

(19)



(11)

EP 3 035 901 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention
of the grant of the patent:

30.10.2019 Bulletin 2019/44

(51) Int Cl.:

A61H 1/02 (2006.01)

A63B 21/005 (2006.01)

A63B 21/16 (2006.01)

A63B 21/00 (2006.01)

A63B 71/00 (2006.01)

(21) Application number: **14752314.6**

(86) International application number:

PCT/EP2014/067397

(22) Date of filing: **14.08.2014**

(87) International publication number:

WO 2015/024852 (26.02.2015 Gazette 2015/08)

(54) **HAND MOTION EXERCISING DEVICE**

VORRICHTUNG ZUM ÜBEN VON HANDBEWEGUNGEN

DISPOSITIF D'EXERCICE DE MOUVEMENT DE MAIN

(84) Designated Contracting States:

**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR**

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(30) Priority: **21.08.2013 EP 13181233**

(43) Date of publication of application:

29.06.2016 Bulletin 2016/26

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(56) References cited:

WO-A1-2010/140984

WO-A1-2011/117901

CN-U- 202 537 871

GB-A- 1 354 215

JP-A- 2002 119 555

JP-A- 2013 106 706

US-A- 5 261 393

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Description

TECHNICAL FIELD

5 **[0001]** The present invention relates to a hand motion exercising device according to the preamble of claim 1.

PRIOR ART

10 **[0002]** In order to gain or regain mobility of the human hand, physical exercise is commonly used as an effective therapeutic measure. In particular after stroke, such physical stimuli are known to improve a patient's mobility.

[0003] WO 93/08882 teaches a system for isolating, evaluating, and exercising muscle groups of the human test subject's hand. The device includes a stationary element and a rotational element, both intended as hand grip portions for one human hand, for providing a series of physical exercises to the test subject.

15 **[0004]** During the exercise, the rotational hand grip portion moves forth and back in the direction of the stationary hand grip portion. Moreover, there is detection means for detecting predetermined parameters of said movement, e.g. speed or torque. This movement is, however, not well adapted to the physiology of the human hand.

[0005] WO 2010/140984 A1 shows a hand motion exercising device with the features of the preamble of claim 1, wherein cables attached to ring element are secured around the thumb and the fingers.

20 **[0006]** US 5,261,393 A shows a similar hand motion exercising device, wherein a thumb rest moves in unison with the movement of the finger rests.

[0007] JP 2013 106706 A discloses perpendicular axes of the thumb and finger movement planes. The attachment of the thumb and finger connections are not above a base element with the linkage being below the base element. Claim 1 is novel over D3.

25 SUMMARY OF THE INVENTION

[0008] It is therefore an object of the present invention to provide a hand motion exercising device which takes better into account the human hand's physiology and is therefore better adapted and suited for exercising hand function, while its construction remains simple and effective.

30 **[0009]** This object is achieved by the hand motion exercising device according to claim 1, wherein two of said thumb movement units are arranged on said hand motion exercising device, wherein said units preferably share one thumb rest element. It is also possible having one or more thumb rest elements for one thumb movement unit, wherein during exercise, only one thumb unit is attached to the exercising device. In other words, a set of finger and thumb rest elements of different sizes or shapes may be provided, such as to choose the rest elements in order to match the human hand to be exercised.

35 **[0010]** These thumb movement units are arranged with respect to the finger movement unit and with respect to one another such that finger movement unit and the thumb rest element attached to one of the thumb movement units allows exercising one human hand. The same thumb rest element, if attached to the other thumb movement unit, allows, in turn, exercising the other human hand, wherein, preferably, the finger rest element is adapted to be attached on the finger movement unit to either allow for exercising said left or said right human hand. By means of this functionality, a minimum number of different parts has to be provided for exercising both hands. Even though the left and right human hand may not be simultaneously exercised with one single hand exercising device, a simple remounting of the finger and thumb rest elements allows for consecutive exercising of both hands.

40 **[0011]** The rest elements for fingers/thumb(s) are adapted for said pressing or pulling action. In case of the pulling action, straps may be provided on the rest elements for attaching the hand to the device.

[0012] It is thus an aspect of the present invention to provide a hand exercising device in which the thumb movement follows a rotation or movement plane that is inclined with respect to a movement plane of the fingers, wherein the movement units are drivable with a single drive motor, e.g. with an electric motor.

45 **[0013]** The term "movement plane" has to be understood as a two dimensional space, in particular a flat surface, in which an object, e.g. a part of the thumb rest element, is moved. The nature of the respective joint, by means of which the object is linked to the base element, determines the orientation and shape of said movement plane.

[0014] According to a preferred embodiment, said first joint comprises a first shaft with a first shaft axis, wherein said second joint comprises a second shaft with a second shaft axis, wherein said first shaft and said second shaft are coupled by said first mechanical motion linkage, and wherein the first mechanical motion linkage is a substantially torque-proof linkage, i.e. there is no or only minimal sliding motion during power transmission between the shafts.

50 **[0015]** Preferably, the first joint further comprises a gaiter for guiding the movement plane of the first shaft into said inclined first movement plane.

[0016] Alternatively, the first joint further comprises a universal joint instead of the gaiter. The first joint thus may

comprise a first swivel axis, wherein the first swivel axis runs at an angle to the first shaft axis, wherein, preferably, the first joint with the first swivel axis further comprises a second swivel axis that is oriented substantially perpendicular to the first swivel axis such that the second joint includes a universal joint. This universal joint is, in a similar manner as the aforementioned gaiter, for the purpose of guiding the movement plane of the first shaft into the inclined or skewed first movement plane, wherein said first movement plane is inclined or skewed with respect to a plane normal to the first shaft axis.

[0017] Preferably, the first and the second shaft axis are substantially parallel and/or spaced apart with respect to one another. Said distance ranges preferably from about 2 to 10 centimeters. This arrangement allows a simple design of the exercising device.

[0018] According to a preferred embodiment, the finger movement unit further comprises at least one third shaft with a third shaft axis, the third shaft axis being preferably substantially parallel and spaced apart to the first and second shaft axis, wherein the hand motion exercising device further comprises a second finger rest element, wherein said second finger rest element is pivotable in a third movement plane about said third shaft axis, and wherein the second shaft and the third shaft are in a second mechanical motion linkage such that a proximal phalanx joint and an intermediate phalanx joint of fingers of the human hand resting on the first and second finger rest element can be actuated individually and simultaneously. Preferably, said second mechanical motion linkage is adjustable to match said human hand. Also the second mechanical motion linkage is preferably a substantially torque-proof linkage. In other words, the finger movement unit may comprise a first finger rest element hinged to the second shaft and a second finger rest element hinged to the first finger rest element such that the metacarpophalangeal and proximal interphalangeal joints of the fingers may be moved simultaneously. This allows a better mobilization of the human hand. Preferably, the second and the third movement plane are substantially parallel to one another.

[0019] It is furthermore advantageous, if the second mechanical motion linkage comprises as transmission element a gear train or a belt drive, and if said gear train or said belt drive is constructed such that the first and the second shaft rotate synchronously and in a substantially torque-proof manner in the opposite direction.

[0020] Preferably, the finger rest element is shaped as a grip cylinder, and/or at least one, preferably all of said rest elements are provided with a resilient coating, wherein said rest elements are pivotable such that at least two of said rest elements come into contact with one another via said coating in or close to the close position, and wherein said coating(s) is(are) compressed upon said contact and therefore provide a reaction force counteracting the rest element movement toward one another in order to guide the rest elements into a defined stop position, and/or wherein, preferably, said reaction force increases with increasing compression of said coating(s). By choice of material and material distribution of this coating, the development of said reaction force upon and during contact may be specifically chosen. For a soft stop, thicker and/or softer materials should be arranged in the contact area, for a harder stop, thinner and or harder materials may be provided.

[0021] The coatings thus provide a defined close position by arranging a suitable abutment, which advantageously relieves the drive motor of providing such a stop, which is, in principal, also possible. In other words: The mechanical stop within the grip cylinder relieves motor and mechanical linkage from forces applied by the human hand.

[0022] According to yet another particularly preferred embodiment, the first mechanical motion linkage between the first shaft and the second shaft is provided as a gear train or as a belt drive, or as a combination thereof.

[0023] A belt of such a belt drive has preferably, at least section wise along its length, a toothing for interlock with at least one accordingly shaped pulley of the belt drive, wherein said toothing is preferably arranged on an outside surface of said belt. Alternatively, depending on the actual looping path of the belt, said toothing may be arranged on the inside surface of said belt or on both surfaces of said belt.

[0024] Preferably, the thumb movement unit is adapted to accommodate the thumb rest element in a detachable manner and the finger movement unit is adapted to accommodate the finger rest element in a detachable manner. In other words, the rest elements are preferably detachable mounting elements attachable directly or indirectly to said first and second shaft (or third shaft, see below), respectively. Moreover, the rest elements are directly or indirectly connectable to the respective shaft in a substantially torque-proof manner. This attaching is most preferably given in a pluggable manner; also other usual interlock techniques may, however, be applied to detachably attach said rest elements to the corresponding elements.

[0025] Preferably, the finger rest element(s) is (are) adapted to accommodate up to four fingers of the human hand. This allows addressing of a maximum number of finger muscles and nerves, which enhances the exercising effect.

[0026] Preferably, the hand motion exercising device further comprises a safety unit, wherein said safety unit is adapted to restrict a finger unit movement range such that a pivot angle of the second shaft cannot exceed a maximum pivot angle, the maximum pivot angle corresponding to an open human hand, and wherein, if the hand motion exercising device comprises two thumb movement units, the safety unit is preferably switchable for allowing either a right human hand or a left human hand exercise.

[0027] According to a preferred embodiment, the safety unit comprises a switching device, the safety unit including a switching pin or lever by means of which the hand motion exercising device is switchable from left to right human hand

exercise configuration and vice-versa, and wherein, preferably, said switching pin or lever is pluggable into said hand motion device or the switching lever tiltable such as to provide an abutment for a moveable part of the device in order to secure said maximum pivot angle.

[0028] The device better matches the human hand's physiology, when additionally the hand motion exercising device comprises at least one thumb movement unit with a thumb rest element, said thumb rest element being pivotable in a first movement plane about a first joint; and a finger movement unit with a first finger rest element, said first finger rest element being pivotable in a second movement plane about a second joint; wherein the thumb rest element and the first finger rest element are adapted to be encompassed and pressed toward one another by a human hand, and wherein the first joint and the second joint are provided such that said second movement plane is skewed with respect to said first movement plane, wherein said first joint is a revolute joint comprising a first shaft with a first shaft axis and wherein said second joint is a second shaft with a second shaft axis, wherein the first and second shaft are linked such as to allow a coordinated and use hand movement, wherein the device preferably comprises the aforementioned first mechanical motion linkage or at least two drive motors, at least one for driving said first shaft and at least one for driving said second shaft, wherein said drive motors are synchronized to provide said linkage.

