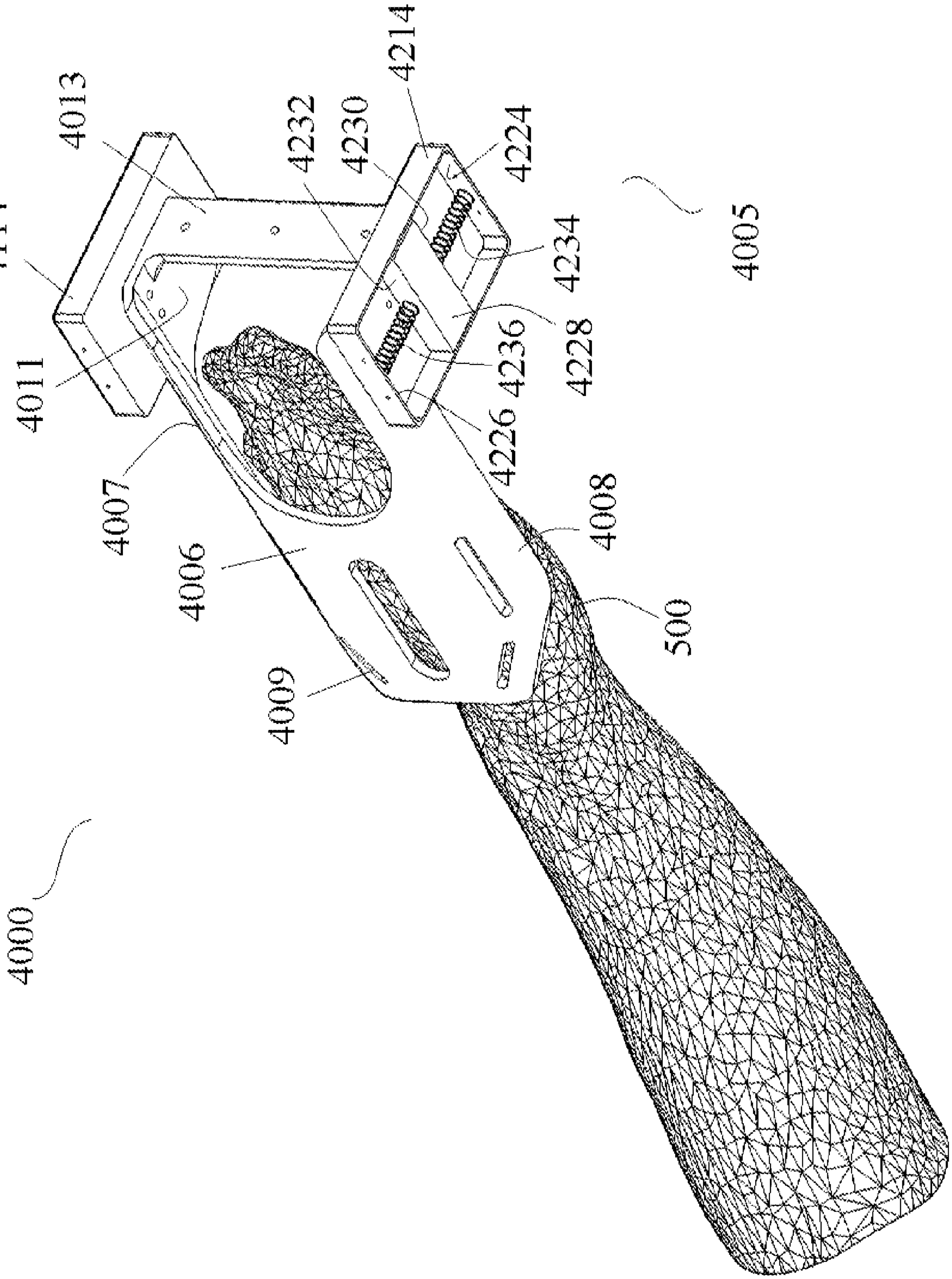
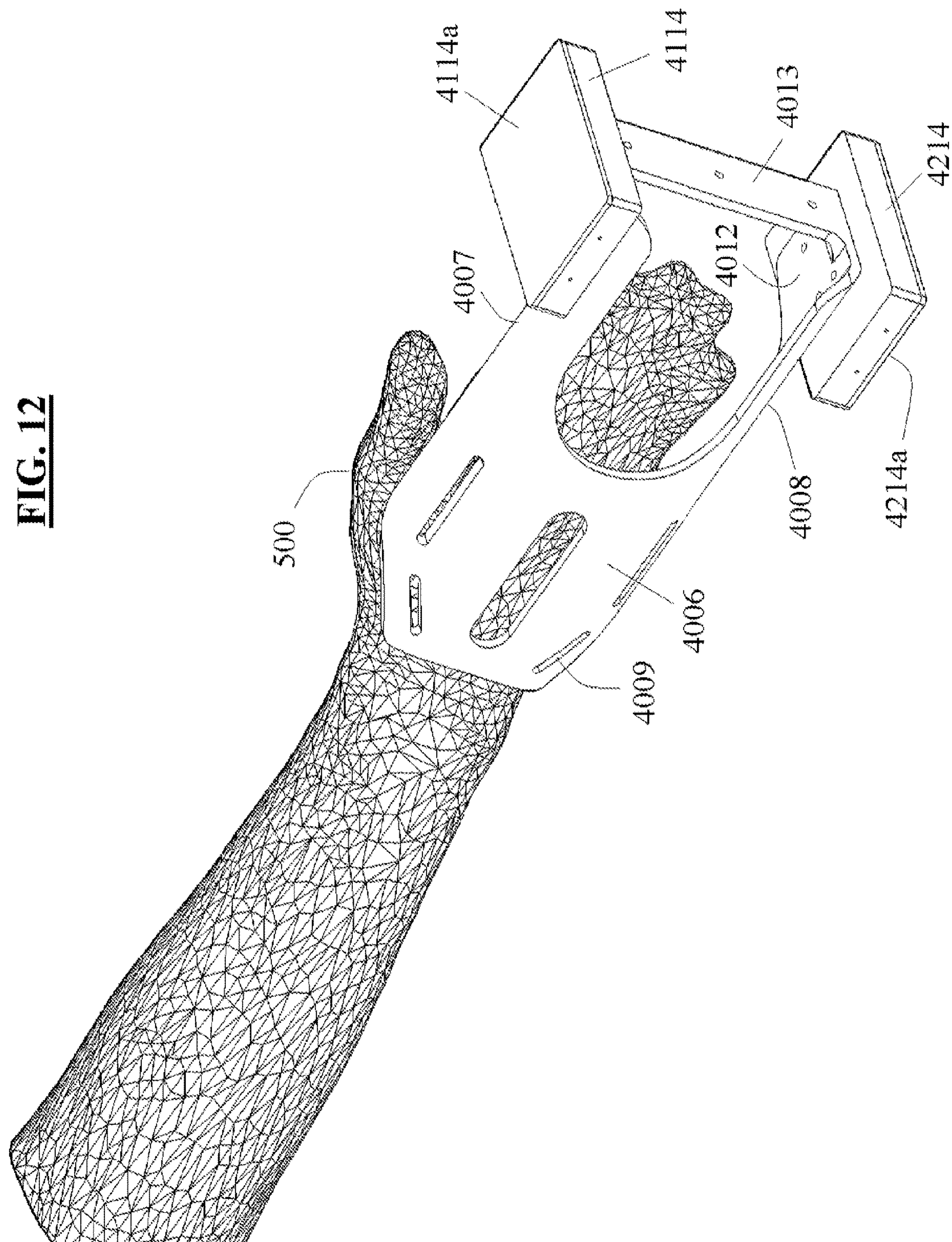

4114
4013
4232
4230
4214
4224
4005
4234
4011
4236
4228
4226
4007
4008
4006
500
4009
4000