[0029] Preferably, if mounted on an arm training device, the herein proposed hand motion exercising devices is constructed such that a distance between wrist and metacarpophalangeal joints is adjustable to match the patient or user.

[0030] The hand motion exercising device proposed herein may be used for rehabilitation of patients with restricted hand function caused by cerebral, neurogenic, spinal, muscular or bone-related disorders.

BRIEF DESCRIPTION OF THE DRAWINGS

[0031] Preferred embodiments of the invention are described in the following with reference to the drawings, which are for the purpose of illustrating the present preferred embodiments of the invention and not for the purpose of limiting the same. In the drawings,

Fig. 1 shows a perspective view on a first preferred embodiment of the hand motion exercising device according to the present invention, including a base element with two thumb movement units with a first shaft with a universal joint each, and one thumb rest element for both units. The device further includes one finger movement unit with a second and a third shaft and a first finger rest element associated with the second shaft and a second finger rest element associated with the third shaft, wherein the parts are arranged for right human hand exercising, and wherein said hand motion exercising device is shown in open position;

Fig. 2 shows, in a perspective view, the hand motion exercising device according to Fig. 1 in close position;

Fig. 3 shows, in a top view, the hand motion exercising device according to Fig. 1 in open position;

Fig. 4 shows, in a top view, the hand motion exercising device according to Fig. 1 in close position, wherein the rest elements are in contact, wherein said contact defines said close position;

Fig. 5 shows, in a side view, the hand motion exercising device according to Fig. 1 in open position;

Fig. 6 shows, in a side view, the hand motion exercising device according to Fig. 1 in close position;

Fig. 7 shows a further preferred embodiment of the hand motion exercising device according to the present invention, wherein the finger movement unit is simplified to comprise no third shaft;

Fig. 8 shows a schematic of a first preferred embodiment of a belt drive as a first mechanical motion linkage between the first and the second shaft of the hand motion exercising device according to Fig. 1 in open position, wherein the first mechanical motion linkage is accommodated in the base element;

Fig. 9 shows a schematic of a second preferred embodiment of said belt drive as the first mechanical motion linkage between the first and the second shaft of the hand motion exercising device according to Fig. 1 in open position;

Fig. 10 shows a schematic of a third preferred embodiment of said belt drive as a first mechanical motion linkage between the first and the second shaft of the hand motion exercising device according to Fig. 1 in open position;

Fig. 11 shows a schematic of a first preferred embodiment of a gear train as a first mechanical motion linkage between the first and the second shaft of the hand motion exercising device according to Fig. 1 in open position, wherein

the first mechanical motion linkage is accommodated in the base element;

Fig. 12 shows a schematic of a further preferred embodiment of the hand motion exercising device according to invention, wherein said exercising device comprises one drive motor for driving the first shaft of the finger movement unit and a second drive motor for driving the thumb movement units via a third mechanical movement linkage;

Fig. 13 shows a schematic of a preferred embodiment of a gear train as a second mechanical motion linkage between the second and the third shaft of the hand motion exercising device according to invention in open position;

Fig. 14 shows a schematic of a preferred embodiment of a belt or cable drive as a second mechanical motion linkage between the second and the third shaft of the hand motion exercising device according to invention in open position;

Fig. 15 shows, in a simplified perspective view from below, a security pin serving as an abutment for a blocking pin of a preferred embodiment of a security unit, wherein the blocking pin is in a right position with respect to a plane through the axes of the second and third shaft and allows right human hand exercise;

Fig. 16 shows, in a simplified perspective view from below, the security pin serving as an abutment for a blocking pin of the preferred embodiment of the security unit of Fig. 15, wherein the blocking pin is in a left position and allows left human hand exercise;

Fig. 17 shows schematically steps of a swapping process from right hand use (a) to left hand use (d) with intermediate steps (b,c); and

Fig. 18 shows schematically a base element of the device according to Fig. 1 attached to an arm exercising device, the base element being in a position relative to the arm exercising device for an extended wrist (a) and a bent wrist (b).

DESCRIPTION OF PREFERRED EMBODIMENTS

[0032] Figures 1 to 6 show a preferred embodiment of the hand motion exercising device 1 according to the present invention, presented from different perspectives and in different actuation positions, *i.e.* either in open position (*cf.* Figs. 1, 3, 5) or in close position (*cf.* Figs. 2, 4, 6).

[0033] The term "open position" is to be understood as a position in which the human hand is stretched out, *i.e.* the metacarpophalangeal and proximal interphalangeal joints of fingers and thumb are stretched. A palm is then substantially flat and the thumb stretched out in substantially normal or inclined direction to said palm. The term "close position" is to be understood as a position in which the human hand is contracted or clenched such as to form an almost fist-like hand with the fingers, thumb, and hand clenched to bend as far as the exercising device 1 allows for, hence the close position is a kind of a grip position, used, *e.g.*, when grabbing a stick.

[0034] The hand motion exercising device 1 comprises a plate-like, flat base element 11 that has, from top view (*cf.* Figs. 3 and 4), a shape like a rhombus. The term "top view" is to be understood as a view onto a top surface 110 of the base element 11. Said top surface 110 faces, during exercise, the human hand, more precisely the side of said hand.

[0035] On the top surface 110, two thumb movement units 2, *i.e.* a left thumb movement unit 2a and a right thumb movement unit 2b, are arranged in two opposing corner regions of the diamond-shaped base element 11, said regions being designated as a left corner region 110a with the left thumb movement unit 2a and a right corner region 110b with the right thumb movement unit 2b.

[0036] Each of the thumb movement units 2a, 2b comprises a first joint 20 with a first shaft 21a or 21b with a first shaft axis 22 that is oriented substantially perpendicular or normal to the top surface 110 of the base element 11. A thumb rest element 26, attached to said first joint 20, is pivotable about the first joint 20 in a first movement plane. The first shaft 21a, 21b protrudes about 1 to 5 centimeters upward beyond the top surface 110. This is to move the first movement plane locally upward with respect to the top surface 110 such that the first movement plane is inclined with respect to the top surface and such that a rotation point of the thumb joint lies within said first movement plane if the human hand is placed properly in the device 1, which avoids harmful shear forces acting on said thumb joint. Proper placement of the hand means that the side of the hand including the pinky, is facing down onto the top surface 110, while the palm is substantially perpendicular to the top surface 110. The fingers encompass the perpendicularly to said top surface 110 extending finger rest elements 36, 37, while the thumb encompasses the thumb rest element 26 of the respective thumb movement unit 2.

[0037] In its top or distal end region, the first shaft 21a, 21b further comprises a universal joint. The first shaft 11 and the universal joint are arranged in a sleeve bushing 27. Said sleeve bushing 27 circumferentially encloses the protruding part of said first shaft 11, including the universal joint. The sleeve bushing 27 is furthermore fixedly connected, at its proximal end, to the base element 11. As for its functionality, the bushing 27 accommodates the first shaft with the universal joint and protects the human hand from moving parts, in particular so during exercising. A distal free end of the universal joint is rotatably accommodated in the tapered distal end region of the bushing 27, where an opening 272 is arranged (*cf.* Fig. 1). Said opening 272 at the distal end of the bushing 27 faces in a predefined direction, wherein said direction includes an angle with respect to the first shaft axis 22 ranging from 60 to 85 degrees and being preferably about 70 degrees. Accordingly, an angle between the top surface 110 and the first movement plane is 5 to 30 degrees, preferably 20 degrees. Said distal free end of the universal joint is further provided with a distal recess 28 for positive-fit interlock with the therein removably attached thumb rest element 26. The recess 28 is accessible through the opening 272. Consequently, the sleeve bushing 27 defines, with its distal free end, in particular with its opening 272, the first movement plane of the first joint 20 of the thumb movement unit 2.

[0038] Preferably, said universal joint guides the movement of the first shaft 21a, 21b about the first shaft axis 22 into the first movement plane being inclined with respect to the top surface 110 by about 5 to 30 degrees, preferably about 20 degrees, toward a second shaft 31 of the finger movement unit 3, the second shaft 31 being arranged on said base element 11.

[0039] Hence, the first joint 20 defines the first movement plane, the latter being skewed with respect to the top surface 110 toward the second shaft 31, while the thumb rest element 26 is pivotable in said first movement plane about the first joint 20 for the purpose of guiding the thumb to be exercised under force loading in a natural grip movement.

[0040] Said inclination of the first movement plane with respect to the top surface 110 may be seen best in Figs. 5 and 6. From these figures the position of the thumb rest element 26 may be seen in open position (Fig. 5) and in close position (Fig. 6). It becomes clear that a thumb of the human hand, resting on said thumb rest element 26, moves on its way from the open position to the close position in a rotation movement about the first joint 20 downward in the inclined first movement plane toward the top surface 110 and said second shaft 31, *i.e.* toward the fingers resting on the finger rest elements 36, 37.

[0041] During this movement, a wrist of said hand remains substantially unmoved such that the movement is a substantially isolated hand motion exercising movement. The thumb movement is moreover preferably such that the first movement plane is substantially parallel to a plane through an oblique arch spanned by the thumb and one finger, preferably the ring finger, and the movement such that said oblique arch is partially collapsed in the positive movement (from open position to close position).

[0042] The sleeve bushing 27 is provided, at its distal end, with a contact element 271, the contact element 271 being arranged around said recess 28 for receiving said thumb rest element 26 without obstructing the aforementioned access from outside to said recess 28. The contact element 271 guides the thumb movement (via said gaiter or universal joint) into the skewed or inclined first movement plane, *i.e.* element 271 defines the orientation of the first movement plane. Preferably, said contact element 271 is made from plastics (like POM), metal, and/or another rigid material.

[0043] The two first shafts 21a, 21b are arranged on said base element 11 in the respective corner regions 110a, 110b with a mutual distance in a range from about 8 to 15 centimeters, wherein they are arranged symmetrically with respect to a mirror plane through a middle point of a connecting line connecting the first shaft axes 22. Said mirror plane is oriented substantially perpendicularly to said connecting line and extends through further corners of base element 11 in a front corner region 110c and a rear corner region 110d of the diamond-shaped base element 11. The second shaft 31 is arranged such as to lie within said mirror plane in the front corner region 110c. The connecting line between the first shafts 21a, 21b and the connecting line between one first shaft 21a, 21b and the second shaft 31 intersect one another at an angle ranging from 30 to 60 degrees, preferably being about 40 degrees.

[0044] A person skilled in the art knows to adapt the specific geometry taught herein to match a user's hand, which may be necessary *e.g.* for children with smaller hands. Particularly advantageous is if the rest elements are adapted for use with substantially smaller (of larger) hands, while these adapted rest elements remain usable with the same hand motion exercising device. A kit of parts including rest elements of different sizes may be provided. Alternatively, it is also possible to provide an overall smaller/larger device for different hand sizes.