FIG. 11

FIG. 12



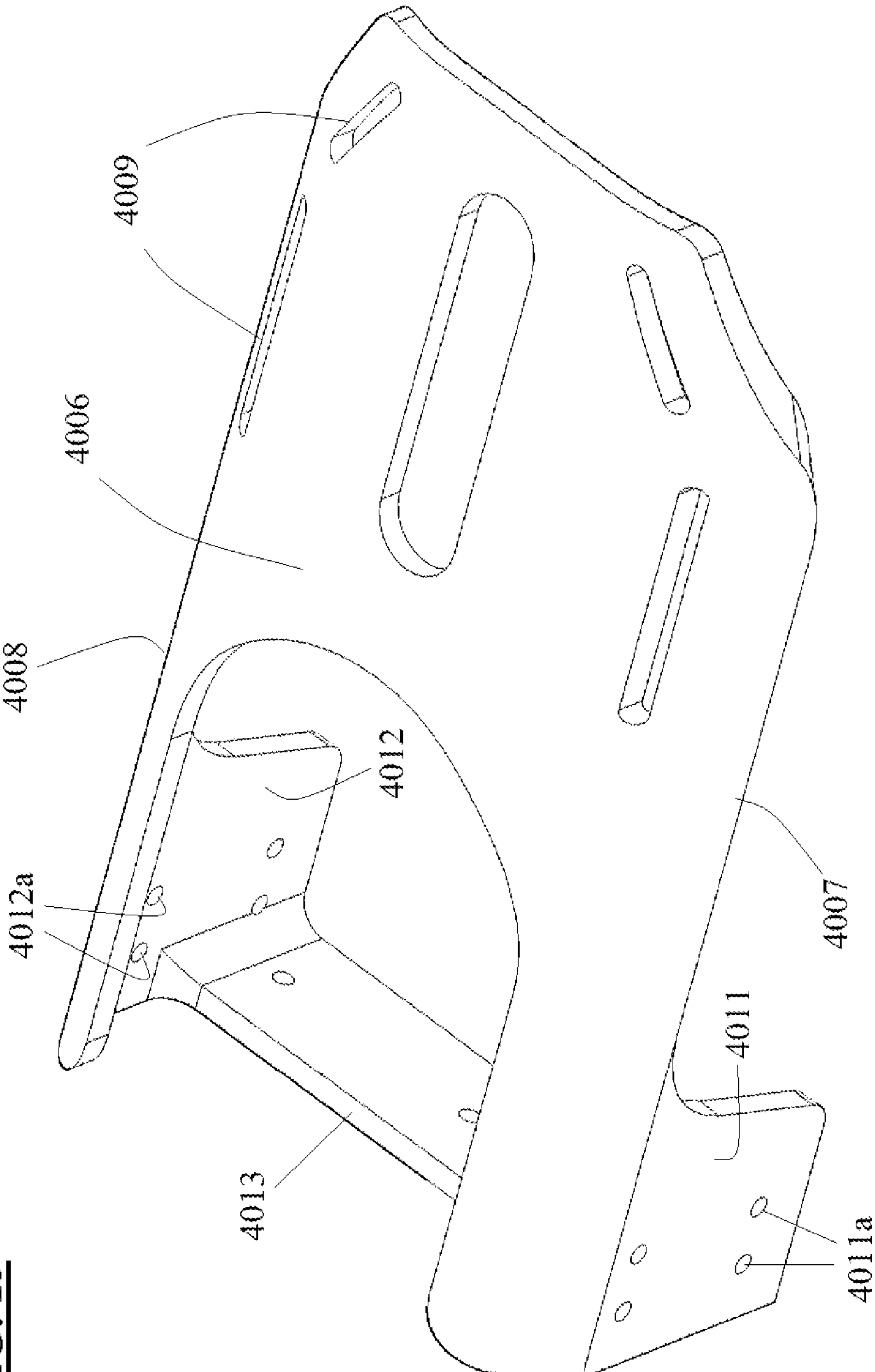


FIG. 13

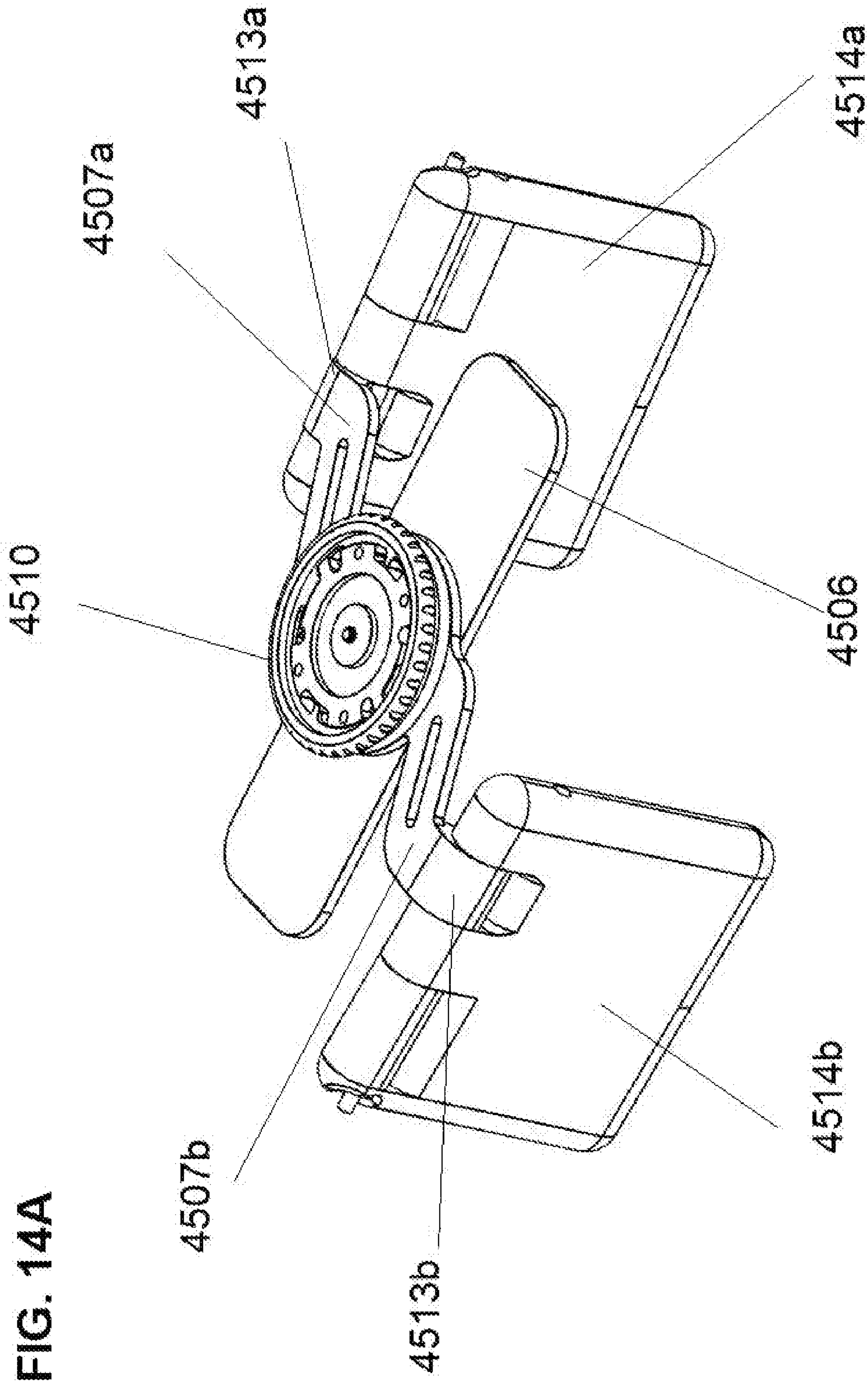


FIG. 14A

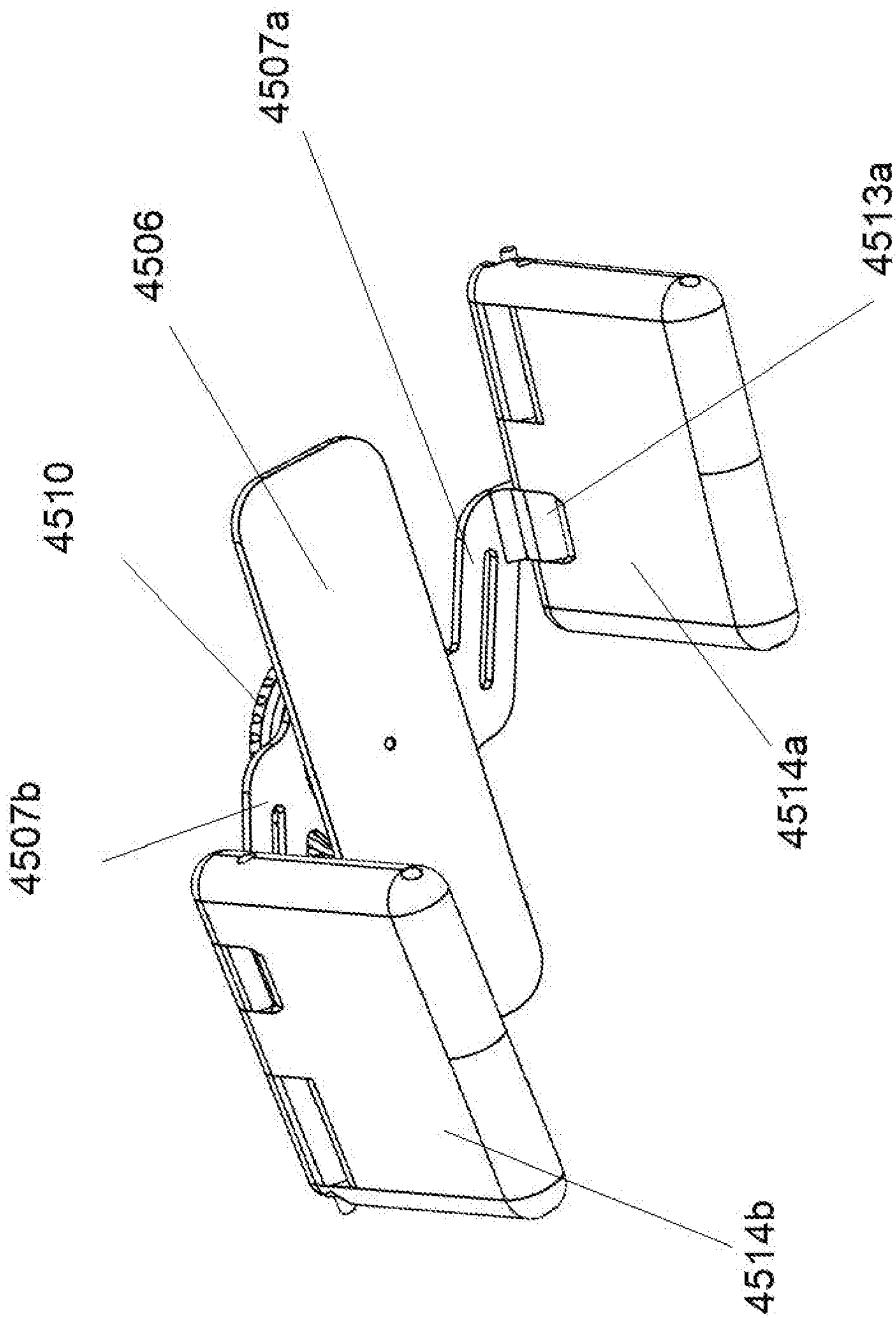


FIG. 14B

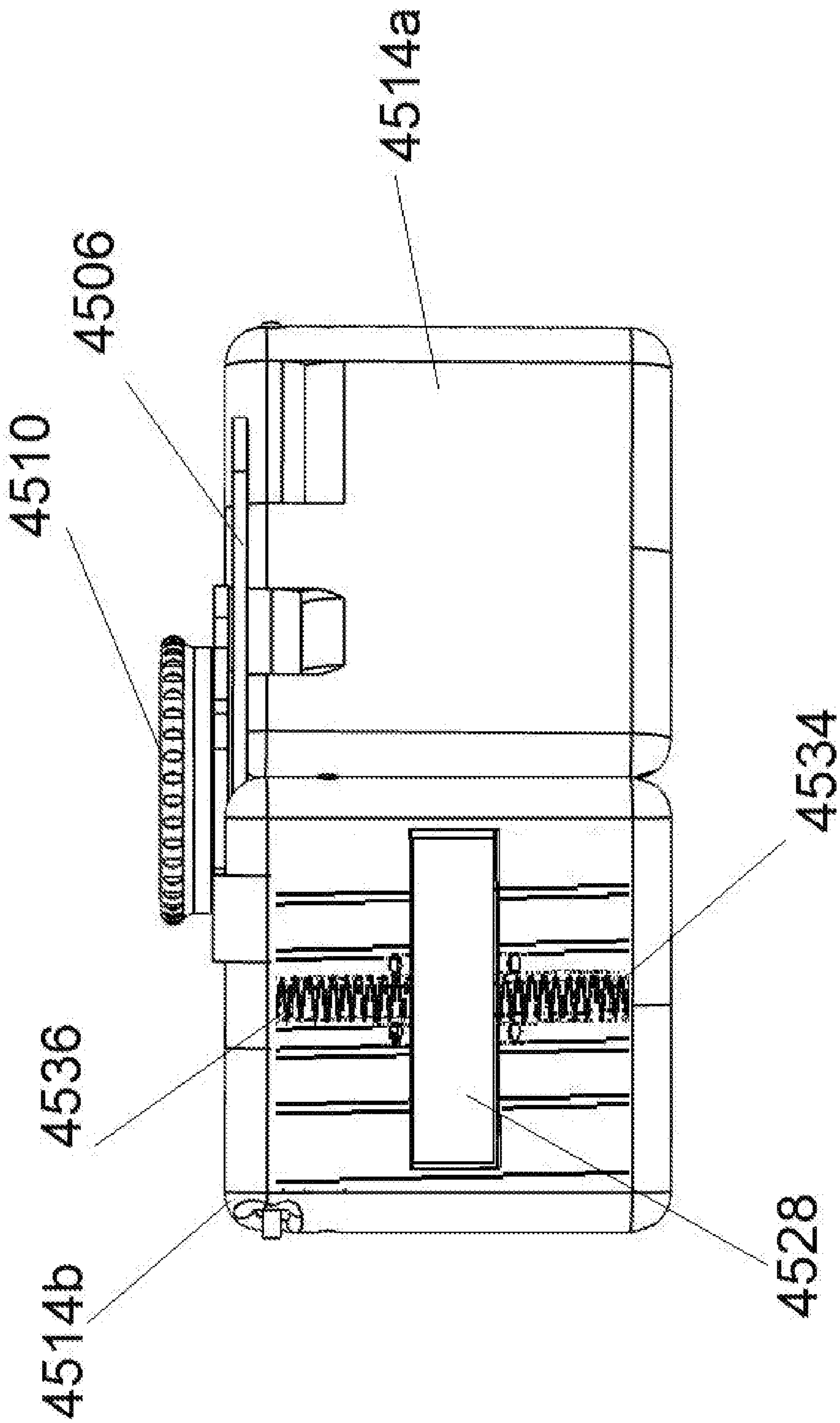


FIG. 14C

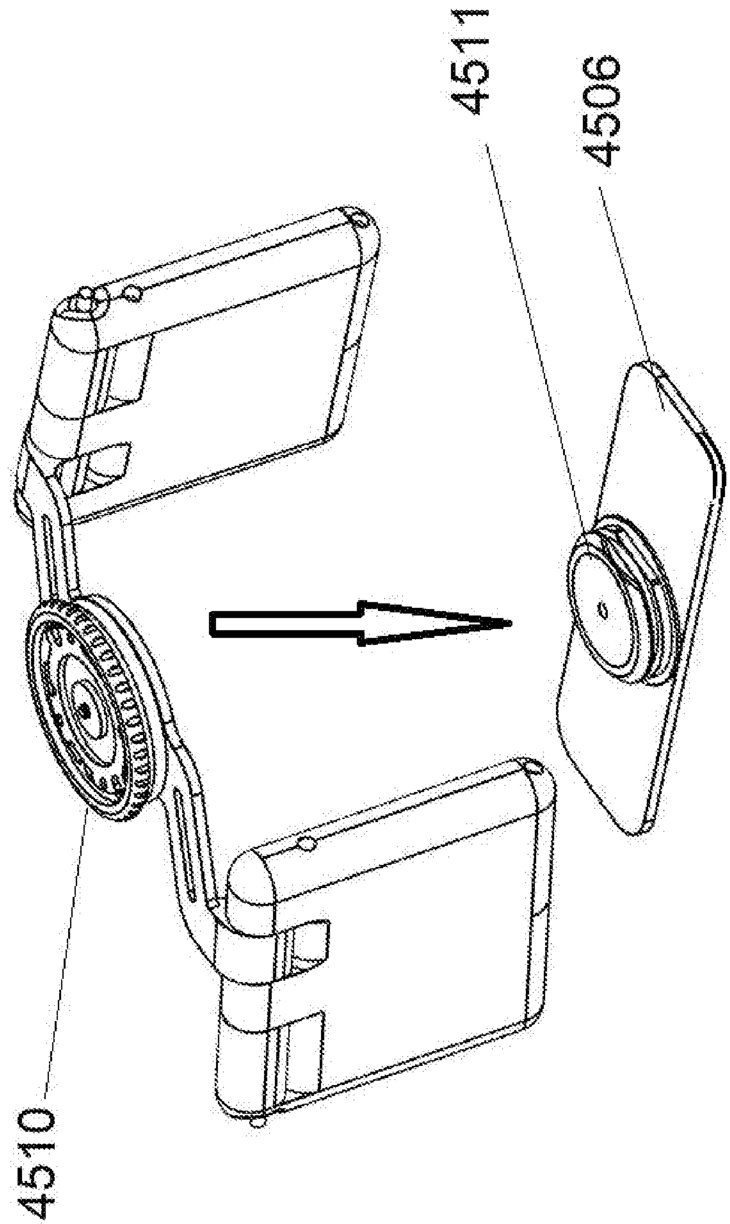


FIG. 14D

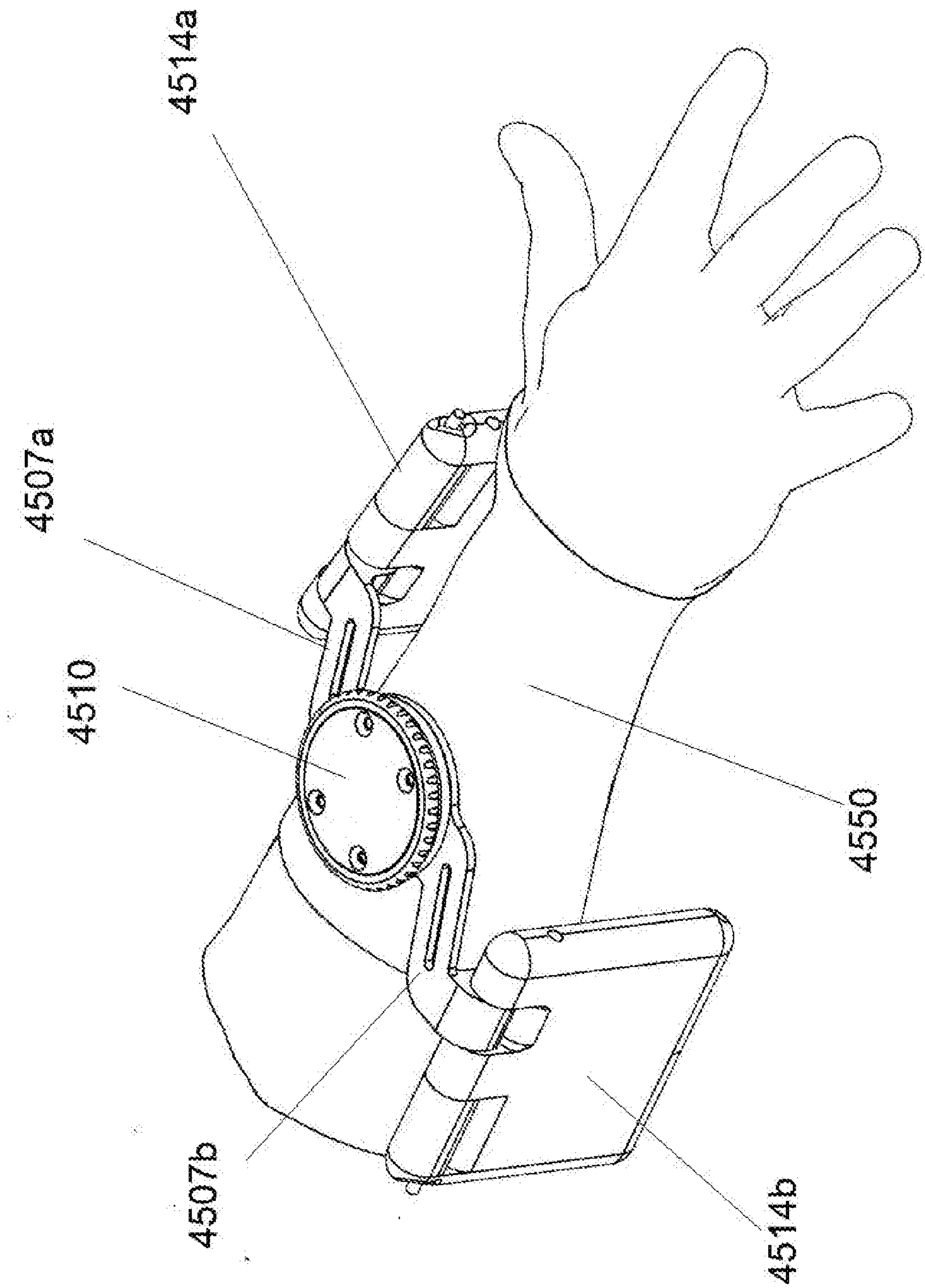


FIG. 14E

FIG. 15A

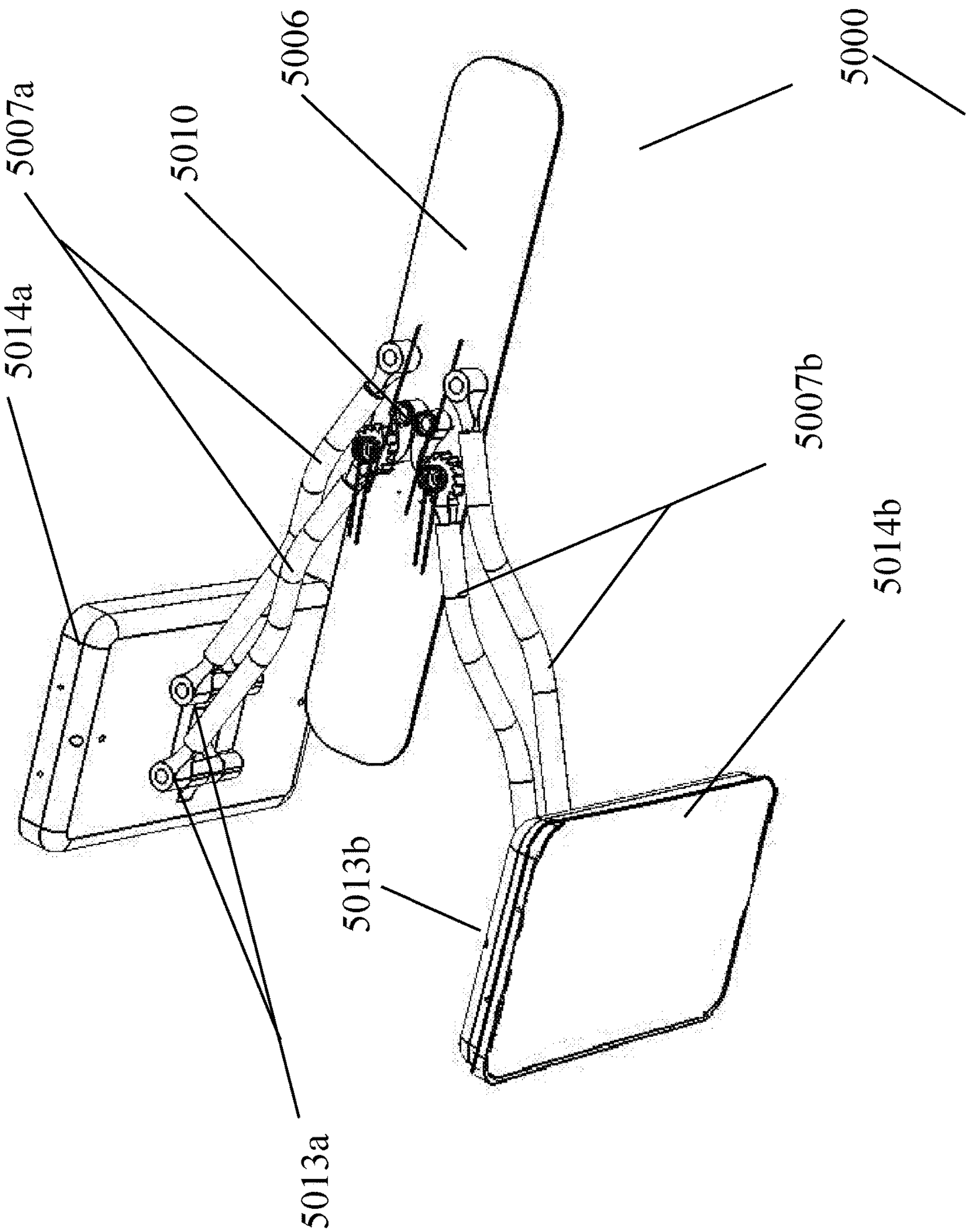


FIG. 15B

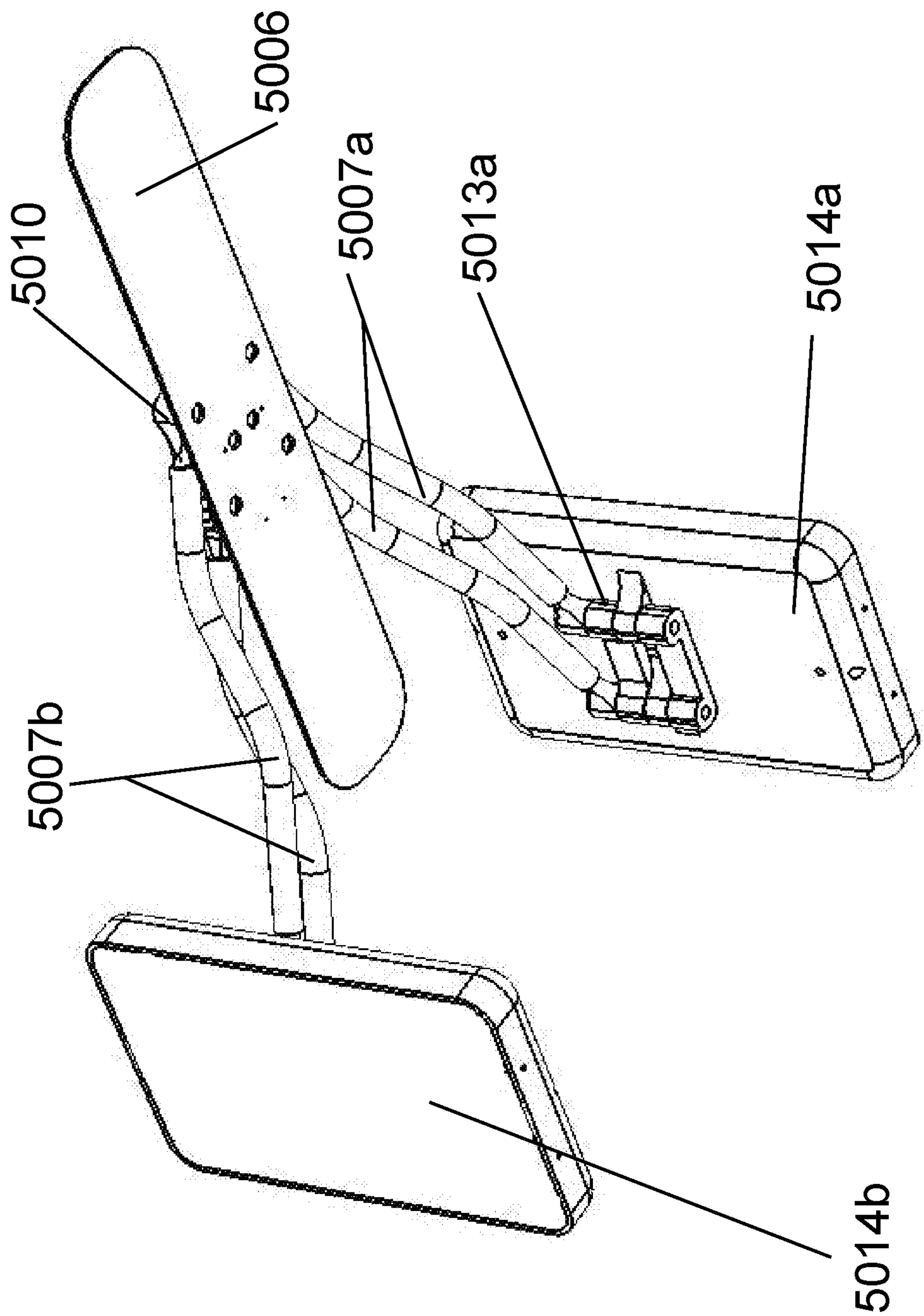


FIG. 15C

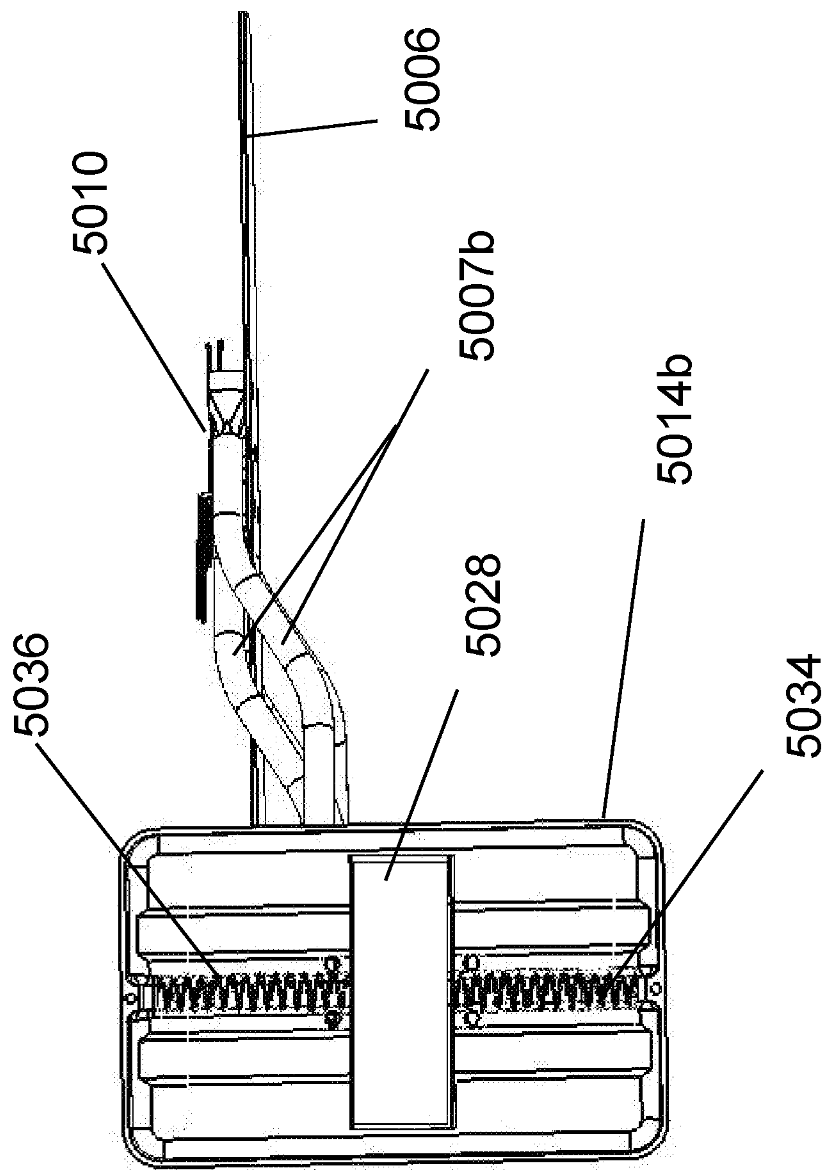


FIG. 15D

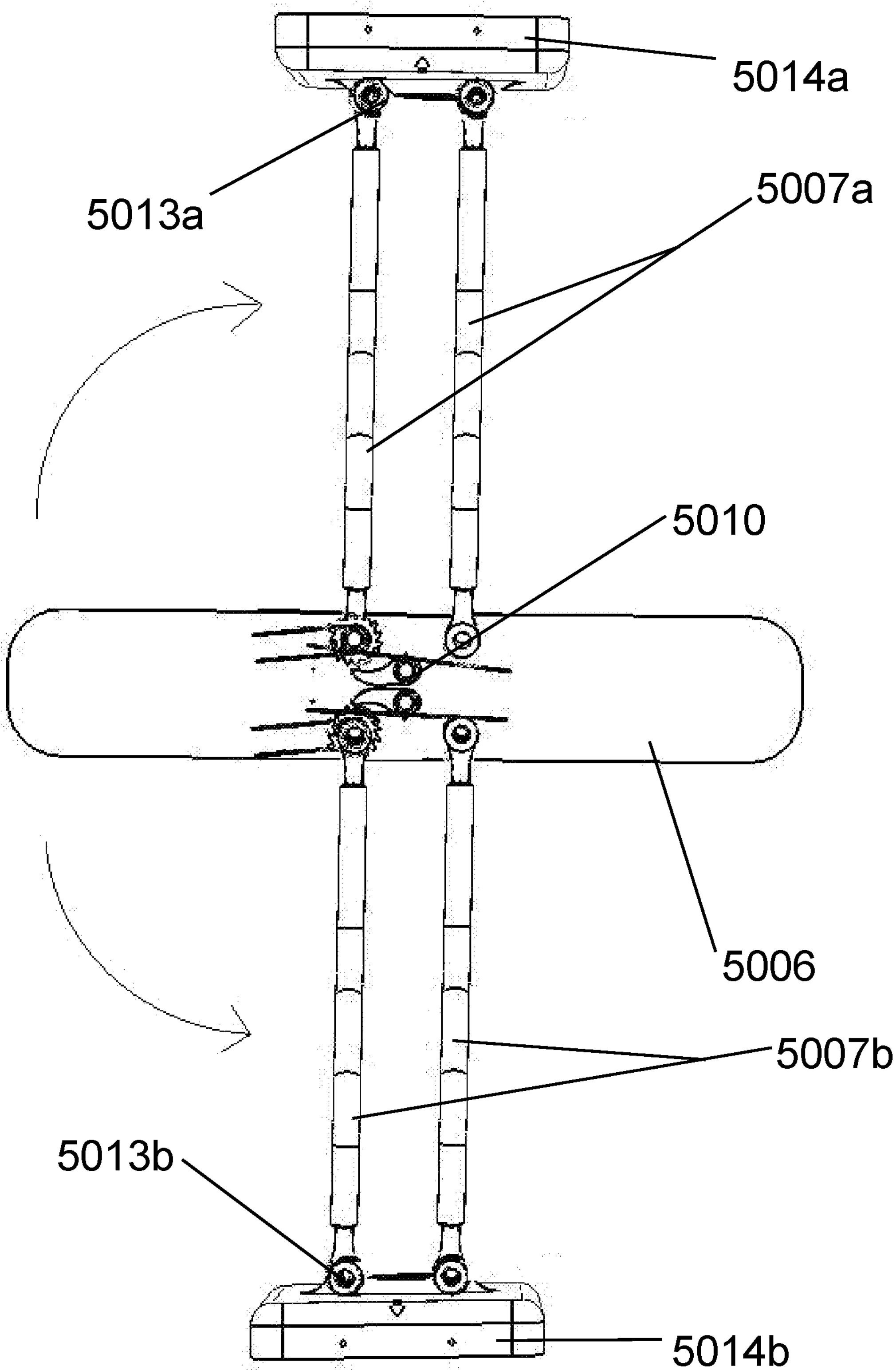


FIG. 15E

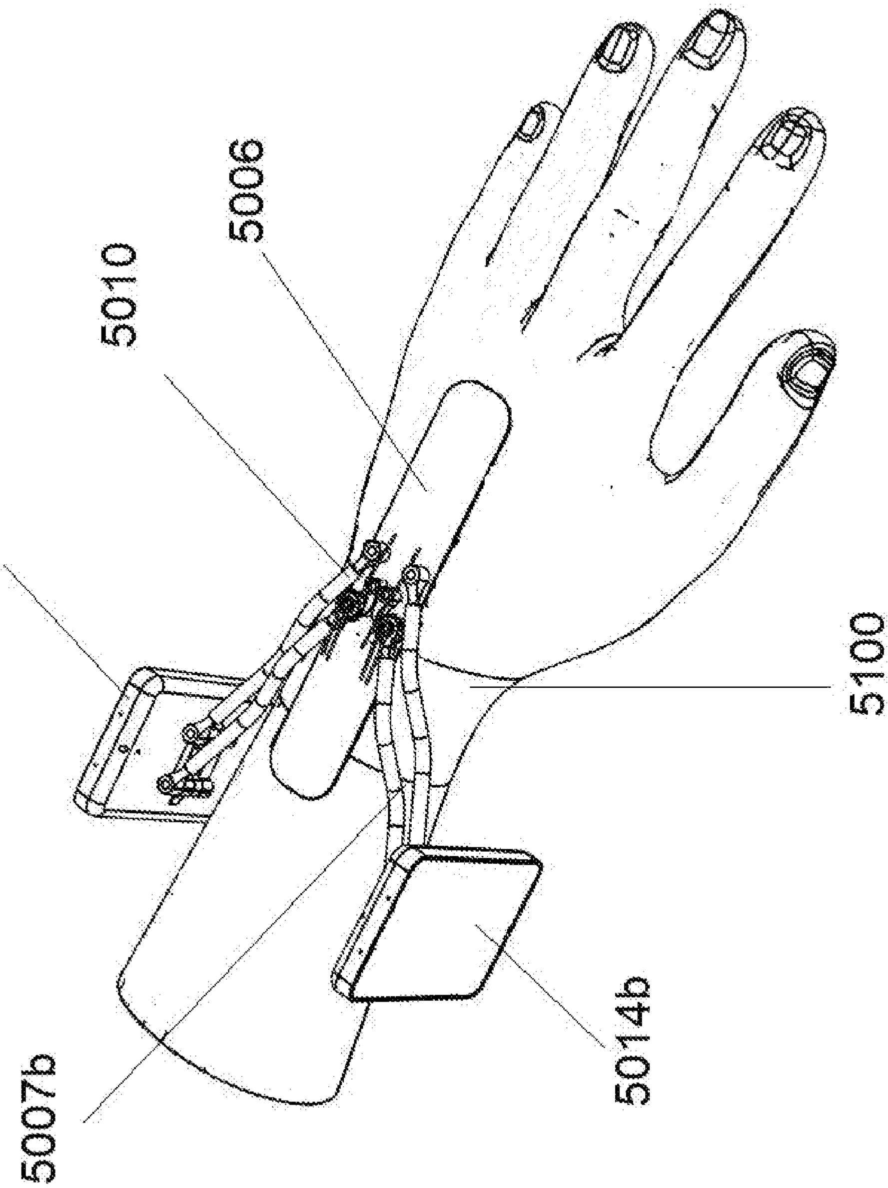


FIG. 16A

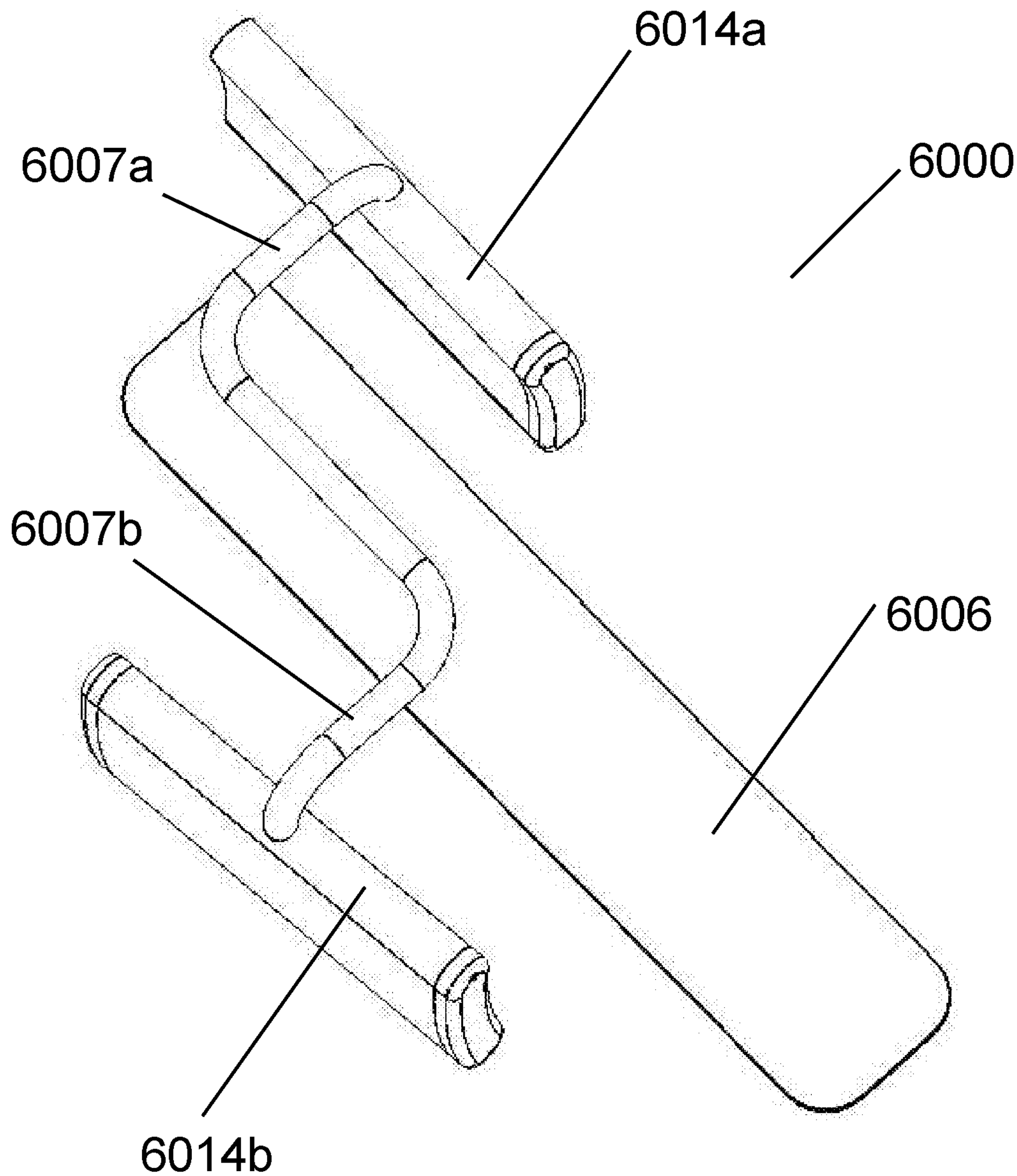


FIG. 16B

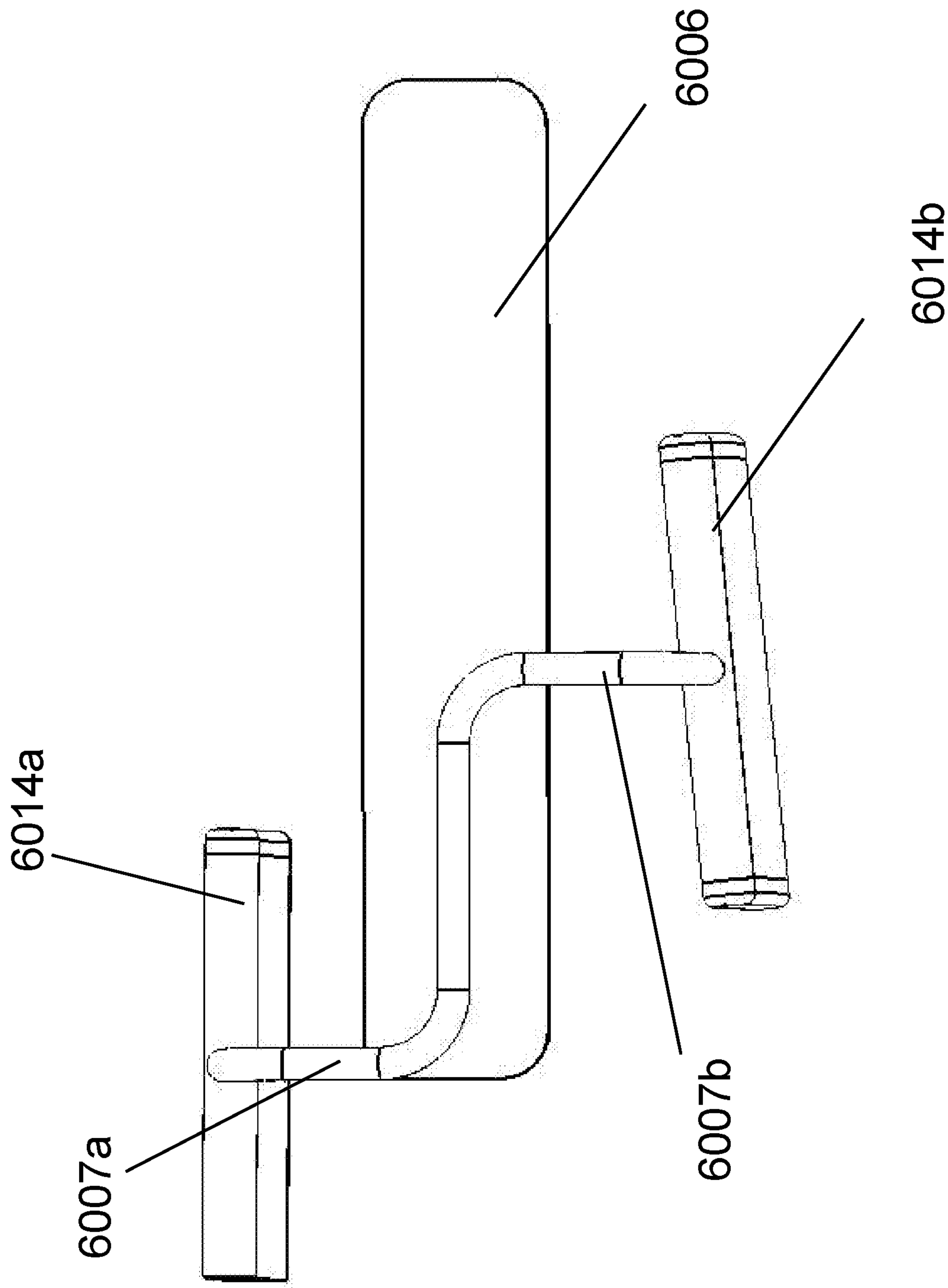


FIG. 16C

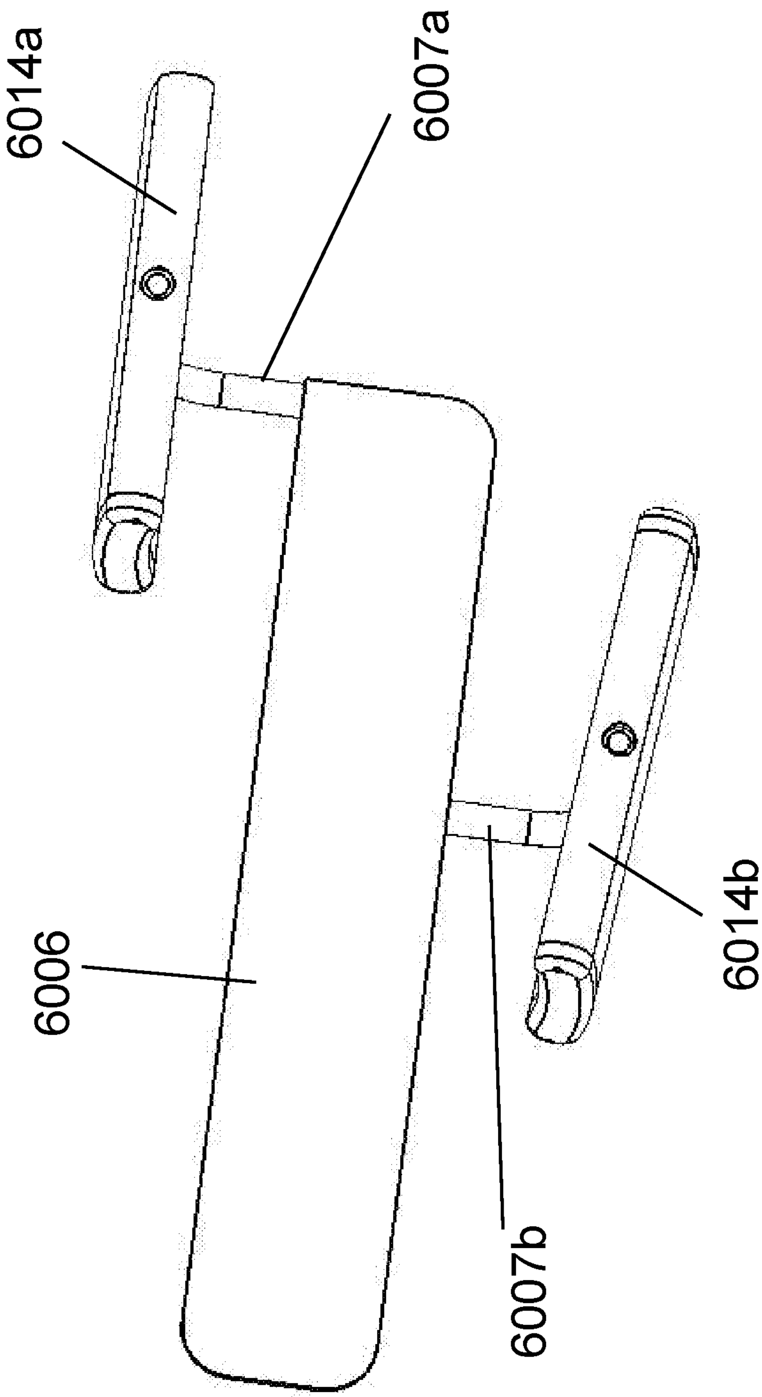
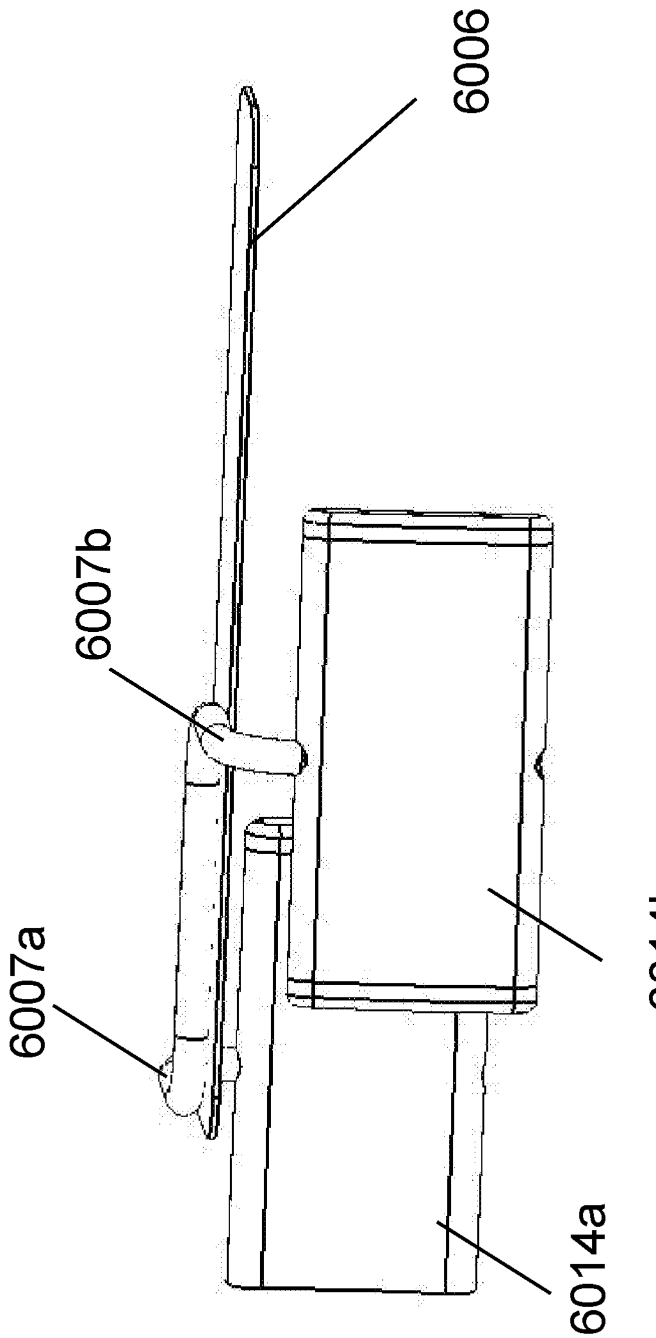


FIG. 16D



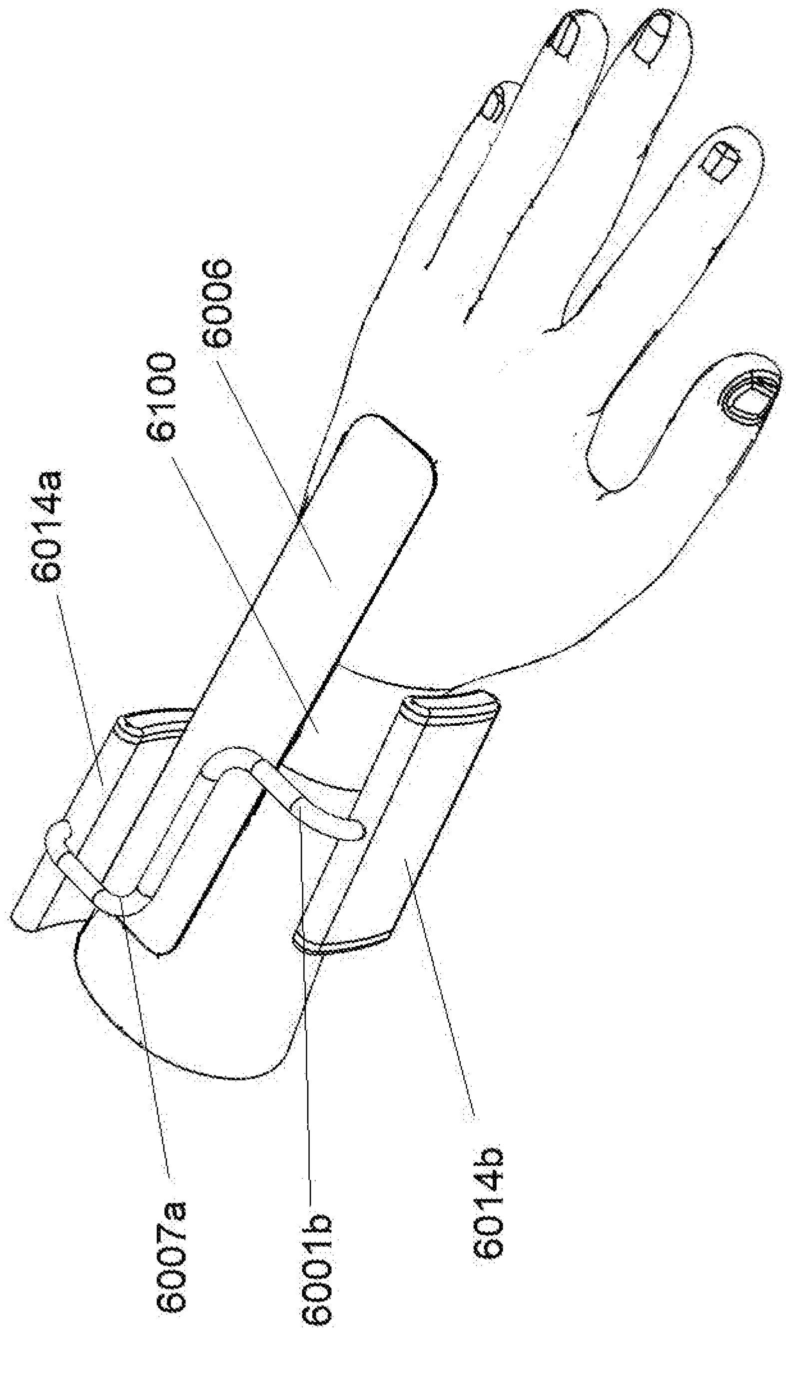


FIG. 16E

TREMOR REDUCTION DEVICE

FIELD OF THE INVENTION

[0001] The present invention relates to improved devices for dampening tremors or uncontrolled movements of the body, and specifically to dampening tremors of the hand.

DISCUSSION OF THE BACKGROUND

[0002] Tremors of various extremities of the human body are common movement disorders, characterized by rhythmic oscillations of the extremity around one or more joints. One of the most important characteristics to be assessed in a patient's tremor is the tremor frequency, which is measured in oscillations per second or cycles per second (Hz). Another important characteristic of tremor is amplitude, which is the linear or angular displacement of the limb or body part. Tremor amplitude is measured in millimeters or degrees. Tremor frequency and amplitude can be measured to a relatively high degree of accuracy by known apparatus and methods.

[0003] Tremors which are caused by Parkinson's disease, i.e., Parkinsonian tremor, and essential tremor can significantly impact the quality of life of the person suffering from these maladies. Daily functions, such as eating, combing one's hair, brushing teeth, etc., which functions are generally taken for granted by persons without tremors—can be demanding and frustrating exercises for those suffering from tremors. Tremor magnitude is frequently reported as being the greater problem from persons suffering from the disorder, because it has a greater impact on a person's ability to perform these daily activities. Because of these issues, a variety of solutions to tremors have been proposed to provide relief from persons suffering from tremor.