[0045] Said thumb rest element 26 is detachably attachable to the first shaft 21a, 21b by plugging it into said recess 28. In the Figs. 1 to 6, the thumb rest element 26 is plugged into the left thumb movement unit 2a for exercising the right hand.

[0046] The thumb rest element 26 is provided with a convexly rounded, almost half pear-shaped thumb rest surface 260 that is basically oriented on the device 1 such as to face upward to receive the thumb. The thumb rest surface 260 follows basically the thumb-sided part of the oblique arches between the thumb and the four fingers of the hand. Moreover, the thumb rest surface 260 is divided, by means of a support web 263 (*cf.* Figs. 1, 5, 6). The web 263 extends substantially in the middle along a length of rest element 26, to form a left half 261 adapted and shaped for accommodation of a right thumb and a right half 262 adapted and shaped for accommodation of a left thumb. Said web 263 is shaped to provide

secure lateral support to the respective thumb such that said thumb may push said thumb rest element 26 toward the second shaft 31, *i.e.* toward the fingers, in particular toward the ring finger or the middle finger of said hand, thereby rotating the first shaft 21a, 21b. In other words, the thumb movement follows substantially a movement in the first movement plane and partly collapses the oblique arches of the hand.

[0047] Preferably, said thumb rest surface 260 and/or said web 263 are, at least in part, made from a resilient material and/or are provided, at least in part, with a resilient material layer such as rubber and/or a surface structure. Such a material choice or design improves, best in combination with an optional surface structuring, grip and comfort of the thumb rest element 26. The same applies for the finger rest elements 36, 37. Also the top surface 110 may be provided with such an enhanced surface function.

[0048] As for the finger movement unit 3, it comprises a second joint 30 and a principally optional further third joint 33 by means of which the finger rest elements 36, 37 are linked to one another. The second joint 30 includes said second shaft 31 and is functionally adapted to allow a pivoting movement of the first finger rest element 36, including the second finger rest element 37 via the third joint 33, in a second movement plane about the second joint 30.

[0049] The third joint 33 includes a third shaft 34 and is functionally adapted to allow a pivoting movement of the second finger rest element 37 in a third movement plane about the third joint 33. The second and third joints 30, 33 are arranged and adapted to guide the finger movement to partly collapse longitudinal arches of the digits. The movement may be described as a clenching movement of the fingers, as if the digits were grabbing a stick. The second and the third movement plane are substantially parallel to the top surface 110 and preferably collapse to one single plane.

[0050] The aforementioned functionality of the finger movement unit 3 is structurally achieved by a stiff bridging element 39, the bridging element 39 being hinged to the base element 11 via the second shaft 31. In other words, the second shaft 31 acts as a hinge joint between the base element 11 and the bridging element 39. Basically, said bridging element 39 accounts for the distance between the first and the intermediate hinge joints of the fingers anatomically provided by the proximal phalanges. The second shaft 31 is arranged in the front corner region 110c of the base element 11. The bridging element 39 protrudes parallel to the top surface 110 of the base element 11 from the second shaft 31. The first finger rest element 36 is detachably attached on said bridging element 39 and extends with its length normal to the top surface 110 from the bridging element 39. The bridging element 39 comprises an upward facing plug-in position and the finger element 36 is adapted to be rigidly connected to the bridging element 39 via said plug-in position.

[0051] At distal end of the bridging element 39, in the region where it terminates, the third shaft 34 of the third joint 33 is arranged. From the third shaft 34 a terminal element 390 extends parallel to the top surface 110. The terminal element 390 accounts for the distance between the intermediate and the distal hinge joints of the fingers anatomically provided by the intermediate phalanges. The terminal element 390 is pivotably linked to the bridging element 39 by means of the third joint 33, the latter including the third shaft 34. In other words, the third shaft 34 acts as a hinge joint between the terminal and the bridging element 39, 390. The second finger rest element 37 is attached to the terminal element 390 in the same or a similar manner like the first finger rest element 36 is attached to the bridging element 39.

[0052] The bridging element 39 and the terminal element 390, including the finger rest elements 36, 37, are dimensioned and arranged with respect to one another such that a comfortable rest for the fingers of the human hand with the herein described functionality is achieved.

[0053] The first finger rest element 36 is shaped such as to provide a rest for the proximal phalanges of the digits. The second finger rest element 37 is shaped such as to provide a rest for the intermediate phalanges of the digits. Through these rest elements 36, 37 the human hand may apply pressure or traction on the second and third joint 20, 30 in order to move from the open position into or toward the close position. In return, it is also possible to actuate via mechanical motion linkages the hand by means of a drive motor such as to force the hand from the close position into or toward the open position or such as to apply resistance to the hand during positive and negative movement, respectively.

[0054] For better attaching the user's hand to the device, straps may be provided on the rest elements.

[0055] As can be seen from Fig. 3, the first finger rest element 36 protrudes further in lateral direction (*i.e.* to the left in Fig. 3) than the second finger rest element 37. Further, it can be seen from Figs. 3 and 4 that the first rest surface 360 and second rest surface 370 facing to the right are shaped slightly convexly for receiving the fingers. The rest surfaces 360, 370 are shifted, with respect to the mirror plane in which the second shaft 31 lies, to the side on which the thumb rest element 26 is. This is achieved by forming the finger rest elements 36, 37 in an L-shape (*cf.* Figs. 1, 2). By means of this construction it is assured that the moving joints of the human hand stay centered on the respective pivoting points of the first, second, and third joint 20, 30, 33 such as to avoid harmful shear forces.

[0056] Also the third shaft 34 lies, in open position, within said mirror plane if the device 1. If the finger elements 36, 37 are moved from the open position into or toward the close position, the third shaft is moved normal to said mirror plane and out of said mirror plane (*i.e.* to the left in Fig. 3, *cf.* Fig. 4).

[0057] The right human hand to be exercised with the configuration according to Fig. 3 and 4 is put into the device 1 with the side of said hand including the pinky facing down on the top surface 110 while the fingers extend along the bridging element 39 and the terminal element 390; one finger is arranged above another in the direction of the second and third shaft axis 32, 35 to form a substantially flat hand. The thumb is bent to run at an angle to the flat hand, *i.e.* the

thumb extends substantially normal or inclined to the flat palm of the hand, and is received by the left thumb rest surface 261 of the thumb rest element 26. Then, upon clenching thumb and fingers, the rest element 26, 36, 37, including the bridging element 39 and the terminal element 390, are moved from the open position (*cf.* Fig. 3) into the close position according to Fig. 4.

[0058] Moreover, the surface of the first finger rest element 36 opposite the first rest surface 360 is shaped slightly concavely such as to engage positively with the convexly shaped thumb rest element 26 if in close position (*cf.* Fig. 4). Figures 3 and 4 also show that the second finger rest element 37 has, from top view, a basically muffin shaped cross section with a tip forming the distal middle end (to the left in Fig. 3). In said cross-sectional view, the concavely shaped flanks dropping away to the right are correspondingly shaped to the contact area with the thumb rest element 26 in close position (*cf.* Fig. 4). The corresponding shapes between the first finger rest 36 and the second finger rest element 37 and corresponding shapes between the finger rest elements 36, 37 and the thumb rest element 26 allow an increased and well-defined contact surface, which contact surface provides a defined abutment and therefore a final stop of the clenching movement of the rest element 26, 36, 37, into the close position.

[0059] Moreover, a desired braking force counteracting the clenching movement of the rest elements 26, 36, 37 actuated by hand may be provided by appropriate choice of material and material thickness in the contact area of the rest elements 26, 36, 37.

[0060] Preferably, said finger rest surfaces 360 and/or 370 and also corresponding areas of the thumb rest element 26 are, at least in part, made from a resilient material or are, at least in part, provided with a resilient material layer such as rubber. Such a choice in material in combination with an optional surface structuring improves grip and comfort of the finger rest elements 36, 37. Further, it avoids metal-to-metal contact.

[0061] The finger rest elements 36, 37 are constructed such that if detached from the bridging element 39 and the terminal element 390, respectively, they may be mounted or swiveled to the other side such that the finger rest surfaces 360, 370 face to the left (not shown in the figures) or to the right (Fig. 3), depending on whether a left or a right human hand should be exercised. The hand exercising device is a symmetrical device in this respect. The thumb rest element 26 may be mounted on the left or the right movement unit 2a, 2b. Hence, the user may choose, by simple remounting, to exercise the left or the right hand.

[0062] Particularly preferred are finger rest elements 36, 37 which have a substantially central swivel axis for swiveling said rest elements 36, 37 into a position for either left hand or right hand exercise; this relieves the user of disassembling and reassembling parts of the device 1. For that swiveling purpose, the finger rest elements 36, 37 are constructed such that they do not block one another during said swivel motion, *i.e.* their radial extension with respect to said swiveling axis is adapted accordingly.

[0063] As already mentioned, the third joint 33 is optional. **Figure 7** shows schematically that the bridging element 39 may be provided for attaching the finger rest element 36 or elements 36, 37, wherein there is provided only the second joint 30 associated with the metacarpophalangeal joints, while the third joint 33 is missing. As for the mechanics, this simplified hand motion exercising device 10 may have a first mechanical motion linkage 4 (see below) between the first and the second shaft 21a, 21b, 31 as described herein, but does not require a second mechanical motion linkage 38 (see below) between the second and the third shaft 31, 34 as the latter is missing. This makes this embodiment cheaper and simpler in production. This embodiment is based on the insight that exercising the metacarpophalangeal joints is of foremost importance.

[0064] Next, the mechanics provided for moving the first, second, and third shaft 21a, 21b, 31, 34, *i.e.* the first and the second mechanical motion linkages 4, 38, are described.

[0065] The first mechanical motion linkage 4 is described with reference to **Figures 8 to 11**. The first mechanical motion linkage 4 couples the first shafts 21a, 21b to the second shaft 31 such that they rotate, substantially torque-proof, in opposite directions, while the first shafts 21a, 21b are coupled to one another to rotate, substantially torque-proof, in the same direction.

[0066] Figures 8 to 10 show preferred embodiments of a first belt drive 6 as a first mechanical motion linkage 4, while Fig. 11 shows a preferred embodiment of a first gear train 7 as a first mechanical motion linkage 4. The first mechanical motion linkage 4 is arranged within the plate-like base element 11. The plate-like base element 11 is shaped as a container with a flat lid, attachable by attachment means like screws. Said lid provides the top surface 110, while the container accommodates the first mechanical linkage 4.