[0004] While drug therapy has been employed to provide relief for persons suffering from these tremors, the expense and potential side effects of the treatment can be an obstacle. There have also been efforts to provide relief without using drugs utilizing electro-mechanical or mechanical devices. For example, one device utilizes a wearable tremor suppression exoskeleton, which appears as a robotic external structure. In the absence of external forces, this device applies dynamic internal forces on the upper limb programmed to reduce the tremor by applying biomechanical loads. Another device is a wearable orthosis which uses a DC motor to reduce tremors at each joint. Some tremor suppression devices attempt to suppress the tremors by application of pressure at a specific location on a human extremity to induce a tremor suppressing stimulus. Another device uses a forearm and wrist splint to attach at least one gyroscope. Other devices utilize braces having compartments containing a viscous fluid to dampen wrist flexion and extension tremor. Another device is a weighted glove which is customizable by size. Patients are able to adjust the weight of the glove by filling integrated pockets in the glove with circular weight disks.

[0005] With many of the known devices, the persons wearing the devices have complained that the devices are bulky, uncomfortable, too heavy, or simply did not provide a satisfactory solution to their tremor problem.

[0006] Thus, there is a need for a simple, relatively light, and effective device which suppresses tremors caused by Parkinson's disease and essential tremor.

SUMMARY OF THE INVENTION

[0007] The present invention relates to a tremor reduction device and methods of using the same. Embodiments of the present invention provide a solution to the need identified above. Embodiments of the invention create neutralizing forces which cancel or reduce the magnitude of the tremor experienced by the person wearing the device. Parkinsonian tremor typically has a frequency in the range of 3-7 Hz, while essential tremor typically has a frequency in the range of 4-12 Hz. The tremors may have a vertical component, a horizontal component, and a rotational component.

[0008] In some embodiments, the tremor reduction device may comprise a plurality of housing members connected together and connected to the hand, wrist, and/or forearm of the user. The housing members may be constructed from at least one of a rigid polymer or plastic, a metal, a metal alloy, carbon fiber, composite materials, and the like. Each housing member may contain a mass which is translatable along an axis between a proximal limit and a distal limit, and a neutral position midway between the proximal limit and the distal limit, where, following imposition of a force having a component along the axis, a biasing means (e.g., a spring) operable to return the mass to the neutral position. The housing members and the translatable masses therein may be arranged to absorb vibrational energy generated by the user's tremors, such Parkinsonian or essential tremors. The housing members and translatable weights may be arranged around the hand, wrist, and/or forearm of the user such that the weights are translatable along different axes, such as along one or more of the x, y, and z axes so that the vibrational energy directed in different axial directions. For example, the tremor reduction device may include at least two housings having weights that are translatable along orthogonal axes. The tremor reduction device may include three housings each having weights that are translatable along substantially orthogonal axes, such that each weight moves along one axis in an about x, y, z arrangement of the axes. The tremor reduction device may further include additional housing members having axes for a translatable weight that are arranged at oblique angles to translatable weight axes of other housings (e.g., to axes of the translatable weights in the first, second, and/or third housing members) such that further vibrational directions are directly addressed by the device. In other embodiments, two or more housings weights may be arranged such that the weights therein are translatable along substantially parallel axes. In still further embodiments, the housings and translatable weights may be arranged such that some of the translatable weights move along substantially parallel axes, while others move along substantially orthogonal axes and/or substantially oblique axes.

[0009] In some embodiments, the plurality of housing members may comprise one or more housing members in close mechanical connection to the hand, wrist, and/or forearm of the user. The tremor reduction device may include at least two housing members (first and second housings) arranged around, e.g., the wearer's wrist. The first housing member may have a first proximal sidewall and a first distal sidewall, where the first proximal sidewall and the first distal sidewall are in opposite facing, spaced-apart relation. A first mass may be disposed between the first proximal side wall and the first distal side wall, wherein the first mass may have a first proximal side and a first distal side. A first proximal spring may be disposed between the first proximal side wall and the first proximal side of the first mass, and a first distal spring may be disposed between the first distal side wall and the first distal side of the first mass.

[0010] The second housing member may have a second proximal sidewall and a second distal sidewall in opposite facing, spaced-apart relation. A second mass may be disposed between the second proximal side wall and the second distal side wall, wherein the second mass has a second proximal side and a second distal side. A second proximal spring may be disposed between the second proximal side wall and the second proximal side of the second mass, and a second distal spring may be disposed between the second distal side wall and the second distal side of the second mass. The translatable weights of the first and second housings may be positioned substantially orthogonally relative to one another to absorb vibrational energies in different directions. In other embodiments, the translatable weight of the first housing may move along an axis that is substantially parallel to the axis of the translatable weight of the second housing.

[0011] The tremor reduction device may further include a third housing member having similar construction to the first and second housing members. The third housing member may have a third proximal sidewall and a third distal sidewall in opposite facing, spaced-apart relation. A third mass may be disposed between the third proximal side wall and the third distal side wall, wherein the third mass has a third proximal side and a third distal side. A third proximal spring may be disposed between the third proximal side wall and the third proximal side of the third mass, and a third distal spring may be disposed between the third distal side wall and the third distal side of the third mass. The third housing member may have a translatable weight that moves along an axis that is substantially orthogonal to both the axes of translatable weights in the first and second housings, which may be positioned substantially orthogonally relative to one another. In other embodiments, the translatable weight of the third housing member may move along an axis that is substantially parallel to one or both of the axes of the translatable weights of the first and second housings. In still other embodiments, the translatable weight of the third housing may move along an axis that is oblique to one or both of the axes of the translatable weights of the first and second housings.

[0012] The tremor reduction device may further include a fourth housing member having similar constructions to the first, second, and third housing members. The fourth housing member may have a fourth proximal sidewall and a fourth distal sidewall in opposite facing, spaced-apart relation. A fourth mass may be disposed between the fourth proximal side wall and the fourth distal side wall, wherein the fourth mass has a fourth proximal side and a fourth distal side. A fourth proximal spring may be disposed between the fourth proximal side wall and the fourth proximal side of the fourth mass, and a fourth distal spring may be disposed between the fourth distal side wall and the fourth distal side of the fourth mass. The fourth housing member may have a translatable weight that moves along an axis that is substantially orthogonal to at least one of the axes of the translatable weights in the first, second, and third housings. In other embodiments, the translatable weight of the third housing may move along an axis that is substantially parallel to one of the axes of the translatable weights of the first, second, and third housings. In still other embodiments, the translatable weight of the fourth housing may move along an axis that is oblique to one of the axes of the translatable weights of the first, second, and third housings. Further embodiments may include additional housing containing translatable weights that are positioned substantially parallel, perpendicular, or oblique to the other housings of the tremor reduction device.

[0013] In some embodiments, the plurality of housings may be connected to the wrist of the individual. For example, each of the four housings described above may be positioned on one side of the wrist (e.g., the first housing may be positioned on the lateral side of the wrist, the second housing may be positioned on the posterior side of the wrist, the third housing may be positioned on the medial side of the wrist, and the fourth housing may be positioned on the anterior side of the wrist). The housings may be held together around the wrist by fastening or binding structures between the housings, such as flexible straps, adjustable connectors, pivoting joints between the housings, combinations thereof, and/or other mechanisms.

[0014] In some embodiments, the first housing member may be flexibly linked to the second housing member, the second housing member may be flexibly linked to the third housing member, the third housing member may be flexibly linked to the fourth housing member, and the fourth housing member may be flexibly linked to the first housing member, thereby forming an interconnected band adapted to encircle a limb (i.e., a wrist) of the user.

[0015] In other embodiments, the present invention may provide a tremor reduction device comprising a frame structure that attaches to the hand, wrist, and/or forearm of the user and supports one or more housing members at a position adjacent to (e.g., lateral, medial, or distal to) the user's hand wrist, or forearm. The securing frame may comprise a coupling plate having a shape that is complementary to the portion of the user's body (e.g., a portion of the hand, a portion of the wrist, and/or a portion of the forearm), having contouring to accommodate the shape of the portion of the user's body, creating an ergonomic fit. For example, the coupling plate may comprise a shape which is complementary to the shape of a back side of a user's hand for an ergonomic fit (e.g., a substantially flat plate with gently curving downturned edges, the edges curving around the sides of the hand).

[0016] The coupling plate may further comprise an attachment element operable to secure the plate to the user's hand, wrist, and/or forearm. For example, the coupling plate may include securing straps that pass through a plurality of slots in the coupling plate and operable to cinched over the user's hand, wrist, and/or forearm to hold the securing frame in place on the user. The straps may include a fastening element such as a snap, a buckle, a hook, a hook and loop device (i.e., Velcro), and the like operable to releasably hold the straps in place around the hand, wrist, or forearm of a user. In some embodiments, the straps may comprise an elastic material operable to stretch around the hand, wrist, and/or forearm of the user and retract to hold the frame structure in place on the user.

[0017] The frame structure may include a scaffolding for connecting one or more brackets to the coupling plate. The scaffolding may extend from an edge or a surface of the coupling plate. For example, the scaffolding may extend medially, laterally or distally from the coupling plate, such that it holds the housing member(s) at a short distance from the coupling plate and the user's hand, wrist, or forearm. The scaffolding may include one or more brackets or attachment points, each operable to receive and secure a housing member containing a translatable weight. In some embodiments, the brackets or attachment points may each be engaged with one or more housing members secured thereto by fasteners. The one or more housings may be secured to the bracket or attachment point by at least one of a screw, a bolt, a rivet, pressure fitting, tab and slot fasteners, an adhesive, and/or other fastening mechanisms.

[0018] In some embodiments, the arrangement of the one or more brackets or attachment points on the scaffolding may position the housings such that the axes of the translatable weights within each housing are substantially parallel, substantially perpendicular, or oblique. For example, the scaffolding may include a first bracket that is lateral to the hand, wrist, or forearm, and a second bracket that is medial to the hand, wrist, or forearm, such that the housing members attached to the brackets and the axes of the translatable weights therein are on substantially parallel planes. The axes of the translatable weights in the first and second housing members may be substantially parallel or substantially perpendicular to each other. The scaffolding may include further brackets for positioning additional housing members such that the axis along which the translatable weight therein moves is substantially parallel, substantially perpendicular, or oblique to the axes of the translatable weights in the first and second housing members. For example, the scaffolding may include a third bracket that is posterior to the hand, wrist, or forearm of the user and perpendicular to the first and second brackets. A third housing member may be secured to the third bracket, positioning the third housing member such that an axis along which the translatable weight therein moves is perpendicular to the axes of the translatable weights in both of the first and second housings. In some embodiments, the scaffolding may include further brackets or attachment points to which additional housing members are attached having translatable weights that move along axes that are substantially parallel, substantially perpendicular, or oblique to the axes of the translatable weights in the other housing members attached to the scaffolding.

[0019] In some embodiments, the tremor reducing device may include two translatable masses that are arranged such that one translatable mass is lateral to the hand, wrist, or arm, and one translatable mass is medial to the hand wrist or arm. The scaffolding of the frame structure may hold the translatable masses in spaced arrangement to the hand, wrist, or arm such that they flank the hand, wrist, or arm (e.g., located distally to the hand). The axes along which the translatable axes slide may be substantially parallel to each other and substantially perpendicular to the length of the patient's arm. This arrangement of the translatable masses results in the translatable masses to counter-act and dampen extension/flexion motions (e.g., at the wrist) and supination/pronation motions (e.g., at the forearm). When extension or flexion occurs, the first and second translatable masses move in the same direction in response and thereby dampen the tremor motion. When supination or pronation occurs, the first and second translatable masses move in opposite directions, counter-acting the rotational motion created by the supination/pronation.

[0020] In further embodiments, the housings holding two translatable masses may be connected to a sleeve or other device that is worn on the forearm and/or to allow the system to be put on the user's limb easily and comfortably. The sleeve may be made from a flexible material that accommodates the anatomy of the user's arm. The sleeve may be made from a relatively soft and elastic material, such as polychloroprene fabric (e.g., Neoprene™), polyether-polyurea copolymer materials (e.g., Spandex™), polyether-polyurea copolymer material blended with cotton, nylon, and other fabrics, and other appropriate materials. The sleeve may include a rigid or semi-rigid platform attached to or embedded therein for the attachment of an assembly including the housings of the translatable masses. The attachment assembly may include a hub that connects directly or indirectly to the platform, arms extending from the hub to position the housings for the translatable weights around the arm, and an attachment mechanism for attaching the hub to the rigid platform. The housings for the translatable masses may be attached to a hub by arms that connect to and extend from the hub to position the translatable masses such that one translatable mass is lateral to the hand, wrist, or arm, and one translatable mass is medial to the hand wrist or arm. In some embodiments, the angle of the housing for the translatable masses relative to the platform may be adjusted to optimize the position of the housings for the particular user. For example, the housings may be attached to the arms by hinge joints that allow the position of the housings to vary along a plane that is substantially perpendicular to the length of the arm. The arms may hold the translatable masses in spaced arrangement to the hand, wrist, or arm such that they flank the hand, wrist, or arm (e.g., located distally to the hand). The axes along which the translatable axes slide may be substantially parallel to each other and substantially perpendicular to the length of the patient's arm. This arrangement of the translatable masses results in the translatable masses to counter-act and dampen extension/flexion motions (e.g., at the wrist) and supination/pronation motions (e.g., at the forearm), as in the embodiment discussed immediately above.

[0021] The hub may be attached to the platform by various attachment mechanisms. For example, the rigid platform may have a magnetic receiver positioned thereon and the hub may have a ferromagnetic structure that magnetically engages with the magnetic receiver. This type of attachment mechanism makes it very easy for the user to don the tremor reduction device, which is important given the users tremor condition impacting the user's motor control. In other examples, the hub may have a circular base with a protruding male coupler with a locking groove that engages with a female coupling receiver on the rigid platform that has a ball-lock style connecting mechanism that engages with the locking groove of the male coupler. In still other embodiments, the hub may have a circular base with a protruding male coupler with a locking groove that engages with a female coupling receiver on the rigid platform that has a pin-lock style connecting mechanism, where pins are mounted around the interior of the female receiver and pushing the locking groove into the female receiver moves pins back and outward and then the shear across pins locks the locking groove into the female receiver. Other attachment mechanisms are contemplated within the scope of the present invention.

[0022] Additional translatable weight may be included in the foregoing embodiments to counteract other vectors of motion, such as flexion/extension motion that creates vertical motion when the arm is held horizontal and outward. For example a third translatable weight having a third axis that is substantially perpendicular to the first and second axes, and is substantially vertical when the arm is held out horizontally may be included in the design to counter-act vertical motion.

[0023] As described above, each of the one or more housing members may contain a mass which is translatable along an axis between a proximal limit and a distal limit, and a neutral position midway between the proximal limit and the distal limit, where, following imposition of a force having a component along the axis, a biasing means (i.e., one or more springs) returns the mass to the neutral position. Each housing member of the tremor reduction device of the present invention may include a sliding means upon which the first mass may slidably translate along its axis. The sliding means may include a guide member and/or a bearing member, such as a rail member, magnetic levitation track, or other bearing structure in mechanical connection to the housing. The sliding means may also include a friction reducing material, such as a liquid lubricant (e.g., a hydrocarbon lubricant), a solid lubricant (e.g., graphite), or other appropriate lubricating material.

[0024] In some embodiments, one or more housings may be attached to the coupling plate by one or more adjustable arms that may be extended from the coupling plate at varying distances from the forearm to place the housings at variable radial distances from the forearm. The adjustable arms may be coupled to the coupling plate by a joint (e.g., a pivot or hinge joint, a ball joint, or other appropriate joint structure) that allows the housings to be positioned at variable distances based on the needs of a particular patient. In the case of a hinge joint, the joint may have a mechanism for reversibly fixing the joint and the adjustable arm in a particular position, such as a ratcheting system or locking pin (e.g., a threaded locking pin). The adjustable arms may be spread out from the forearm like wings by movement at the joint in a range between a position where the arm(s) are collapsed and parallel or substantially parallel with the coupling plate and a position where the arm(s) are fully extended at a 90° angle relative to the coupling plate, placing the housings at the farthest possible distance from the coupling plate. In some embodiments, the adjustable arms may be rotated past 90° from the forearm such that the housings may be positioned at a varying points along the length of the arm. In such embodiments, the arms may be positioned in a substantially 180° range from being collapsed on the coupling plate to a point substantially 180° from the collapsed position such that the adjustable arm is parallel with the forearm, but on the other side of the adjustable joint. The adjustable arms also allow the housing and weight to be collapsed against the coupling plate in order to avoid collision with other objects and make the device less unwieldy in situations where the tremor reduction device is not needed (e.g., while walking).

[0025] In some embodiments, the adjustable joint (e.g., a hinge joint) of at least one adjustable arm may be oriented such that the adjustable arm is movable through an arc in a plane that is parallel to the longitudinal axis of the forearm. In some embodiments, at least one adjustable joint is oriented such that the adjustable arm is movable through an arc that is oblique to the longitudinal axis of the forearm. In embodiments in which one or more of the adjustable joints is a ball joint or other multi-planar joint, the adjustable arm may be oriented at various angles in substantially hemispheric range relative to the coupling plate.