[0067] **Figure 8** shows a first belt drive arrangement for mechanical motion linking of the first and the second shaft 21a, 21b, 31 for transmission of power. A belt 61 is provided as a loop of preferably flexible material that is looped over two first shaft pulleys 63, 64 in the base element 11. Figure 8 shows a top view into the open base element 11. The two first shaft pulleys 63, 64 are arranged symmetrically around the respective left first shaft 21a and right first shaft 21b, respectively. Via first and second tensioner pulleys 66, 67, said tensioner pulleys 66, 67 being arranged within the belt loop, the belt 61 is pressed against a second shaft pulley 68 arranged around the second shaft 31 and outside said belt loop. The bridging element 39 is fixedly connected to the second shaft pulley 68 such that if said pulley 68 rotates, the bridging element 39 rotates accordingly. Moreover, a further third tensioner pulley 65 is arranged outside said belt loop,

opposite the second shaft pulley 68 and between the two first shaft pulleys 63, 64, in order to control the overall tension of the belt 61. The third tensioner pulley 65 may be shifted by an eccentric element (not shown) toward the first shaft pulley, whereby the tension in the belt 61 is increased. Shifting the tensioner pulley 65 in the opposite direction decreases said belt tension.

[0068] Moreover, said belt 61 may be provided with a toothing 62 for better contact between shaft pulleys 63, 64, 68 and belt 61. This toothing 62 is arranged on an outside surface 610 of the belt 61. For this purpose, the second shaft pulley 68 is correspondingly toothed and the first shaft pulley 63, 64 are provided with a clamp (not shown) that is fixedly connected to the respective pulley 63, 64 and that extends radially outwardly to encompass the belt and to engage with the belt toothing 62 on the outside surface 610 of the belt 61. The belt 61 is preferably only toothed in the relevant sections of its length. Said clamp is, however, optional; depending on the actual path of belt 61, said belt may also be toothed on the inside surface (double-sided tooth belt).

[0069] **Figure 9** shows a further embodiment of the first belt drive arrangement, wherein the belt 61 is crossed between the left first shaft 21a and the second shaft 31 and between the right first shaft 21b and the second shaft 31. Here, the belt 61 may be two separate belts 61, one between each, between the left first shaft 21a and the second shaft 31 and between the right first shaft 21b and the second shaft 31, or the belt 61 may be a single belt. Moreover, a toothing as described herein may be provided optionally, at least along relevant sections of the belt 61 and shaft pulleys 63, 64.

[0070] **Figure 10** shows yet another preferred embodiment of the first belt drive arrangement, wherein the belt 61 is provided as a single belt, looped around the left and right first shaft 21a, 21b then crossed and looped around the second shaft 31. This looping provides a strong coupling of the belt 61 to the second shaft 31, which is advantageous, if the radius of the second shaft pulley 68 is smaller than the radii of the first shaft pulleys 63, 64. Moreover, a toothing as described herein may be provided optionally, at least along relevant sections of the belt 61 and shaft pulleys 63, 64.

[0071] It is to be understood, that instead of the belt drive arrangement as described above, also a cable or chain drive or the like may be used.

[0072] **Figure 11** shows a preferred embodiment of a first gear train 7 provided as the first mechanical motion linkage 4 between the first and the second shaft 21a, 21b, 31. About each of the first and second shafts 21a, 21b, 31 a cog wheel 73, 74, 78 is arranged, fixedly connected to the respective shaft 21a, 21b, 31. The bridging element 39 is fixedly connected to the second shaft cog wheel 78 such that if said cog wheel 78 rotates, the bridging element 39 rotates accordingly. The right first shaft cog wheel 73 is connected via a first transmission cog wheel 75 and a third transmission cog wheel 77 to the second shaft cog wheel 78. The left first shaft cog wheel 74 is connected via a second transmission cog wheel 76 and the third transmission cog wheel 77 to the second shaft cog wheel 78. Through cog wheel combing action, the two first shafts 21a, 21b and the second shaft 31 are rotationally coupled in a substantially torque-proof manner. This coupling via gear train 7 is in summary designed such that between the first shafts 21a, 21b there are three transmission wheels 75, 76, 77, while between the first shafts 21a, 21b and the second shaft 31, there are two transmission wheels 75, 77 or 76, 77.

[0073] The second mechanical motion linkage 38 is described with reference to **Figures 13 and 14**. The second mechanical motion linkage 38 is provided within the bridging element 39. This is advantageous, like providing the first mechanical motion linkage 4 within the base element 11, as the moving parts are hidden away from the user, thereby decreasing the risk of injury and the risk of jamming the mechanics with foreign objects. The second mechanical motion linkage 38 couples the second shaft 31 and the third shaft 34 in a substantially torque-proof manner such that they rotate simultaneously in the same direction. For this purpose, again, a second gear train or belt drive may be used.

[0074] **Figure 13** shows a second gear train with a second shaft cog wheel 381 fixedly connected to the second shaft 31 and a third shaft cog wheel 382 fixedly connected to the third shaft 34. These two shaft cog wheels 381, 382 are coupled by two transmission cog wheels 383 provided between said shaft cog wheels 381, 382. The cog wheels 381, 382, 383 are mounted on a flat bearing rod 384 functioning as the bridging element 39.

[0075] **Figure 14** shows a second belt drive with a second shaft pulley 385 fixedly connected to the second shaft 31 and a third shaft pulley 386 fixedly connected to the third shaft 34. These two shaft pulleys 385, 386 are coupled by a belt 387 looped around and crossed between said shaft pulleys 385, 386. The pulleys 385, 386 are mounted on a flat bearing rod 388 functioning as the bridging element 39.

[0076] Instead of a belt drive, a cable drive or chain drive may be used. The path of the cable drive may be that from **Fig. 14**.

[0077] The first and second mechanical motion linkages 4, 38 are formed such that a predefined transmission ratio is achieved. Preferably, for the first mechanical motion linkage 4, in general for all embodiments, a first rotation ratio ranges from 1:1 to 1:1.6 (first shaft rotation : second shaft rotation, *i.e.* thumb : fingers), said first rotation ratio being preferably about 1:1.2. Preferably, for the second motion linkage 38, in general for all embodiments, a second rotation ratio ranges from 1:0.8 to 1:1.2 (second shaft rotation : third shaft rotation, *i.e.* metacarpophalangeal (MCP) joints : proximal interphalangeal (PIP) joints), said second rotation ratio being preferably about 1:1.

[0078] By means of the at least one drive motor 8, 81 a force is provided for setting the device 1 from the close position into the open position and vice versa. Said reset force is guided onto the hand via a drive shaft (not shown in the figures)

and the mechanical motion linkage(s) 4, 38. Preferably, the first shaft pulley 68 or the first shaft cog wheel 78 is directly connected to said drive shaft. Moreover, said reset force may be used to counteract the force applied by the hand during the movement from open to close position.

[0079] The hand motion exercising device 1 is mountable on an arm training device. For linking purposes, the base element 11 has the rear corner region 110d, where linkage means are provided for connection of the hand motion exercising device 1 with said arm training device. Moreover, said linkage means are constructed such that by simple manipulation, such as switching a lever or unscrewing a pin, a relative distance between the hand motion exercising device 1 and the arm exercising device is adjustable to match the users arm.

[0080] Consequently, the diamond shape of the base element 11 is advantageous, as the left and right corner regions 110a, 110b serve for attachment of the thumb movement units 2a, 2b, the front corner region 110c serves for attachment of the finger movement unit 3, and the rear corner region 110d serves for the attachment of the hand device 1 to the arm exercising device. As can be seen from **Figure 18** the diamond shape of base element 11 allows for an efficient accommodation of the base element 11 on the arm exercising device with a minimum space requirement and a maximum freedom of action. Figure 18(a) shows the situation for an extended wrist position while Fig. 18(b) shows the situation for an arm position with a bent wrist.

[0081] An alternative mechanical construction is depicted in **Figure 12**. In this embodiment, the left and right first shafts 21a, 21b are coupled by a third mechanical motion linkage 29, being constructed like the second mechanical motion linkage 38 or by a simple stiff rod, wherein a first drive motor 8 drives, preferably via the third mechanical motion linkage 29, the second shaft 31 and a second, separate drive engine 81 drives the first shafts 21a, 21b. The coupling between the first and the second shafts 21a, 21b, 31 may then be achieved by control electronics controlling said drive motors 8, 81. The other elements of this embodiment, e.g. like the movement units or the second mechanical motion linkage 38 are constructed as described herein.

[0082] The safety unit 5 is described with reference to **Figures 15** and **16**. The hand motion exercising device 1 preferably comprises a safety unit 5 having a switching device 51. Said safety unit 5 includes a switching pin 52 by means of which the hand motion exercising device 1 is switchable for left or for right human hand exercise. Said switching pin 52 is pluggable into the hand motion device 1 with a guide tube or the like (not shown in Fig. 15 and 16) allows moving the pin 52 in the direction of its longitudinal axis. The switching pin 52 interacts, with its front part, with a blocking pin 53 that protrudes through an oblong slit 54 of the bridging element 39. Figure 15 shows the position of a switching pin 52 in a first securing position, while Fig. 16 shows the pin 52 in a second securing position. Blocking pin 53 can be moved in the oblong slit 54 in a sliding movement to provide an abutment for securing a maximum pivot angle $\alpha_{\max}$ of the finger movement unit 3 such that the fingers are not overstretched either for a right hand or a left hand configuration of the device 1, 10. In Fig. 15, the blocking pin 53 is secured by the switching pin 52 in a right position. In Fig. 16, the blocking pin 53 is secured by the switching pin 52 in a left position in the transversal through slit 54.

[0083] **Figure 17** shows a sequence of situations (a) to (d) as they arise if one swaps the hand motion exercising device 1 from right hand use to left hand use.

[0084] **Figure 17(a)** shows the hand motion exercising 1, i.e. the base element 11 with the attached bridging element 39 from below and in a position ready for right hand use (like in Fig. 16): the switching pin 52 is in locked position, the blocking pin 53 safely caged in a right half of oblong slit 54 in Fig. 17(a) by the switching pin 52, preferably with a spring reset acting on the switching pin 52. The device 1 is in extended finger position. The blocking pin 53 acts such as to allow a swivel movement of the bridging element 11 from the situation according to Fig. 17(a) to the right of Fig. 17(a) (which is the patient's left as the device is shown from below) while a movement to the left of Fig. 17(a) is blocked; the device 1 is thus ready for right hand use and blocks movements that would overstretch a user's right hand.

[0085] **Figure 17(b)** shows a first intermediate step during swapping the device 1 from right to left hand use. The switching pin 52 is unlocked, the blocking pin 53 therefore free to move along and in the oblong slit 54.

[0086] **Figure 17(c)** shows a further intermediated step, wherein the switching pin 52 is unlocked and the bridging element 39 is rotated to the left of Fig. 17(c) such that the blocking pin 53 is left of the switching pin 52 in Fig. 17(c).