[0026] The housings may each be placed at a point on one of the adjustable arms (e.g., at a distal end of one of the adjustable arms). In this way, the amount of rotational energy dissipated by the tremor reduction device may be adjusted to the needs of the patient by moving the adjustable arms nearer or further away from the forearm, and therefore the housings nearer of farther away. The housings may each be attached to the extendable arms by a joint that allows the housing to be positioned at a desired angle relative to the forearm (e.g., a hinge joint, a ball joint, or other appropriate joint structure).

[0027] In some embodiments, the tremor reduction device may include adjustable arms in pairs, each connected individually to the coupling plate at their proximal ends by a movable joint, where the arms are arranged in a parallel fashion. For example, each arm in the pair may be attached to the coupling plate by a rotating pivot or hinge joint. Each pair of adjustable arms may be attached to a housing at its distal end. The pairs of adjustable arms may be arranged in parallel configuration to allow the arms to be rotated through a range of angles relative to the coupling plate with minimal restriction in motion. In some embodiments, the pairs of adjustable arms may have contours therein to accommodate the anatomy of the limb to which the tremor reduction device is attached. For example, in some examples, the adjustable arms may be arranged such that the rotate outward from the medial line of the forearm along the frontal plane of the body (assuming the body in is anatomical position), and when rotated distally toward the hand, the contours provide room for accommodation of the anatomy of the thumb and outer areas of the hand, allowing the adjustable arms to move over such anatomy. In such embodiments, the housing may be positioned such that the translatable weights move along an axis that is perpendicular or substantially perpendicular to the plane of the hand in anatomical position.

[0028] In still further embodiments, the tremor reduction device may include fixed eccentric weight members attached to the coupling plate by rods or frame structures. The eccentric weights may be positioned at a radius from the forearm in order to counter and dampen tremors experienced by the patient. The fixed eccentric weights may be static such that they are not translated along an axis. Like embodiment that include translatable weights, the eccentric weights increase the mass moment of inertia of the combined arm and device. The increased inertia dampens the tremors experienced by the patient. The increased moment of inertia provided by tremor reduction device embodiments that utilize static eccentric weights may be sufficient to dampen tremors for some patients. Other patients may have more severe tremors and may need the additional counteracting force of translating masses to dampen their tremors.

[0029] The fixed eccentric weights may each be held in a static position relative to the coupling plate and the forearm. In such embodiments, the fixed eccentric weights may be connected to the coupling plate by fixed or adjustable rods that hold the eccentric weights at a radial distance from the forearm. The positioning of the eccentric weights may vary based on the patient's needs. In the case of fixed rods, the rod configuration and eccentric weight positioning may be determined through a patient assessment, and then the rods may be manipulated through bending or other physical or mechanical manipulation such that the eccentric weights can be attached in a pre-determined position relative to the coupling plate that accommodates the patient's needs. In embodiments in which the rods are adjustable, the rods may be attached to the coupling plate by a movable joint, such as a sliding track that allows the rod to be moved to various positions along the coupling plate. In such embodiments, the rod may also be extendable, e.g., the rod may be a telescoping rod with nested sections that can be extended or collapsed. The location of the eccentric weights may be designated to both increase the mass moment of inertia of the arm/weight combination for the patient's needs and to minimize interference of the eccentric weights with other objects.

[0030] The tremor reduction device may include a plurality of eccentric weights. For example, the tremor reduction device may include two eccentric weights positioned on medial and lateral sides of the forearm in anatomical position such that the eccentric weights dampen tremors experienced by the patient. In some examples, the two eccentric weights may be in aligned with each other across the longitudinal axis of the forearm, and in other examples the eccentric weights may be staggered along the length of the forearm. In further examples, the tremor reduction device may include additional eccentric weights (e.g., three or four eccentric weights connected to the coupling plate via fixed or adjustable rods).

[0031] In further embodiments, the tremor reduction device may include a combination of fixed eccentric weights and housings that include translatable weights. For example, the tremor reduction device may include two eccentric weights positioned on medial and lateral sides of the forearm in anatomical position and a housing having a translatable weight therein, where the housing connected to the coupling plate and located in a third position. The addition of the translatable weight may provide energy absorption in addition to the dampening effect of the fixed eccentric weights.

[0032] The frame and coupling plate structures may comprise any material or combination of materials with rigidity sufficient to maintain its shape while transferring force caused by Parkinsonian or essential tremors from the user to the housing or eccentric weight members. In some embodiments, the frame and/or coupling plate may comprise at least one of a rigid polymer or plastic, a metal, a metal alloy, carbon fiber, composite materials, and the like. The housing members may similarly be comprised of rigid polymer or plastic, a metal, a metal alloy, carbon fiber, composite materials, and the like. In some embodiments, the housing member(s) may comprise the same material as the frame and coupling plate structures.

[0033] The embodiments of the tremor reduction device of the present invention may include padding material on a surface contacting the skin of the user to prevent abrasion and injury to the wrist. For example, if one or more of the housings, the frame structure, or coupling plate contacts the patients hand, wrist, or forearm, a padding material may be attached to a surface of such structure for positioning between the rigid structure and the skin of the user. The padding material may be memory foam to allow for a snug fit and comfort. In some embodiments, the padding material may be relatively resistant to compression, such that it has a negligible damping effect on the tremors of the user, such that most or substantially all of the vibrational energy of the tremor is transferred to the housings. For example, the padding may include a material having a Shore A hardness in a range of 20 Shore A to about 60 Shore A (e.g., about 30 Shore A to about 45 Shore A, or any value or range of values therein). Examples of padding materials including vulcanized rubber, polychloroprene rubber, butyl rubber, and other appropriate materials.

[0034] Also disclosed herein is a method for reducing tremors in a limb of a person caused by Parkinson's disease or essential tremor utilizing the following steps. First, at least the horizontal and vertical frequency and/or amplitude of the tremors is measured on the person suffering from the condition. Once this information is determined for a particular person suffering from Parkinson's disease or essential tremor, a tremor reduction device is configured. In some embodiments the tremor reduction device has a plurality of housings as described herein (e.g., linked together around the wrist, attached to a frame structure, etc.). In some embodiments, the housings may be connected to movable arms that can be adjusted to a desired position relative to the forearm, thereby adjusting the position of the housing relative to the forearm. Each of the plurality of housing members contains its own mass which is translatable along an axis between a proximal limit and a distal limit set within the housing. A neutral position is defined between the proximal limit and the distal limit. Each of the housings also contains a biasing means for returning the mass to the neutral position. The mass and biasing means are sized according to at least one of the horizontal frequency and the vertical frequency of the measured tremors. The configured tremor reduction device is then placed about the limb of the person.

[0035] In other embodiments, the tremor reduction device may include one or more fixed eccentric weights connected to a coupling plate attached to the forearm such that the eccentric weights are positioned to dampen tremors experienced by the patient. In such embodiments, the positioning of the fixed eccentric weights may be determined based on assessment of the patient.

[0036] The patient's tremors may be assessed by measuring the frequency and/or amplitude of the tremors along X, Y, and Z axes, and the plurality of housing members or eccentric weights are configured and positioned to counteract vibrational energy along all three axis. For example, three or more housing members, each containing translatable masses that move along one of three perpendicular X, Y, Z axes. The arrangement and configuration of the translatable weight axes may be matched to the tremor movement during measurement of the patient's tremors. For example, where the patient was tested during exercises in which the hand is held out horizontally (e.g., in attempting to hold a spoon or other eating utensil), the tremor reduction device may be configured and calibrated such that (1) a first translatable weight will be positioned on an axis that runs medial to lateral with respect to the wrist (assuming anatomical position) and may be calibrated to counteract the vertical tremor motion exhibited by the patient during the test, (2) a second translatable weight will be positioned on an axis that runs anterior to posterior with respect to the wrist (assuming anatomical position) and may be calibrated to counteract the horizontal medial/lateral tremor motion exhibited by the patient during the test, and (3) a third translatable weight will be positioned on an axis that runs proximal to distal with respect to the wrist and may be calibrated to counteract the horizontal anterior/posterior tremor motion exhibited by the patient during the test.

[0037] Embodiments of the present invention may be designed to address the tremors suffered by a particular patient. The frequency and amplitude of a person's tremors may be measured on each extremity. Once the frequency and amplitude are known, the size of the mass contained within each of the housing members may be specified. Alternatively, or in addition, the magnitude of the biasing means may be adjusted. For example, if springs are utilized as a biasing means, the spring force may be adjusted by either using springs having a different spring force, or increasing or decreasing the number of springs. The installation of different mass sizes and/or different biasing means is facilitated with embodiments of the present invention which have housings which are adapted to receive a variety of interchangeable weights and springs which may be exchanged within the housing with relative ease.

[0038] In modeling tremor and the effectiveness of embodiments of the present invention, the inventor herein found that by utilizing the present invention, the magnitude of tremor is substantially reduced. For example, utilizing a machine which models tremor having a frequency of 4 to 5 Hz, the tremor had a horizontal magnitude of 10 millimeters and a vertical magnitude of 21 millimeters without application the tremor reduction device of the present invention. With an embodiment of the invention placed about the "wrist" utilized in the model, the horizontal magnitude was reduced to 3.5 millimeters and the vertical magnitude was reduced to 7.0 millimeters.

[0039] Further objects and aspects of the present invention will be apparent from the description provided herein.

[0040] The presently disclosed invention includes, but is not limited, to the following embodiments.

[0041] In one aspect, the invention relates to a tremor reduction device worn by a user comprising a wearable attachment device for attaching said tremor reduction device to a portion of said user's body; a docking mechanism attached to said wearable attachment device; a hub operable to reversibly connect with said docking station; at least one housing member attached to said hub, said housing member containing a mass for counteracting and damping a tremor produced by a patient said portion of said user's body. The mass may be translatable along an axis between a proximal limit and a distal limit within said housing. The device may further include a biasing mechanism operable to return said mass to a neutral position between the proximal limit and the distal limit when said mass is displaced from said neutral position by a force having a component along the axis. The at least one housing member may include a first housing member enclosing a first mass, and a second housing member enclosing a second mass. The tremor reduction device may be operable to reduce a rotational component of a Parkinsonian or essential tremor. The first housing member may include a first sliding means and the first mass slidably translates along the first sliding means. The first sliding means may include a first rail member. The first mass may translate along a first axis, and the second mass translates along a second axis. The first axis may be in parallel alignment with the second axis. The portion of said user's body may be the user's arm. The first axis and the second axis may be substantially perpendicular to the longitudinal axis of said arm. The wearable attachment device may be a sleeve comprising a stretchable material. The docking mechanism may include a magnetic connector.

[0042] In a second aspect, the invention relates to a tremor reduction device worn by a user comprising a first tremor damping member comprising a first mass for counteracting a tremor of a user; a second tremor damping member comprising a second mass for counteracting said tremor; a hub to which said first and second tremor damping members are attached, said hub having a docking member; and a wearable attachment member operable to be worn on a portion of the user's body, said wearable attachment member having a docking receiver operable to attach to said docking member of said hub. The wearable attachment member may be attached to a portion of an arm of the user and hold said first and second damping members in a predetermined position relative to said portion of the arm. The first mass may be translatable along a first axis between a first proximal limit and a first distal limit, the first mass may have a first neutral position midway between the first proximal limit and the first distal limit, and said first mass may be operable to be displaced from said first neutral position by a force generated by said tremor having a component along the first axis. The second mass may be translatable along a second axis between a second proximal limit and a second distal limit, the second mass may have a second neutral position midway between the second proximal limit and the second distal limit, and said second mass may be operable to be displaced from said neutral position by a force generated by said tremor having a component along the second axis. The first biasing means may be operable to return the first mass to the first neutral position. The device may further include a second biasing means operable to return the second mass to the second neutral position. The first mass may translate along a first axis, and the second mass translates along a second axis, and said first and second axes are parallel. The wearable attachment member may include a coupling plate on which said docking receiver is mounted, said coupling plate having a contoured surface for complementary fitting to the portion of the user's body.

[0043] In a third aspect, the invention related to a tremor reduction device worn by a user comprising a body for attaching said tremor reduction device to a portion of said a limb of said user's body; at least one arm structure attached to said body, said arm structure operable to position a mass at a radial distance from a longitudinal axis of said limb; and at least one mass in mechanical communication with a distal portion of said at least one arm structure. The device may further comprise at least one housing member attached to said distal portion of said at least one arm structure. The mass is contained in said at least one housing member, said mass being translatable along an axis between a proximal limit and a distal limit within said housing. The device may further comprise a biasing mechanism operable to return said mass to a neutral position between the proximal limit and the distal limit when said mass is displaced from said neutral position by a force having a component along the axis. The at least one housing member may include a first housing member enclosing a first mass, and a second housing member enclosing a second mass. The at least one arm structure may include a first arm structure and a second arm structure, each attached to said body. The first and second arm structures may each attached to said body by a movable joint, allowing said first and second arm structures to be moved and repositioned relative to the body. The first housing member may be attached to a distal end of said first arm structure by a first pivoting joint. The second housing member may be attached to a distal end of said second arm structure by a second pivoting joint. The first arm structure may include a first set of parallel arms. The second arm structure may include a second set of parallel arms. The first housing member may be operable to be maintained in a parallel position with respect to the longitudinal axis of the limb as the first arm structure is repositioned with respect to the body. The second housing member may be operable to be maintained in a parallel position with respect to the longitudinal axis of the limb as the second arm structure is repositioned with respect to the body. The device may further comprise a ratcheting mechanism in mechanical connection with said movable joints attaching said first and second arm structures to said body. The device may be operable to reduce a horizontal component of a Parkinsonian or essential tremor. The device may be operable to reduce a rotational component of a Parkinsonian or essential tremor. The device may be operable to reduce a vertical component of a Parkinsonian or essential tremor. The at least one housing member comprises a first sliding means and the mass slidably translates along the first sliding means. Each of the first and second housing members may comprise a sliding means and the masses slidably translate along the sliding means. The first sliding means may comprise a first rail member. The first mass may translate along a first axis, and the second mass may translate along a second axis. The first axis may be in parallel alignment with the second axis. The at least one arm structure may be fixedly attached to said body at its proximal end.

BRIEF DESCRIPTION OF THE DRAWINGS

[0044] FIG. **1** shows a front perspective view of an embodiment of the disclosed tremor reduction device placed about the wrist of a user.

[0045] FIG. **2** shows a front perspective view of the embodiment depicted in FIG. **1** an embodiment of the invention secured about the wrist of a user with a strap and hook and loop fasteners, with housing covers in place.

[0046] FIG. **3** shows a top perspective view of an alternative embodiment.

[0047] FIG. **4** shows a front side perspective view of an embodiment utilizing a exterior strap for securing to the wrist of a user.

[0048] FIG. **5** shows a side perspective view of the embodiment depicted in FIG. **4**.

[0049] FIG. **6** shows a front side perspective view of the embodiment depicted in FIG. **4** with the housing covers removed.

[0050] FIG. **7** shows a side perspective view of the embodiment depicted in FIG. **4** with the housing covers removed.

[0051] FIG. **8** shows a front perspective view of the embodiment depicted in FIG. **4** with the housing covers removed.

[0052] FIG. **9** shows a perspective view of a tremor reduction device, according to an embodiment of the present invention.

[0053] FIG. **10** shows a perspective view of a tremor reduction device, according to an embodiment of the present invention.

[0054] FIG. **11** shows a perspective view of a tremor reduction device, according to an embodiment of the present invention.

[0055] FIG. **12** shows a perspective view of a tremor reduction device with the housing covers removed, according to an embodiment of the present invention.

[0056] FIG. **13** shows a perspective view of a securing frame, according to an embodiment of the present invention.

[0057] FIG. **14** shows a perspective view of a tremor reduction device, according to an embodiment of the present invention.

[0058] FIG. **14**A shows a perspective view of a tremor reduction device according to an embodiment of the present invention.

[0059] FIG. **14**B shows a perspective view of a tremor reduction device according to an embodiment of the present invention.

[0060] FIG. **14**C shows a side elevation view of a tremor reduction device according to an embodiment of the present invention.

[0061] FIG. **14**D shows attachment of a tremor reduction device according to an embodiment of the present invention.

[0062] FIG. **14**E shows a perspective view of a tremor reduction device according to an embodiment of the present invention.

[0063] FIG. **15**A shows a perspective view of a tremor reduction device according to an embodiment of the present invention.

[0064] FIG. **15**B shows a perspective view of a tremor reduction device according to an embodiment of the present invention.

[0065] FIG. **15**C shows a side elevation view of a tremor reduction device according to an embodiment of the present invention.

[0066] FIG. **15**D shows a top plan view of a tremor reduction device according to an embodiment of the present invention.

[0067] FIG. **15**E shows a perspective view of a tremor reduction device according to an embodiment of the present invention.

[0068] FIG. **16**A shows a perspective view of a tremor reduction device according to an embodiment of the present invention.

[0069] FIG. **16**B shows a top plan view of a tremor reduction device according to an embodiment of the present invention.

[0070] FIG. **16**C shows a bottom plan view of a tremor reduction device according to an embodiment of the present invention.

[0071] FIG. **16**D shows a side elevation view of a tremor reduction device according to an embodiment of the present invention.

[0072] FIG. **16**E shows a perspective view of a tremor reduction device according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE DRAWINGS

[0073] Reference will now be made in detail to certain embodiments of the invention, examples of which are illustrated in the accompanying drawings. While the invention will be described in reference to these figures and certain implementations and examples of the embodiments, it will be understood that such implementations and examples are not intended to limit the invention. To the contrary, the invention is intended to cover alternatives, modifications, and equivalents that are included within the spirit and scope of the invention as defined by the claims. In the following disclosure, specific details are given to provide a thorough understanding of the invention. References to various features of the "present invention" throughout this document do not mean that all claimed embodiments or methods must include the referenced features. It will be apparent to one skilled in the art that the present invention may be practiced without these specific details or features.

[0074] Reference will be made to the exemplary illustrations in the accompanying drawings, and like reference characters may be used to designate like or corresponding parts throughout the several views of the drawings.

[0075] The present invention relates to a tremor reduction device. More specifically, the present invention pertains to a wearable band or gauntlet-like frame structure having one or more housings or fixed eccentric weights for damping tremors in the limbs of a patient suffering from Parkinson's disease, essential tremors, or other related condition. In embodiments that include weight housings, each housing encloses a mass which is translatable along an axis between a proximal limit and a distal limit, where following imposition of a force having a component along the axis, a biasing means (i.e., a spring) returns the mass to a neutral position, e.g., centered on the axis. In embodiments that include fixed eccentric weights, the weights are positioned at fixed radial distances from the patient's limb to damp the patient's tremors.

[0076] Referring now to the figures, FIG. **1** shows a first embodiment of the disclosed tremor reduction device **1000**, as worn around a user's wrist **500**. In one embodiment of the invention, the tremor reduction device **1000** has a plurality of housing members **1014** flexibly connected together. The embodiment shown in FIG. **1** has four housing members **1014** flexibly connected together to encircle the user's wrist **500**, with a first housing member **1114** adjacent to the top side **502** of the wrist, a second housing member **1214** adjacent to the palm side **504** of the wrist, a third housing member **1314** adjacent the thumb side **506** of the wrist, and a fourth housing member **1414** adjacent to the little finger side **508** of the wrist **500**. Each of the housing members **14** contains a mass **28** which is translatable along an axis A between a proximal limit P and a distal limit D, and a neutral position N midway between the proximal limit P and the distal limit D, wherein, following imposition of a force having a component along the axis, a biasing means returns the mass to the neutral position.

[0077] A second embodiment of the tremor reduction device is depicted in FIG. **3**. The second embodiment **2000** is secured about the user's wrist **500** by a strap **2002** which loops around strap posts of adjacent housing members **2114**. Strap **2002** will have an attachment mechanism, such as a buckle, clasp, snap buttons, or hook and loop fasteners, for securing the strap and enclosing the device around the user's wrist. Housing members **2114** of the second embodiment **2000** are identical to the housing members **3114** of the third embodiment **3000** and are described in detail below.

[0078] FIGS. **4-8** depict a third embodiment **3000** of the tremor reduction device wherein first housing member **3114** has a housing cover **3110**, second housing member **3214** has a housing cover **3210**, third housing member **3314** has a housing cover **3310**, and fourth housing member **3414** has a housing cover **3410**. Third embodiment **3000** may be secured around the user's wrist **500** by a continuous strap **3010** which wraps around the outsides of the housing members **3114**, **3214**, **3314** and **3414**. Each housing cover **3110**, **3214**, **3314** and **3414** may have attachment means, such as piece of hook and loop fastener, **3012**, for further securing continuous strap **3010**. The inside surface of the tremor reduction device may comprise a layer of memory foam **3014** which may be disposed between any embodiment **1000**, **2000**, **3000** of the tremor reduction device and the wrist **500** of the user.

[0079] The housing members of the tremor reduction device **3000** may have the following configuration. First housing member **3114** may have a first proximal sidewall **3124** and a first distal sidewall **3126**, with the first proximal sidewall **3124** and the first distal sidewall **3126** in opposite facing spaced-apart relation. A first mass **3128** is disposed between the first proximal side wall **3124** and the first distal side wall **3126**. The first mass **3128** has a first proximal side **3130** and a first distal side **3132**. A first proximal spring **3134** is disposed between the first proximal side wall **3124** and the first proximal side **3130** of the first mass **3128**. A first distal spring **3136** is disposed between the first distal side wall **3126** and the first distal side **3132** of the first mass **3128**. First mass **3128** is translatable along axis A.sub.1 between a first proximal limit set by first proximal side wall **3124** and first distal side **3132**, where following imposition of a first force having a component along axis A.sub.1, first proximal spring **3134** and first distal spring **3136** return first mass **3128** to a first neutral position at an approximate midpoint between first proximal side wall **3124** and first distal side wall **3126**. FIGS. **6-8** depict first mass **3128** at the first neutral position. It is to be appreciated that during a tremor episode the first mass **3128** may be in near constant oscillation between the first proximal side wall **3124** and the first distal side wall **3126**, such that the first mass **3128** does not come to a static condition at the first neutral position. The first neutral position is achieved when no external forces—such as a tremor—act upon the first mass.

[0080] First proximal sidewall **3124** and first distal sidewall **3126** may be attached to or may be integral to a first base plate **3140**. First base plate **3140** may have a sliding means upon which the first mass **3128** may slidably translate. The sliding means may include a rail member, magnetic levitation, air suspension or a layer of a friction reducing medium, such as balls.

[0081] Likewise, second housing member **3214** may have a second proximal sidewall **3224** and a second distal sidewall **3226**, with the second proximal sidewall **3224** and the second distal sidewall **3226** in opposite facing spaced-apart relation. A second mass **3228** is disposed between the second proximal side wall **3224** and the second distal side wall **3226**. The second mass **3228** has a second proximal side **3230** and a second distal side **3232**. A second proximal spring **3234** is disposed between the second proximal side wall **3224** and the second proximal side **3230** of the second mass **3228**. A second distal spring **3236** is disposed between the second distal side wall **3226** and the second distal side **3232** of the second mass **3228**. Second mass **3228** is translatable along axis A.sub.2 between a second proximal limit set by second proximal side wall **3224** and second distal side **3232**, where following imposition of a second force having a component along axis A.sub.2, second proximal spring **3234** and second distal spring **3236** return second mass **3228** to a second neutral position at an approximate midpoint between second proximal side wall **3224** and second distal side wall **3226**. FIGS. **6-8** depict second mass **3228** at the second neutral position. It is to be appreciated that during a tremor episode the second mass **3228** may be in near constant oscillation between the second proximal side wall **3224** and the second distal side wall **3226**, such that the second mass **3228** does not come to a static condition at the second neutral position. The second neutral position is achieved when no external forces—such as a tremor—act upon the second mass.

[0082] Second proximal sidewall **3224** and second distal sidewall **3226** may be attached to or may be integral to a second base plate **3240**. Second base plate **3240** may have a sliding means upon which the second mass **3228** may slidably translate. The sliding means may include a rail member, magnetic levitation, air suspension or a layer of a friction reducing medium, such as balls.

[0083] Likewise, third housing member **3314** may have a third proximal sidewall **3324** and a third distal sidewall **3326**, with the third proximal sidewall **3324** and the third distal sidewall **3326** in opposite facing spaced-apart relation. A third mass **3328** is disposed between the third proximal side wall **3324** and the third distal side wall **3326**. The third mass **3328** has a third proximal side **3330** and a third distal side **3332**. A third proximal spring **3334** is disposed between the third proximal side wall **3324** and the third proximal side **3330** of the third mass **3328**. A third distal spring **3336** is disposed between the third distal side wall **3326** and the third distal side **3332** of the third mass **3328**. Third mass **3328** is translatable along axis A.sub.3 between a third proximal limit set by third proximal side wall **3324** and third distal side **3332**, where following imposition of a third force having a component along axis A_3, third proximal spring **3334** and third distal spring **3336** return third mass **3328** to a third neutral position at an approximate midpoint between third proximal side wall **3324** and third distal side wall **3326**. FIGS. **6-8** depict third mass **3328** at the approximate third neutral position. It is to be appreciated that during a tremor episode the third mass **3328** may be in near constant oscillation between the third proximal side wall **3324** and the third distal side wall **3326**, such that the third mass **3328** does not come to a static condition at the third neutral position. The third neutral position is achieved when no external forces—such as a tremor—act upon the third mass.

[0084] Third proximal sidewall **3324** and third distal sidewall **3326** may be attached to or may be integral to a third base plate **3340**. Third base plate **3340** may have a sliding means upon which the third mass **3328** may slidably translate. The sliding means may include a rail member, magnetic levitation, air suspension or a layer of a friction reducing medium, such as balls.

[0085] Likewise, fourth housing member **3414** may have a fourth proximal sidewall **3424** and a fourth distal sidewall **3426**, with the fourth proximal sidewall **3424** and the fourth distal sidewall **3426** in opposite facing spaced-apart relation. A fourth mass **3428** is disposed between the fourth proximal side wall **3424** and the fourth distal side wall **3426**. The fourth mass **3428** has a fourth proximal side **3430** and a fourth distal side **3432**. A fourth proximal spring **3434** is disposed between the fourth proximal side wall **3424** and the fourth proximal side **3430** of the fourth mass **3428**. A fourth distal spring **3436** is disposed between the fourth distal side wall **3426** and the fourth distal side **3432** of the fourth mass **3428**. Fourth mass **3428** is translatable along axis A_4 between a fourth proximal limit set by fourth proximal side wall **3424** and fourth distal side **3432**, where following imposition of a fourth force having a component along axis A_4, fourth proximal spring **3434** and fourth distal spring **3436** return fourth mass **3428** to a fourth neutral position at an approximate midpoint between fourth proximal side wall **3424** and fourth distal side wall **3426**. FIGS. **6-8** depict fourth mass **428** at the fourth neutral position. It is to be appreciated that during a tremor episode the fourth mass **3428** may be in near constant oscillation between the fourth proximal side wall **3424** and the fourth distal side wall **3426**, such that the fourth mass **3428** does not come to a static condition at the fourth neutral position. The fourth neutral position is achieved when no external forces—such as a tremor—act upon the fourth mass.

[0086] Fourth proximal sidewall **3424** and fourth distal sidewall **3426** may be attached to or may be integral to a fourth base plate **3440**. Fourth base plate **3440** may have a sliding means upon which the fourth mass **3428** may slidably translate. The sliding means may include a rail member, magnetic levitation, air suspension or a layer of a friction reducing medium, such as balls.

[0087] As shown in the Figures, the axes of translation of each side of the device are in parallel alignment. That is, axis A_1 is in parallel alignment with axis A_2 and axis A_3 is in parallel alignment with axis A_4. In this configuration, the translation of the first mass **3128** along axis A_1 and the translation of the second mass **3228** along axis A_2 collectively reduce tremor along a first translational direction which is parallel to axis A_1 and axis A_2. Likewise, the translation of the third mass **3328** along the axis A_3 and the translation of the fourth mass **3428** along axis A_4 reduce tremor along a second translational direction which is parallel to axis A_3 and A_4 the sum of the forces generated by the translation of first mass **3128** along axis A_1, second mass **3228** along axis A_2, third mass **3328** along axis A_3 and fourth mass along axis A_4 reduce tremor having a rotational direction.

[0088] The different embodiments **1000**, **2000**, and **3000** may have interchangeable weight for use as the required mass (e.g., **3128**, **3218**, **3318**, and **3418** for the third embodiment) for providing the required force for neutralizing the force generated by the tremor. Likewise, the spring size and stiffness can be adjusted as necessary to provide the required biasing force for translation of each of the masses. Embodiments of the device may have features which facilitate interchanging different weights and springs to allow empty housings to be configured as required for the needs of a particular patient.

[0089] As seen in FIGS. **9-13**, some embodiments of the present invention may provide a tremor reduction device **4000** comprising a frame structure **4005** and a plurality of housing members **4114**, **4214**. The frame structure **4005** may comprise a coupling plate **4006** and a plurality of brackets **4011**, **4012** for mounting the plurality of housing members **4114**, **4214**. The frame structure **4005** may comprise a rigid material (e.g., plastic, metal, composite, etc.) operable to maintain its shape while transferring force caused by tremors from the user to the plurality of housing member **4114**, **4214**.

[0090] The coupling plate **4006** may comprise a substantially flat shape with first curving edge **4007** and a second curving edge **4008**, the first and second curving edges **4007**, **4008** curving around the sides of a user's hand **500**. The plate **4006** may further comprise an attachment element **4009** for securing straps to the plate **4006**, the straps being operable to hold the frame structure **4005** in place on the user's hand **500**. The attachment element **4009** may comprise a plurality of slots for the straps to pass through.

[0091] The frame structure **4005** may include a scaffolding **4010** that extends distally from the coupling plate **4006** and includes attachment brackets **4011** and **4012**. The scaffolding **4010** may extend from the first curving edge **4007** and the second curving edge **4008**, such that the first bracket **4011** and second bracket **4012** are positioned at or near the distal end of the user's hand. The scaffolding may include a reinforcing crossbar **4013** between the first and second brackets **4011** and **4012**. The first bracket **4011** may comprise a substantially flat shape having a first plurality of holes **4011***a* and the second bracket may comprise a substantially flat shape having a second plurality of holes **4012***a*. The first plurality of holes **4011***a* may be operable to receive a first securing device (not shown) for securing the first housing member **4114** to the first bracket **4011**, and the second plurality of holes **4012***a* may be operable to receive a second securing device (not shown) for securing the second housing member **4214** to the second bracket **4012**.

[0092] The first housing member **4114** may enclose a first sidewall **4124** and a second sidewall **4126**, where the first sidewall **4124** and the second sidewall **4126** are in opposite facing, spaced-apart relation. A first mass **4128** may be disposed between the first proximal side wall **4124** and the first distal side wall **4126**, wherein the first mass **4128** may have a first side **4130** and a second side **4132**. A first spring **4134** may be disposed between the first side wall **4124** and the first side **4130** of the first mass **4128**, and a second spring **4136** may be disposed between the second side wall **4126** and the second side **4132** of the first mass **4128**. The first sidewall **4124** and the second sidewall **4126** may be attached to or may be integral to a first base plate. The first base plate may have a sliding means **4135** upon which the first mass **4128** may slidably translate. The sliding means **4135** may include a rail member, a track, magnetic levitation track, or other structure along which the first mass **4128** may slide. The sliding means may also include a layer of solid or liquid lubricating material. The first housing member **4114** may comprise a removable first housing cover **4114***a*. The first housing cover **4114***a* is depicted in FIG. **12**, but is removed in FIGS. **9** through **11** for the purpose of clarity.

[0093] The second housing member **4214** may have a first sidewall **4224** and a second sidewall **4226** in opposite facing, spaced-apart relation. A second mass **4228** may be disposed between the first side wall **4224** and the second side wall **4226**, wherein the second mass **4228** has a first side **4230** and a second side **4232**. A first spring **4234** may be disposed between the first side wall **4224** and the first side **4230** of the second mass **4228**, and a second spring **4236** may be disposed between the second side wall **4226** and the second side **4232** of the second mass **4228**. The first sidewall **4224** and second sidewall **4226** may be attached to or may be integral to a second base plate. The second base plate may have a sliding means **4235** upon which the second mass **4228** may slidably translate. The sliding means may include a rail member, a track, magnetic levitation track, or other structure along which the second mass **4228** may slide. The sliding means may also include a layer of solid or liquid lubricating material. The second housing member **4214** may comprise a removable second housing cover **4214***a*. The second housing cover **4214***a* is depicted in FIG. **12**, but is removed in FIGS. **9** through **11** for the purpose of clarity.

[0094] The first mass **4128** and the second mass **4228** may each move along an axis when a tremor applies a horizontal force to the securing frame, the first mass **4128** moving along a first axis which is substantially parallel to a longitudinal (horizontal in the embodiment shown) axis of the first housing member **4114**, and the second mass moving along a second axis which is substantially parallel to a longitudinal (horizontal in the embodiment shown) axis of the second housing member **4214**. In the embodiment shown in FIGS. **9** through **12**, the first spring **4134** and the second spring **4136** may be mounted within the first housing **4114** so as to be co-located with the first axis, and the first spring **4234** and second spring **4236** may be mounted within the second housing **4214** so as to be co-located with the second axis.