[0087] **Figure 17(d)** shows the device 1 ready for left hand use, the device 1 being in extended finger position. After moving the switching pin 52 from the situation in Fig. 17(c) into locking position (like in Fig. 17(a)), the bridging element 39 is rotated back to the right of Fig. 17(d) to extend in distal direction like in Fig. 17(a). When the bridging element 39 is moving to the right of Fig. 17(d), the blocking pin 53 is eventually contacting the switching pin 52, whereafter any further movement of the blocking pin 53 to the right of Fig. 17(d) is blocked. Therefore, the blocking pin 53 is moved relative to the bridging element 39 in the oblong slit 54 to the left of Fig 17(d); hence, the blocking pin 53 moves from the right half in the left half of slit 54 (as seen from below). After that, the blocking pin 53 is caged in the left half of the oblong slit 54, by the switching pin 52, preferably with a spring reset acting on the switching pin 52.

[0088] The safety unit 5 thus provides the opposite abutment to the mechanical stop provided by the finger and thumb rests 26, 36.

[0089] The blocking pin 53 blocks then almost half the pivot angle (it blocks out either the left or the right side movement), but allows for full stretch of the fingers due to the sliding.

[0090] The switching pin 52 is mounted below the second mechanical linkage 38 and stays in place. The bridging element 39 is blocked from pivoting.

LIST OF REFERENCE SIGNS

5	1	hand motion exercising device	3	finger movement unit
	10	simplified hand motion exercising device	30	second joint
	11	base element	31	second shaft
10	110	top surface of 11	32	second shaft axis
	110a	left corner region	33	third joint
	110b	right corner region	34	third shaft
	110c	front corner region	35	third shaft axis
	110d	rear corner region	36	first finger rest element
15			360	rest surface on 36
	2	thumb movement unit	37	second finger rest element
	2a	left thumb movement unit	370	rest surface on 37
	2b	right thumb movement unit	38	second mechanical motion linkage
20	20	first joint	381	second shaft cog wheel
	21a, 21b	first shaft	382	third shaft cog wheel
	22a,b	left and right first shaft axis	383	transmission cog wheel
	23	first swivel axis	384	bearing rod
	24	second swivel axis	385	second shaft pulley
25	26	thumb rest element	386	third shaft pulley
	260	thumb rest surface	387	second belt
	261	left thumb rest surface	388	bearing rod
	262	right thumb rest surface	39	bridging element
30	263	web	390	terminal element
	27	sleeve bushing	4	first mechanical motion linkage
	271	resilient contact element		
	272	opening		
	28	recess	5	safety unit
35			51	switching device
	29	third mechanical linkage	52	switching pin
	53	blocking pin	7	gear train
	54	slit	73	right first shaft cog wheel
40	6	first belt drive	74	left first shaft cog wheel
	61	belt	75	first transmission cog wheel
	610	outside surface	76	second transmission cog wheel
	62	toothing	77	third transmission cog wheel
45	63	right first shaft pulley	78	second shaft cog wheel
	64	left first shaft pulley		
	65	third tensioner pulley	8	drive motor
	66	first tensioner pulley	81	second drive motor
	67	second tensioner pulley		
50	68	second shaft pulley	α	pivot angle
			$\alpha_{\max}$	maximum pivot angle

Claims

1. A hand motion exercising device (1) comprising

a base element (11),
 a thumb movement unit (2) with a thumb rest element (26), said thumb rest element (26) being pivotable in a first movement plane about a first joint (20); and
 a finger movement unit (3) with a first finger rest element (36), said first finger rest element (36) being pivotable
 in a second movement plane about a second joint (30);
 wherein the thumb rest element (26) and the first finger rest element (36) are adapted to be encompassed and
 pressed toward one another or pulled apart from one another by a human hand, and
 wherein the first joint (20) and the second joint (30) are provided such that said second movement plane is
 skewed with respect to said first movement plane, **characterized in that**

wherein two thumb movement units (2a, 2b) are provided and arranged on said hand motion exercising device (1)
 such that, with respect to the finger movement unit (3) and with respect to one another, the thumb rest element (26)
 attached to one thumb movement unit (2a;2b) allows exercising a left human hand and the thumb element (26)
 attached to the other thumb movement unit (2b;2a) allows exercising a right human hand.

2. The hand motion exercising device (1) according to claim 1, wherein the finger rest element (36,37) is adapted to
 be attached on the finger movement unit (3) to either allow for exercising said left or said right human hand.

3. The hand motion exercising device (1) according to claim 1 or 2, wherein
 the thumb movement unit (2) and the finger movement unit (3) are connected via a first mechanical motion linkage
 (4) arranged under the base element (11) such that both movement units (2,3) are drivable by one and the same
 drive motor (8).

4. The hand motion exercising device (1) according to claim 3, wherein said first joint (20) comprises a first shaft
 (21a,21b) with a first shaft axis (22) and wherein said second joint (3) comprises a second shaft (31) with a second
 shaft axis (32), wherein said first shaft (21a,21b) and said second shaft (31) are coupled by said first mechanical
 motion linkage (4), wherein the first mechanical motion linkage (4) is substantially torque-proof.

5. The hand motion exercising device (1) according to claim 3 or 4, wherein the first joint (20) further comprises a gaiter
 or a universal joint.

6. The hand motion exercising device (1) according to any one of claims 3 to 5, wherein the first and the second shaft
 axis (22,32) are substantially parallel and/or spaced apart to one another.

7. The hand motion exercising device (1) according to any one of claims 3 to 6, wherein the finger movement unit (3)
 further comprises at least one third shaft (34) with a third shaft axis (35), wherein the hand motion exercising device
 (1) further comprises a second finger rest element (37), wherein said second finger rest element (37) is pivotable
 in a third movement plane about said third shaft axis (35), and wherein the second and the third shaft (31,34) are
 in a second mechanical motion linkage (38) such that a proximal phalanx joint and an intermediate phalanx joint of
 fingers of the human hand resting on the first and second finger rest element (36,37) can be actuated individually
 and simultaneously.

8. The hand motion exercising device (1) according to claim 7, wherein the two thumb movement units (2a, 2b) are
 connected via a third mechanical motion linkage (29).

9. The hand motion exercising device (1) according to claim 8, wherein the two thumb movement units (2a, 2b) are
 connected via said third mechanical motion linkage (29) such that both thumb movement units (2a,2b) are drivable
 by one and the same drive motor (8,81), wherein said third mechanical motion linkage (29) is preferably substantially
 torque-proof.

10. The hand motion exercising device (1) according to any one of claims 7 to 9, wherein the second mechanical motion
 linkage (38) comprises as transmission element a gear train or a belt drive or a cable drive or a chain drive, and
 wherein said gear train or said belt drive is constructed such that the first and the second shaft (21a,21b,31) rotate
 synchronously and in a substantially torque-proof manner in the opposite direction.

11. The hand motion exercising device (1) according to any one the preceding claims 3 to 10, wherein the finger rest
 element (36;37) is shaped as a grip cylinder, and/or wherein at least one, preferably all of said rest elements
 (26,36,37) are provided with a resilient coating, wherein said rest elements (26,36,37) are pivotable such that at

least two of said rest elements (26,36,37) come into contact with one another via said coating, and wherein said coating(s) is(are) compressed upon said contact and provides a reaction force counteracting the rest element movement toward one another in order to guide the rest elements (26,36,37) into a defined stop position and in order to relieve the drive motor (8) and the mechanical motion linkage (4) from forces applied by the human hand, and wherein, preferably, said reaction force increases with increasing compression of said coating(s).

12. The hand motion exercising device (1) according to any one of the preceding claims 3 to 11, wherein the first mechanical motion linkage (4) between the first shaft (21a,21b) and the second shaft (31) is provided as a gear train (7) or as a belt drive (6) or as a cable or chain drive.

13. The hand motion exercising device (1) according to any one of the preceding claims 3 to 12, wherein the thumb movement unit (2) is adapted to accommodate the thumb rest element (26) and the finger movement unit (3) is adapted to accommodate the finger rest element (36,37), the rest elements (26,36,37) being preferably detachable mounting elements attachable to said first and second shaft (21a,21b,31), respectively, most preferably in a pluggable manner and/or wherein the finger rest element (36,37) is adapted to accommodate up to four fingers of the human hand.

14. The hand motion exercising device (1) according to any one of the preceding claims further comprising a safety unit (5), wherein said safety unit (5) is adapted to restrict a finger unit movement range such that a pivot angle (α) of the second shaft (31) cannot exceed a maximum pivot angle ($\alpha_{\max}$) corresponding to an open position of the hand of the user, and wherein, if the hand motion exercising device (1) comprises two thumb movement units (2) according to the preceding claim, the safety unit (5) is preferably switchable for allowing either a right human hand or a left human hand exercise.

15. The hand motion exercising device (1) according to the preceding claim, wherein the safety unit (5) comprises a switching device (51), the safety unit (5) including a switching pin (52) by means of which the hand motion exercising device (1) is switchable for left or for right human hand exercise, wherein, preferably, said switching pin (52) is pluggable into said hand motion device (1) to provide an abutment for securing said maximum pivot angle ($\alpha_{\max}$).

Patentansprüche

1. Handbewegungsübungsvorrichtung (1), umfassend
ein Basiselement (11),
eine Daumenbewegungseinheit (2) mit einem Daumenauflageelement (26), wobei das Daumenauflageelement (26) in einer ersten Bewegungsebene um ein erstes Gelenk (20) schwenkbar ist; und
eine Fingerbewegungseinheit (3) mit einem ersten Fingerauflageelement (36), wobei das erste Fingerauflageelement (36) in einer zweiten Bewegungsebene um ein zweites Gelenk (30) schwenkbar ist;
wobei das Daumenauflageelement (26) und das erste Fingerauflageelement (36) ausgestaltet sind, um durch eine menschliche Hand umgriffen und aufeinander zu gedrückt oder voneinander weg auseinandergezogen zu werden, und
wobei das erste Gelenk (20) und das zweite Gelenk (30) so vorgesehen sind, dass die zweite Bewegungsebene in Bezug auf die erste Bewegungsebene windschief ist,
dadurch gekennzeichnet, dass
wobei zwei Daumenbewegungseinheiten (2a, 2b) vorgesehen und an der Handbewegungsübungsvorrichtung (1) so angeordnet sind, dass in Bezug auf die Fingerbewegungseinheit (3) und in Bezug aufeinander das an einer Daumenbewegungseinheit (2a; 2b) befestigte Daumenauflageelement (26) das Üben einer linken menschlichen Hand ermöglicht und das an der anderen Daumenbewegungseinheit (2b; 2a) befestigte Daumenelement (26) das Üben einer rechten menschlichen Hand ermöglicht.
2. Handbewegungsübungsvorrichtung (1) nach Anspruch 1, wobei das Fingerauflageelement (36, 37) ausgestaltet ist, um an der Fingerbewegungseinheit (3) befestigt zu werden, um entweder das Üben der linken oder der rechten menschlichen Hand zu ermöglichen.
3. Handbewegungsübungsvorrichtung (1) nach Anspruch 1 oder 2, wobei die Daumenbewegungseinheit (2) und die Fingerbewegungseinheit (3) über eine erste mechanische Bewegungsanlenkung (4), die unter dem Basiselement (11) so angeordnet ist, dass beide Bewegungseinheiten (2,3) von ein und demselben Antriebsmotor (8) antreibbar sind, verbunden sind.

4. Handbewegungsübungs Vorrichtung (1) nach Anspruch 3, wobei das besagte erste Gelenk (20) eine erste Weile (21a, 21b) mit einer ersten Wellenachse (22) umfasst und wobei das besagte zweite Gelenk (3) eine zweite Welle (31) mit einer zweiten Wellenachse (32) umfasst, wobei die besagte erste Welle (21a, 21b) und die besagte zweite Welle (31) durch die erste mechanische Bewegungsanlenkung (4) gekoppelt sind, wobei die erste mechanische Bewegungsanlenkung (4) im Wesentlichen drehfest ist.
5. Handbewegungsübungs Vorrichtung (1) nach Anspruch 3 oder 4, wobei das erste Gelenk (20) ferner ein Faltenbalg oder ein Universalgelenk umfasst.
6. Handbewegungsübungs Vorrichtung (1) nach einem der Ansprüche 3 bis 5, wobei die erste und die zweite Wellenachse (22, 32) im Wesentlichen parallel und/oder beabstandet zueinander sind.
7. Handbewegungsübungs Vorrichtung (1) nach einem der Ansprüche 3 bis 6, wobei die Fingerbewegungseinheit (3) ferner mindestens eine dritte Welle (34) mit einer dritten Wellenachse (35) umfasst, wobei die Handbewegungsübungs Vorrichtung (1) ferner ein zweites Fingerauflageelement (37) umfasst, wobei das zweite Fingerauflageelement (37) in einer dritten Bewegungsebene um die dritte Wellenachse (35) schwenkbar ist, und wobei die zweite und die dritte Wellenachse (31, 34) in einer zweiten mechanischen Bewegungsanlenkung (38) sind, so dass ein proximales Phalanxgelenk und ein Zwischenphalanxgelenk von Fingern der menschlichen Hand, die auf dem ersten und zweiten Fingerauflageelement (36, 37) ruhen, einzeln und gleichzeitig betätigt werden können.
8. Handbewegungsübungs Vorrichtung (1) nach Anspruch 7, wobei die beiden Daumenbewegungseinheiten (2a, 2b) über eine dritte mechanische Bewegungsanlenkung (29) verbunden sind.
9. Handbewegungsübungs Vorrichtung (1) nach Anspruch 8, wobei die beiden Daumenbewegungseinheiten (2a, 2b) über die dritte mechanische Bewegungsanlenkung (29) derart verbunden sind, dass beide Daumenbewegungseinheiten (2a, 2b) von ein und demselben Antriebsmotor (8, 81) antreibbar sind, wobei die dritte mechanische Bewegungsanlenkung (29) vorzugsweise im Wesentlichen drehfest ist.
10. Handbewegungsübungs Vorrichtung (1) nach einem der Ansprüche 7 bis 9, wobei die zweite mechanische Bewegungsanlenkung (38) als Übertragungselement einen Zahnradantrieb oder einen Riemenantrieb oder einen Kabelantrieb oder einen Kettenantrieb umfasst, und wobei der besagte Zahnradantrieb oder der besagte Riemenantrieb so konstruiert ist, dass sich die erste und die zweite Welle (21a, 21b, 31) synchron und im Wesentlichen in einer drehfesten Weise in der entgegengesetzten Richtung drehen.
11. Handbewegungsübungs Vorrichtung (1) nach einem der vorstehenden Ansprüche 3 bis 10, wobei das Fingerauflageelement (36;37) als Greifzylinder ausgebildet ist, und/oder wobei mindestens ein, vorzugsweise alle Auflageelemente (26, 36, 37) mit einer elastischen Beschichtung versehen sind, wobei die Auflageelemente (26, 36, 37) so schwenkbar sind, dass mindestens zwei der Auflageelemente (26, 36, 37) über die besagte Beschichtung miteinander in Kontakt kommen, und wobei die Beschichtung(en) bei dem Kontakt komprimiert wird (werden) und eine Reaktionskraft bereitstellen, die der Bewegung der Auflageelemente zueinander entgegenwirkt, um die Auflageelemente (26, 36, 37) in eine definierte Endposition zu führen und um den Antriebsmotor (8) und die mechanische Bewegungsanlenkung (4) von den von der menschlichen Hand ausgeübten Kräften zu befreien, und wobei vorzugsweise die Reaktionskraft mit zunehmender Kompression der Beschichtung(en) zunimmt.
12. Handbewegungsübungs Vorrichtung (1) nach einem der vorhergehenden Ansprüche 3 bis 11, wobei die erste mechanische Bewegungsanlenkung (4) zwischen der ersten Welle (21a, 21b) und der zweiten Welle (31) als Getriebezug (7) oder als Riementrieb (6) oder als Seil- oder Kettenantrieb vorgesehen ist.
13. Handbewegungsübungs Vorrichtung (1) nach einem der vorhergehenden Ansprüche 3 bis 12, wobei die Daumenbewegungseinheit (2) zur Aufnahme des Daumenaufnahmeelements (26) und die Fingerbewegungseinheit (3) zur Aufnahme des Fingeraufnahmeelements (36, 37) ausgebildet ist, wobei die Auflageelemente (26, 36, 37) vorzugsweise abnehmbare Befestigungselemente sind, die jeweils an der besagten ersten und zweiten Welle (21a, 21b, 31) am bevorzugtesten steckbar befestigt werden können und/oder wobei das Fingeraufnahmeelement (36, 37) zur Aufnahme von bis zu vier Fingern der menschlichen Hand ausgebildet ist.
14. Handbewegungsübungs Vorrichtung (1) nach einem der vorhergehenden Ansprüche, die ferner eine Sicherheitseinheit (5) umfasst, wobei die Sicherheitseinheit (5) angepasst ist, um einen Bewegungsbereich der Fingereinheit so einzuschränken, dass ein Schwenkwinkel (α) der zweiten Welle (31) einen maximalen Schwenkwinkel ($\alpha_{\max}$)

entsprechend einer offenen Position der Hand des Benutzers nicht überschreiten kann, und wobei, wenn die Handbewegungsübungsanordnung (1) zwei Daumenbewegungseinheiten (2) nach dem vorhergehenden Anspruch umfasst, wobei die Sicherheitseinheit (5) vorzugsweise schaltbar ist, um entweder einer rechten menschlichen Hand oder einer linken menschlichen Hand das Üben zu ermöglichen.

15. Handbewegungsübungsanordnung (1) nach dem vorstehenden Anspruch, wobei die Sicherheitseinheit (5) eine Schaltvorrichtung (51) umfasst, wobei die Sicherheitseinheit (5) einen Schaltbolzen (52) beinhaltet, mit dem die Handbewegungsübungsanordnung (1) für das Über mit der linken oder rechten Hand schaltbar ist, wobei vorzugsweise der Schaltbolzen (52) in die Handbewegungsanordnung (1) einsteckbar ist, um ein Widerlager zur Sicherung des maximalen Schwenkwinkels ($\alpha_{\max}$) bereitzustellen.

Revendications

1. Dispositif d'exercice de mouvement de main (1) comprenant un élément de base (11), une unité de mouvement du pouce (2) avec un élément d'appui de pouce (26), ledit élément d'appui de pouce (26) pouvant pivoter dans un premier plan de mouvement autour d'une première articulation (20) ; et une unité de mouvement de doigt (3) avec un premier élément d'appui de doigt (36), ledit premier élément d'appui de doigt (36) pouvant pivoter dans un second plan de mouvement autour d'une seconde articulation (30) ; dans lequel l'élément d'appui de pouce (26) et le premier élément d'appui de doigt (36) sont adaptés pour être entourés et pressés l'un contre l'autre ou séparés l'un de l'autre par une main humaine, et dans lequel la première articulation (20) et la seconde articulation (30) sont prévues de telle sorte que ledit second plan de déplacement est incliné par rapport audit premier plan de déplacement, **caractérisé en ce que** dans lequel deux unités de mouvement de pouce (2a, 2b) sont prévues et disposées sur ledit dispositif d'exercice de mouvement de main (1) de telle sorte que, par rapport à l'unité de mouvement de doigt (3) et l'un par rapport à l'autre, l'élément d'appui de pouce (26) fixé à une unité de mouvement de pouce (2a ; 2b) permet d'exercer une main humaine gauche et l'élément d'appui de pouce (26) fixé à l'autre unité de mouvement de pouce (2b ; 2a) permet d'exercer une main humaine droite.
2. Dispositif d'exercice de mouvement de main (1) selon la revendication 1, dans lequel l'élément d'appui de doigt (36, 37) est adapté pour être fixé sur l'unité de mouvement de doigt (3) pour permettre l'exercice de ladite main humaine gauche ou droite.
3. Dispositif d'exercice du mouvement de main (1) selon la revendication 1 ou 2, dans lequel l'unité de mouvement de pouce (2) et l'unité de mouvement de doigt (3) sont reliées par l'intermédiaire d'une première liaison de mouvement mécanique (4) disposée sous l'élément de base (11) de telle sorte que les deux unités de mouvement (2, 3) peuvent être entraînées par un seul et même moteur d'entraînement (8).
4. Dispositif d'exercice de mouvement de main (1) selon la revendication 3, dans lequel ladite première articulation (20) comprend un premier arbre (21a, 21b) avec un premier axe d'arbre (22) et dans lequel ladite seconde articulation (3) comprend un second arbre (31) avec un second axe d'arbre (32), ledit premier arbre (21a, 21b) et ledit second arbre (31) étant couplés par ladite première liaison de mouvement mécanique (4), où la première liaison de mouvement mécanique (4) est essentiellement solidaire en rotation.
5. Dispositif d'exercice de mouvement de main (1) selon la revendication 3 ou 4, dans lequel la première articulation (20) comprend en outre une guêtre ou une articulation universelle.
6. Dispositif d'exercice de mouvement de main (1) selon l'une quelconque des revendications 3 à 5, dans lequel le premier et le deuxième axe d'arbre (22, 32) sont sensiblement parallèles et/ou espacés l'un de l'autre.
7. Dispositif d'exercice de mouvement de main (1) selon l'une quelconque des revendications 3 à 6, dans lequel l'unité de mouvement de doigt (3) comprend en outre au moins un troisième arbre (34) avec un troisième axe d'arbre (35), dans lequel le dispositif d'exercice de mouvement de main (1) comprend en outre un deuxième élément d'appui de doigt (37), dans lequel ledit deuxième élément d'appui de doigt (37) peut être pivoté dans un troisième plan de mouvement autour dudit troisième axe d'arbre (35), et dans lequel les deuxième et troisième arbres (31, 34) sont dans une deuxième liaison de mouvement mécanique (38) de telle sorte qu'une articulation phalangienne proximale et une articulation phalangienne intermédiaire des doigts de la main humaine reposant sur les premier et deuxième

éléments d'appui de doigt (36, 37) puissent être actionnées individuellement et simultanément.