[0095] In some embodiments, the first axis and the second axis may be in parallel with each other, and linear forces generated by the first mass **4128** and the second mass **4228** may significantly reduce the effect of a tremor which has a force parallel with the first axis and the second axis (i.e., a side-to-side motion of the user's hand **500**). In such embodiments, the sum of a rotational force generated by the first mass **4128** and second mass **4228** may also reduce the effect of a tremor which has a rotational direction (i.e., a twist of the user's hand **500**).

[0096] Also disclosed herein is a method for reducing tremors in a limb of a person caused by Parkinson's disease or essential tremor utilizing the following steps. First the horizontal and vertical frequency of the tremors is measured on the person suffering from the condition. Once this information is determined for a particular person suffering from Parkinson's disease or essential tremor, a tremor reduction device is configured, such as one of the embodiments **1000**, **2000**, **3000** of the presently disclosed device. As described above, the tremor reduction device has a plurality of housings linked together in a closed loop configuration. Each of the plurality of housings contains its own mass which is translatable along an axis between a proximal limit and a distal limit set within the housing. A neutral position is defined between the proximal limit and the distal limit. Each of the housings also contains a biasing means for returning the mass to the neutral position. The mass and biasing means are sized according to the horizontal frequency and the vertical frequency of the measure tremors. The configured tremor reduction device is then placed about the limb of the person.

[0097] As seen in FIGS. **14**A-______, some embodiments of the present invention may provide a tremor reduction device **4500** comprising a coupling plate **4506** that is attachable to the forearm or other limb via one or more straps, cuffs, or other coupling mechanism, or by a sleeve or brace. Housing members **4514***a* and **4514***b* may be connected to the coupling plate **4506** by arms **4507***a* and **4507***b*, respectively. The coupling plate **4506** may comprise a rigid material (e.g., plastic, metal, composite, etc.) operable to maintain its shape while transferring force caused by tremors from the user to the plurality of housing member **4514***a*, **4514***b*.

[0098] The coupling plate **4506** may comprise a substantially flat shape operable to lay over a portion of the forearm or other limb. In some embodiments, the coupling plate **4506** may have a contoured structure operable to lie flush over the anatomy of the patient's limb. The arms **4507***a* and **4507***b* may each be rigid arms that are operable to be set in a fixed position relative to the coupling plate and forearm or other limb. The arms **4507***a* and **4507***b* may be attached to a central hub **4510** that is reversible attachable to the coupling plate through a docking mechanism **4511**. The docking mechanism **4511** may include a magnetic connector in the form of a disc, ring, or other magnetic structure and the hub may have a ferromagnetic structure that magnetically engages with the magnetic connector. This type of docking mechanism makes it very easy for the user to don the tremor reduction device, which is important given the users tremor condition impacting the user's motor control. In other examples, the docking mechanism may be a ball-lock style mechanism or a pin-lock style mechanism as described herein, or other appropriate docking mechanism.

[0099] The arms **4507***a* and **4507***b* may be connected to the housings **4514***a* and **4514***b* by joints **4513***a* and **4513***b*, respectively. In some embodiments, the housings may be adjustable via joints **4513***a* and **4513***b*, allowing the position of the housing member **4514***a*, **4514***b* to be set in an optimal arrangement prior to use. Once the position of each housing member **4514***a* and **4514***b* is chosen and set, the housing member **4514***a*, **4514***b* may remain in their optimized arrangement. The optimized arrangement may be based on testing the apparatus as it is worn by the patient in multiple arrangements to determine the arrangement that most dampens the patient's tremors. Once the most effective arrangement is determined, the housing member **4514***a*, **4514***b* may be reversibly fixed in the selected arrangement.

[0100] Each housing member **4514***a* and **4514***b* may enclose a translatable mass **4528** that may be translatable along an axis running perpendicular or substantially perpendicular to the plane of the coupling plate **4506**. FIG. **14**C provides an interior view of housing **4514***b*, where the translatable mass **4528** is engaged with first spring **4534** and second spring **4536**. The first spring **5034** may be disposed between the first side wall and a first side of the translatable mass **4528**, and the second spring **4536** may be disposed between a second side wall and a second side of the translatable mass **4528**. The floor or first base plate of the housing may have a sliding means upon which the translatable mass **4528** may slidably translate. The sliding means may include a rail member, a track, magnetic levitation track, or other structure along which the translatable mass **4528** may slide. The sliding means may also include a layer of solid or liquid lubricating material.

[0101] The tremor reduction device **4500** may further include a securing sleeve **4550** attached to coupling plate **4506**. The securing strap may be used to hold the coupling plate **4506** in place on the user's forearm, as shown in FIG. **14**E. The coupling plate may be embedded in the sleeve **4550** with the docking mechanism **4511** exposed through the sleeve **4550** to allow the hub **4510** to dock with the docking mechanism as shown in FIG. **14**D. It is to be understood that other securing mechanisms are contemplated within the scope of the present invention.

[0102] As seen in FIGS. **15**A-**15**E, some embodiments of the present invention may provide a tremor reduction device **5000** comprising a coupling plate **5006** that is attachable to the forearm or other limb via one or more straps, cuffs, or other coupling mechanism. Housing members **5014***a* and **5014***b* may be connected to the coupling plate **5006** by adjustable arm pairs **5007***a* and **5007***b*, respectively. The coupling plate **5006** may comprise a rigid material (e.g., plastic, metal, composite, etc.) operable to maintain its shape while transferring force caused by tremors from the user to the plurality of housing member **5014***a*, **5014***b*.

[0103] The coupling plate **5006** may comprise a substantially flat shape operable to lay over a portion of the forearm or other limb. In some embodiments, the coupling plate **5006** may have a contoured structure operable to lie flush over the anatomy of the patient's limb. The arm pairs **5007***a* and **5007***b* may each have parallel or substantially parallel paired arms that are operable to move together through a range of angles of substantially 180° relative to the coupling plate and in a plane that is parallel or substantially parallel to the coupling plate **5006**.

[0104] Each of the arms in arm pairs **5007***a* and **5007***b* may be attached to the coupling plate **5006** by rotatable pivot or hinge joints. The position of the joints may be controlled by a ratcheting mechanism **5010** that allows movement of the arm pairs **5007***a* and **5007***b* when the pawls of the ratcheting mechanism are disengaged, and fixes the arm pairs **5007***a* and **5007***b* when the pawls are engaged with the gears. The gears may be connected to at least one arm of each of the arm pairs **5007***a* and **5007***b*. Comparing the position of the adjustable arm pairs **5007***a* and **5007***b* in FIG. **15**A to those shown in FIG. **15**D demonstrates how the position of the adjustable arm pairs **5007***a* and **5007***b* (and the housings **5014***a* and **5014***b*) may be adjusted to compensate the needs of a patient. FIG. **15**D shows the adjustable arm pairs **5007***a* and **5007***b* each rotated distally to positions that are 90° relative to the centerline of the coupling plate **5006**. Each of the adjustable arm pairs can be further rotated forward to the point that they are nearly parallel to the center line of the coupling plate **5006**. The adjustable arm pairs **5007***a* and **5007***b* can be fixed into position by the ratcheting mechanism **5010** at several positions in their respective rotational ranges. Additionally, the adjustable arm pairs **5007***a* and **5007***b* can be positioned in asymmetrical arrangements with respect to each other (e.g., where arm pair **5007***a* is rotated more distally than arm pair **5007***b*).

[0105] The housings **5014***a* and **5014***b* may be attached to the distal ends of the adjustable arm pairs **5007***a* and **5007***b* by paired hinge joints **5013***a* and **5013***b*, respectively. The spacing between the paired hinge joints is same or substantially the same as the spacing between the hinge joints attaching the proximal ends of the adjustable arm pairs to the coupling plate. This arrangement places the arms of each of the adjustable arm pairs in a spaced, parallel relationship that allows each of the adjustable arm pairs to be rotated through a large range of angles (substantially 180°). Paired hinge joints **5013***a* and **5013***b* also maintain the housings **5014***a* and **5014***b* in a parallel or substantially parallel position relative to the coupling plate **5006** as the adjustable arm pairs **5007***a* and **5007***b* are rotated relative to the coupling plate **5006**. As a result, the axis along which the translatable mass in each housing moves may remain in a parallel or substantially parallel relationship to the coupling plate and the longitudinal axis of the forearm or other limb of a patient.

[0106] Each housing member **5014***a* and **5014***b* may enclose a translatable mass **5028** that may be translatable along an axis running perpendicular or substantially perpendicular to the plane of the coupling plate **5006**. FIG. **15**C provides an interior view of housing **5014***b*, where the translatable mass **5028** is engaged with first spring **5034** and second spring **5036**. The first spring **5034** may be disposed between the first side wall and a first side of the translatable mass **5028**, and the second spring **5036** may be disposed between a second side wall and a second side of the translatable mass **5028**. The floor or first base plate of the housing may have a sliding means upon which the translatable mass **5028** may slidably translate. The sliding means may include a rail member, a track, magnetic levitation track, or other structure along which the translatable mass **5028** may slide. The sliding means may also include a layer of solid or liquid lubricating material.

[0107] The tremor reduction device **5000** may further include a securing strap **5100** attached to coupling plate **5006**. The securing strap may be used to hold the coupling plate **5006** in place on the user's hand, as shown in FIG. **15**E. It is to be understood that other securing mechanisms are contemplated within the scope of the present invention.

[0108] As seen in FIGS. **16**A-**16**E, some embodiments of the present invention may provide a tremor reduction device **6000** comprising a coupling **6006** that is attachable to the forearm or other limb via one or more straps, cuffs, or other coupling mechanism. Fixed eccentric weights **6014***a* and **6014***b* may be connected to the coupling plate **6006** by fixed arms **6007***a* and **6007***b*, respectively. The coupling plate **6006** may comprise a rigid material (e.g., plastic, metal, composite, etc.) operable to maintain its shape while transferring force caused by tremors from the patient's arm to the fixed eccentric weights **6014***a*, **6014***b*.

[0109] The coupling plate **6006** may comprise a substantially flat shape operable to lay over a portion of the forearm or other limb. In some embodiments, the coupling plate **6006** may have a contoured structure operable to lie flush over the anatomy of the patient's limb. The fixed arms **6007***a* and **6007***b* may be fixedly attached to the coupling plate **6006** by a bracket, clamp, or other mechanism. The fixed arms **6007***a* and **6007***b* can be positioned such that the eccentric weights are in a symmetrical arrangement with respect to each other, where the fixed eccentric weights **6014***a* and **6014***b* are aligned along the longitudinal axis of the forearm or other limb. In other embodiments, the fixed eccentric weights **6014***a* and **6014***b* may be positioned in asymmetrical arrangements with respect to each other along the longitudinal axis of the limb (e.g., where fixed eccentric weight **6014***a* is positioned more proximally than fixed eccentric weight **6014***b*).

[0110] The fixed eccentric weights **6014***a* and **6014***b* may be attached to the distal ends of the fixed arms **6007***a* and **6007***b*, respectively. The eccentric weights may be attached by fastening screws or other mechanical attachment mechanism, such as bracket.

[0111] The tremor reduction device **6000** may further include a securing strap **6100** attached to coupling plate **6006**. The securing strap may be used to hold the coupling plate **6006** in place on the user's hand, as shown in FIG. **16**E. It is to be understood that other securing mechanisms are contemplated within the scope of the present invention.

[0112] It is to be understood that variations, modifications, and permutations of embodiments of the present invention, and uses thereof, may be made without departing from the scope of the invention. It is also to be understood that the present invention is not limited by the specific embodiments, descriptions, or illustrations or combinations of either components or steps disclosed herein. The embodiments were chosen and described in order to best explain the principles of the invention and its practical application, to thereby enable others skilled in the art to best utilize the invention and various embodiments with various modifications as are suited to the particular use contemplated. Although reference has been made to the accompanying figures, it is to be appreciated that these figures are exemplary and are not meant to limit the scope of the invention. It is intended that the scope of the invention be defined by the claims appended hereto and their equivalents.

1. A tremor reduction device worn by a user, the device comprising:

a. a wearable attachment device for attaching said tremor reduction device to a portion of said user's body;
b. a docking mechanism attached to said wearable attachment device;
c. a hub operable to reversibly connect with said docking station;
d. at least one housing member attached to said hub, said housing member containing a mass for counteracting and damping a tremor produced by a patient said portion of said user's body.

2. (canceled)

3. The device of claim **2**, wherein said mass is translatable along an axis between a proximal limit and a distal limit within said housing, and said device further comprises a biasing mechanism operable to return said mass to a neutral position between the proximal limit and the distal limit when said mass is displaced from said neutral position by a force having a component along the axis.

4. The device of claim **1**, wherein the at least one housing member comprises a first housing member enclosing a first mass, and a second housing member enclosing a second mass.

5. (canceled)

6. The device of claim **4**, wherein the first housing member comprises a first sliding means and the first mass slidably translates along the first sliding means.

7. (canceled)

8. The device of claim **4**, wherein the first mass translates along a first axis, and the second mass translates along a second axis.

9. The device of claim **8**, wherein the first axis is in parallel alignment with the second axis.

10. (canceled)

11. The device of claim **10**, wherein the portion of said user's body is the user's arm, and the first axis and the second axis are substantially perpendicular to the longitudinal axis of said arm.

12. The device of claim **1**, wherein the wearable attachment device is a sleeve comprising a stretchable material.

13. The device of claim **1**, wherein said docking mechanism includes a magnetic connector.

14. A tremor reduction device worn by a user, the device comprising:

a. a first tremor damping member comprising a first mass for counteracting a tremor of a user;
b. a second tremor damping member comprising a second mass for counteracting said tremor;
c. a hub to which said first and second tremor damping members are attached, said hub having a docking member; and
d. a wearable attachment member operable to be worn on a portion of the user's body, said wearable attachment member having a docking receiver operable to attach to said docking member of said hub.

15. The device of claim **14**, wherein said wearable attachment member is attached to a portion of an arm of the user and hold said first and second damping members in a predetermined position relative to said portion of the arm.

16. The device of claim **14**, wherein said first mass is translatable along a first axis between a first proximal limit and a first distal limit, the first mass having a first neutral position midway between the first proximal limit and the first distal limit, and said first mass is operable to be displaced from said first neutral position by a force generated by said tremor having a component along the first axis.

17. The device of claim **16**, wherein said second mass is translatable along a second axis between a second proximal limit and a second distal limit, the second mass having a second neutral position midway between the second proximal limit and the second distal limit, and said second mass is operable to be displaced from said neutral position by a force generated by said tremor having a component along the second axis.

18. The device of claim **16**, further comprising a first biasing means operable to return the first mass to the first neutral position.

19. The device of claim **17**, further comprising a second biasing means operable to return the second mass to the second neutral position.

20. (canceled)

21. The tremor reduction device of claim **15**, wherein said wearable attachment member includes a coupling plate on which said docking receiver is mounted, said coupling plate having a contoured surface for complementary fitting to the portion of the user's body.

22. A tremor reduction device worn by a user, the device comprising:

a. a body for attaching said tremor reduction device to a portion of said a limb of said user's body;

b. at least one arm structure attached to said body, said arm structure operable to position a mass at a radial distance from a longitudinal axis of said limb; and

c. at least one mass in mechanical communication with a distal portion of said at least one arm structure.

23. The device of claim **22**, further comprising at least one housing member attached to said distal portion of said at least one arm structure.

24. The device of claim **23**, wherein said mass is contained in said at least one housing member, said mass being translatable along an axis between a proximal limit and a distal limit within said housing, and said device further comprising a biasing mechanism operable to return said mass to a neutral position between the proximal limit and the distal limit when said mass is displaced from said neutral position by a force having a component along the axis.

25. (canceled)

26. The device of claim **23**, wherein the at least one housing member comprises a first housing member enclosing a first mass, and a second housing member enclosing a second mass.

27. The device of claim **26**, wherein said at least one arm structure includes a first arm structure and a second arm structure, each attached to said body.

28. The device of claim **27**, wherein said first and second arm structures are each attached to said body by a movable joint, allowing said first and second arm structures to be moved and repositioned relative to the body.

29. (canceled)

30. (canceled)

31. (canceled)

32. (canceled)

33. (canceled)

34. (canceled)

35. (canceled)

36. (canceled)

37. (canceled)

38. (canceled)

39. (canceled)

40. (canceled)

41. (canceled)

42. (canceled)

43. (canceled)

44. (canceled)

* * * * *