8. Dispositif d'exercice de mouvement de main (1) selon la revendication 7, dans lequel les deux unités de mouvement de pouce (2a, 2b) sont reliées par une troisième liaison de mouvement mécanique (29).
9. Dispositif d'exercice de mouvement de main (1) selon la revendication 8, dans lequel les deux unités de mouvement de pouce (2a, 2b) sont reliées par l'intermédiaire de ladite troisième liaison de mouvement mécanique (29) de sorte que les deux unités de mouvement de pouce (2a, 2b) peuvent être entraînées par un seul et même moteur de commande (8, 81), ladite troisième liaison de mouvement mécanique (29) étant de préférence essentiellement solidaire en rotation.
10. Dispositif d'exercice de mouvement manuel (1) selon l'une quelconque des revendications 7 à 9, dans lequel la seconde liaison de mouvement mécanique (38) comprend comme élément de transmission un train d'engrenages ou un entraînement par courroie ou par câble ou un entraînement par chaîne, et dans lequel ledit train d'engrenages ou ledit entraînement par courroie est construit de sorte que le premier et le second arbres (21a, 21b, 31) tournent synchroniquement et de manière essentiellement solidaire en rotation dans le sens opposé.
11. Dispositif d'exercice de mouvement de main (1) selon l'une quelconque des revendications précédentes 3 à 10, dans lequel l'élément d'appui de doigt (36, 37) a la forme d'un cylindre de préhension, et/ou dans lequel au moins un, de préférence tous lesdits éléments d'appui de doigt (26, 36, 37) sont pourvus d'un revêtement élastique, dans lequel lesdits éléments d'appui de doigt (26, 36, 37) peuvent pivoter de telle sorte qu'au moins deux desdits éléments d'appui de doigt (26, 36, 37) viennent en contact l'un avec l'autre à travers ledit revêtement, et dans lequel ledit (lesdits) revêtement(s) est (sont) comprimé(s) lors dudit contact et fournissent une force de réaction s'opposant au mouvement de l'élément d'appui l'un vers l'autre afin de guider les éléments d'appui (26, 36, 37) dans une position de butée définie et afin de libérer le moteur d'entraînement (8) et la liaison de mouvement mécanique (4) des forces appliquées par la main humaine et, de préférence, ladite force de réaction augmente lorsque la compression dudit ou desdits revêtement(s) augmente.
12. Dispositif d'exercice de mouvement de main (1) selon l'une quelconque des revendications précédentes 3 à 11, dans lequel la première liaison de mouvement mécanique (4) entre le premier arbre (21a, 21b) et le deuxième arbre (31) est prévue comme un engrenage (7) ou comme un entraînement par courroie (6) ou comme un entraînement par câble ou chaîne.
13. Dispositif d'exercice de mouvement de main (1) selon l'une quelconque des revendications précédentes 3 à 12, dans lequel l'unité de mouvement de pouce (2) est adaptée pour recevoir l'élément d'appui de pouce (26) et l'unité de mouvement de doigt (3) est adaptée pour recevoir l'élément d'appui de doigt (36, 37), les éléments d'appui (26, 36, 37) étant de préférence des éléments de montage amovibles pouvant être fixés audit premier et second arbre (21a, 21b, 31) respectivement, plus particulièrement de manière embrochable et/ou l'élément d'appui de doigt (36, 37) est adapté pour recevoir jusqu'à quatre doigts de la main humaine.
14. Dispositif d'exercice de mouvement de main (1) selon l'une quelconque des revendications précédentes comprenant en outre une unité de sécurité (5), dans lequel ladite unité de sécurité (5) est adaptée pour limiter une plage de mouvement de l'unité de doigt telle qu'un angle de pivotement (α) du deuxième arbre (31) ne peut pas dépasser un angle de pivotement maximum ($\alpha_{\max}$) correspondant à une position ouverte de la main de l'utilisateur, et dans lequel, si le dispositif d'exercice de mouvement de main (1) comprend deux unités de mouvement de pouce (2) selon la revendication précédente, l'unité de sécurité (5) peut être activée de préférence pour permettre soit un entraînement avec une main humaine droite ou avec une main humaine gauche.
15. Dispositif d'exercice de mouvement de main (1) selon la revendication précédente, dans lequel l'unité de sécurité (5) comprend un dispositif de commutation (51), l'unité de sécurité (5) comprenant une broche de commutation (52) au moyen de laquelle le dispositif d'exercice de mouvement de main (1) peut être activé pour un exercice de la main humaine gauche ou droite, de préférence dans lequel ladite broche de commutation (52) est embrochable dans ledit dispositif (1) pour assurer un appui afin de fixer ledit angle maximal de rotation ($\alpha_{\max}$).

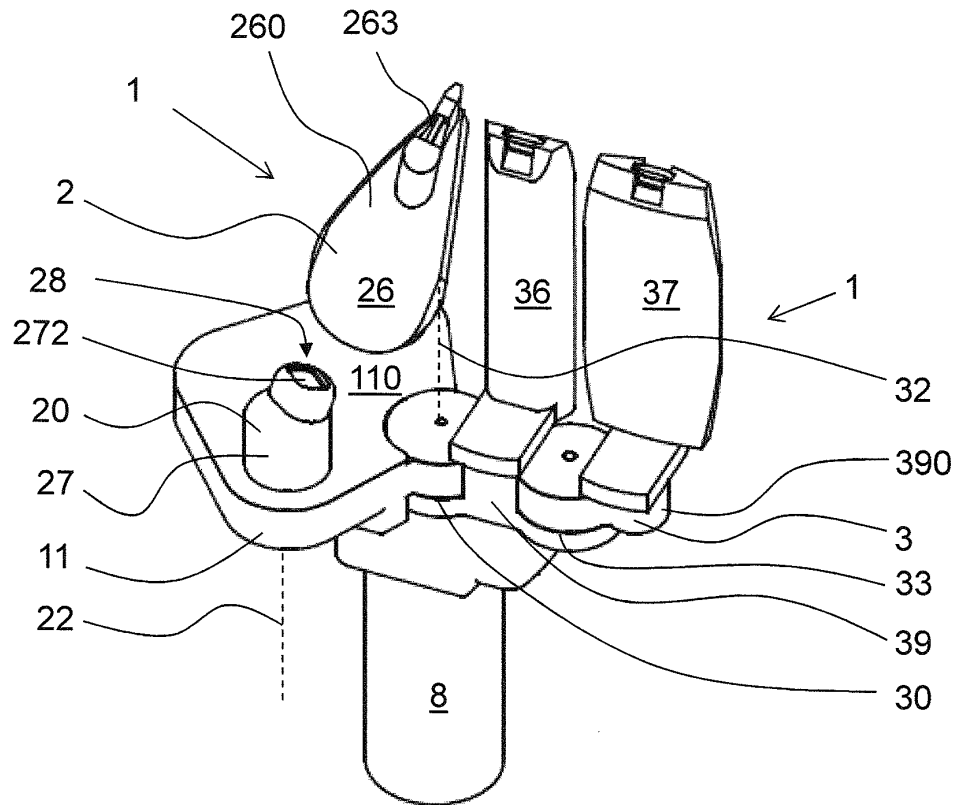


FIG. 1

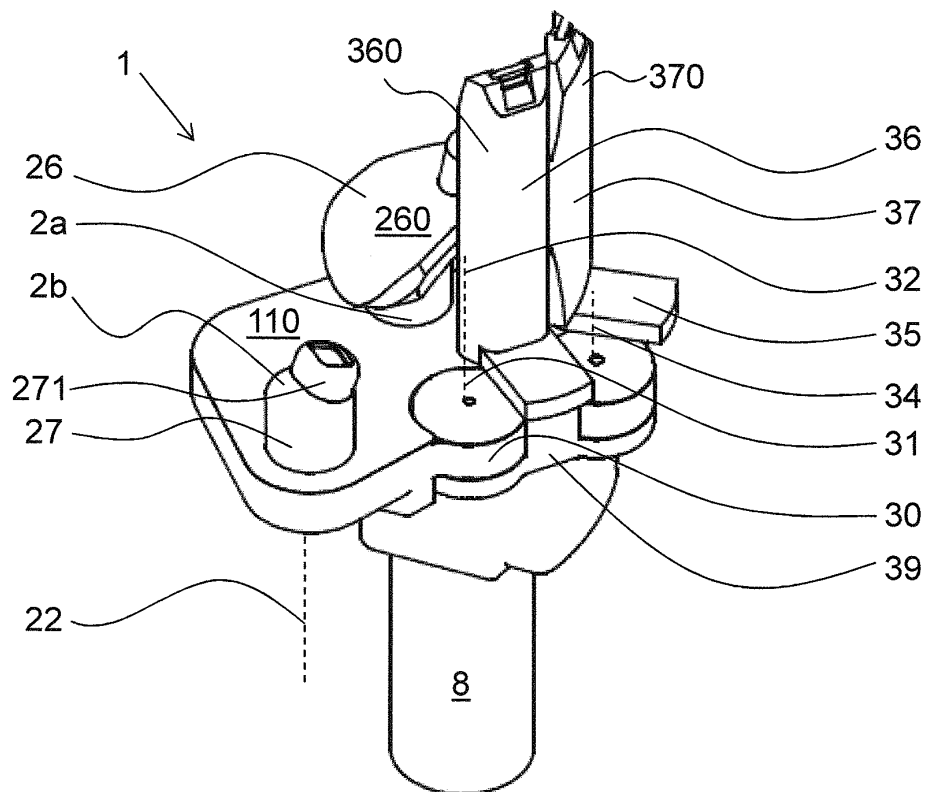


FIG. 2

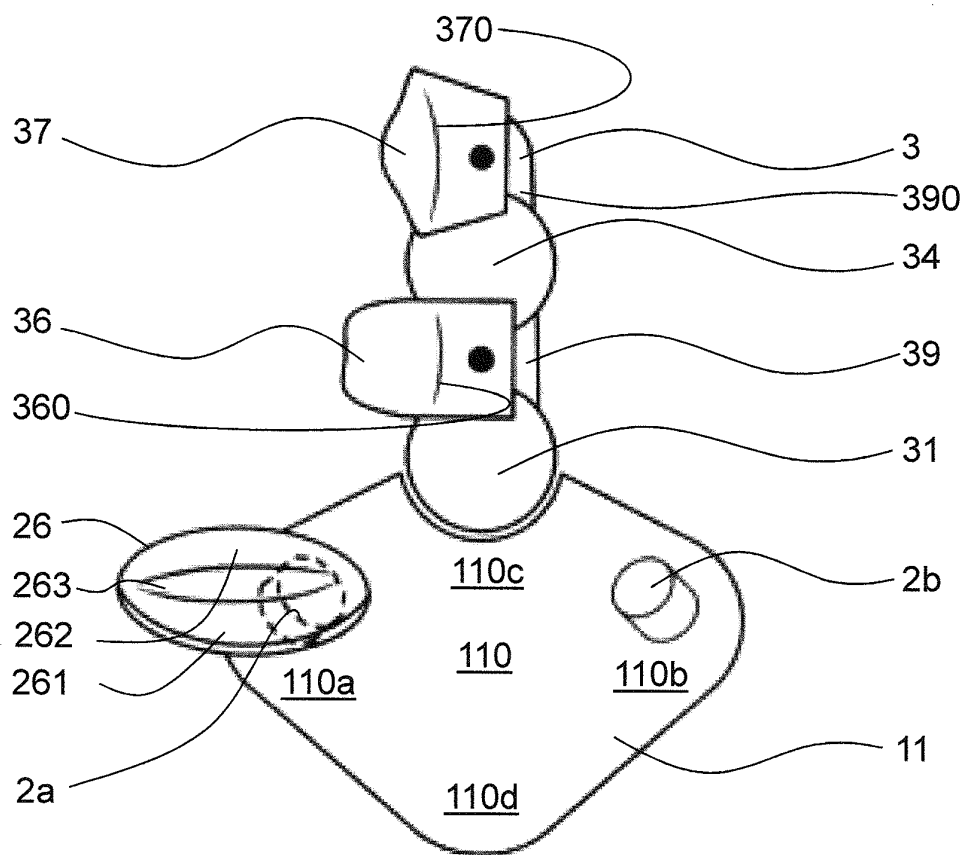


FIG. 3

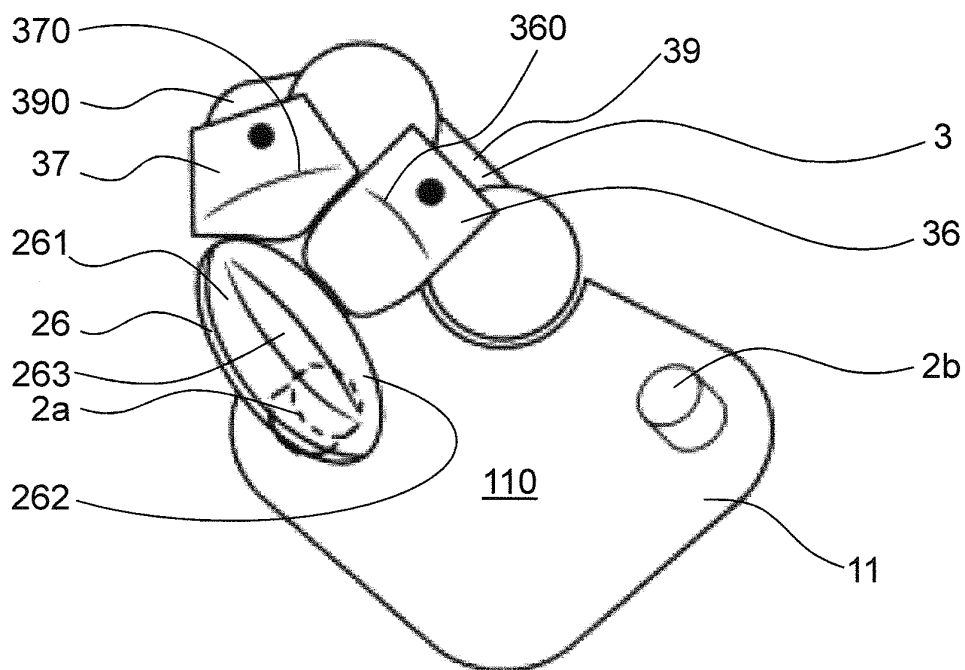


FIG. 4

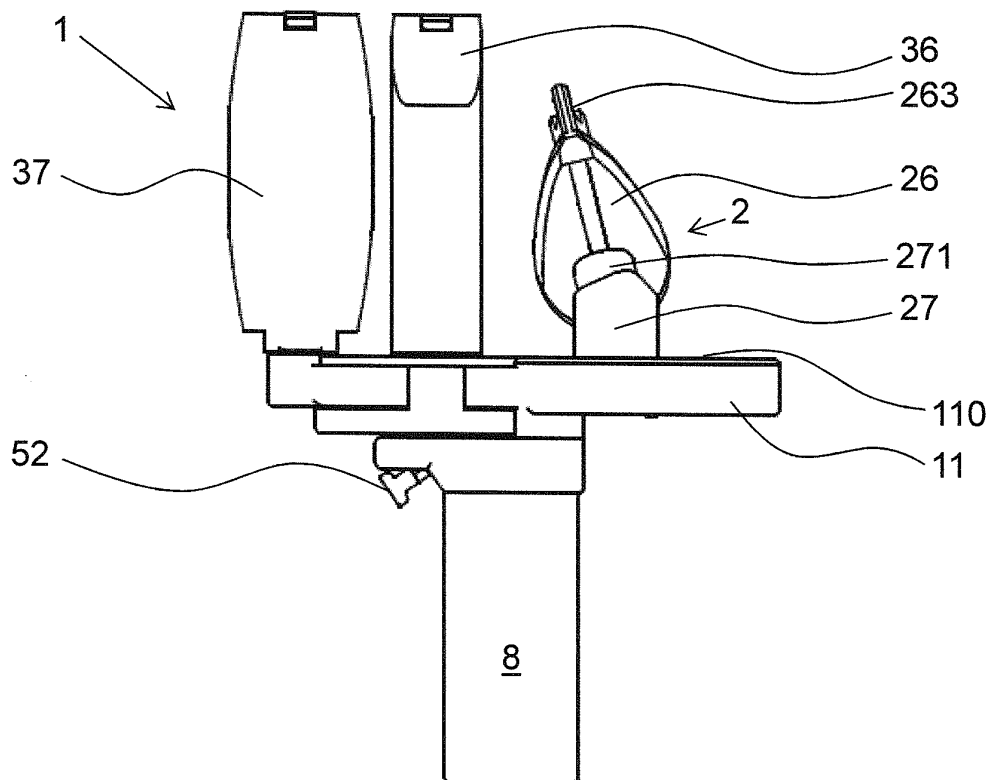


FIG. 5

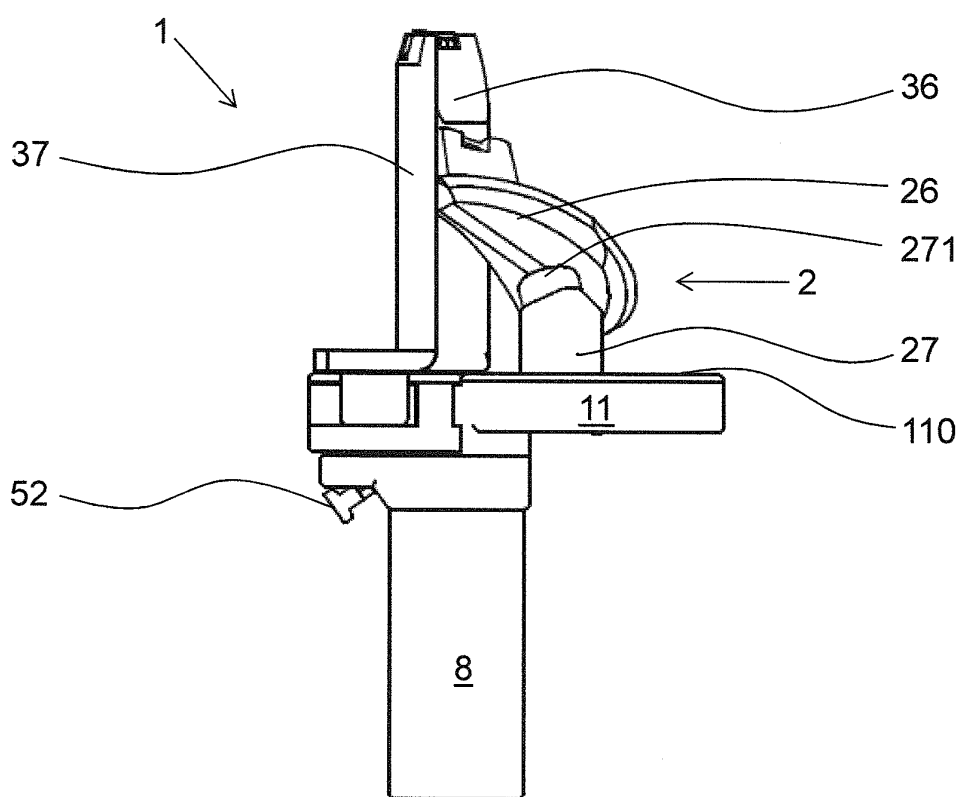


FIG. 6

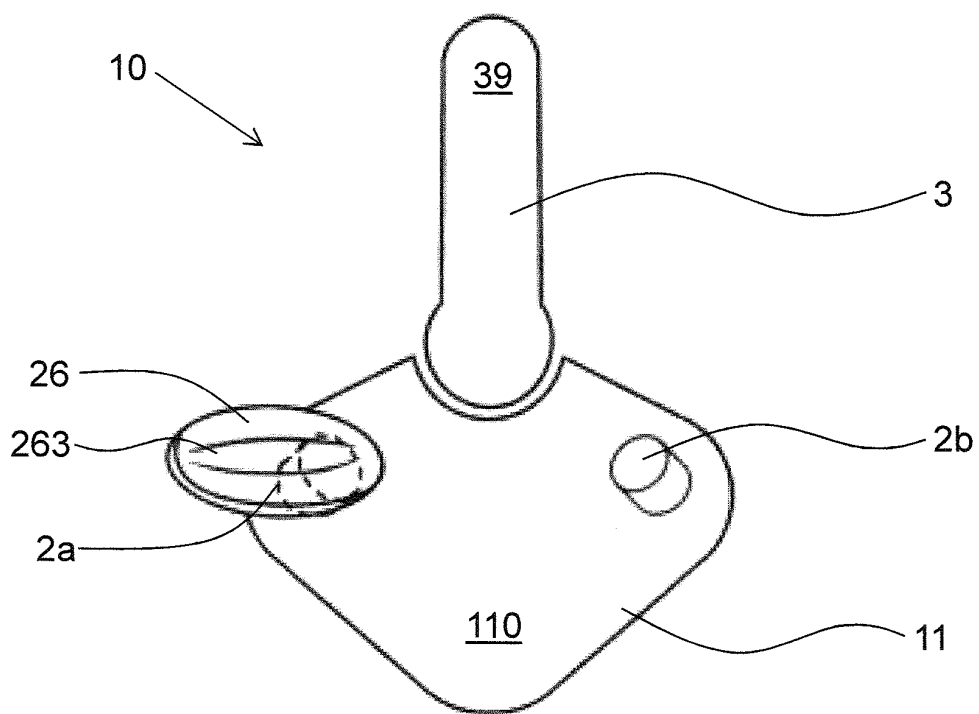


FIG. 7

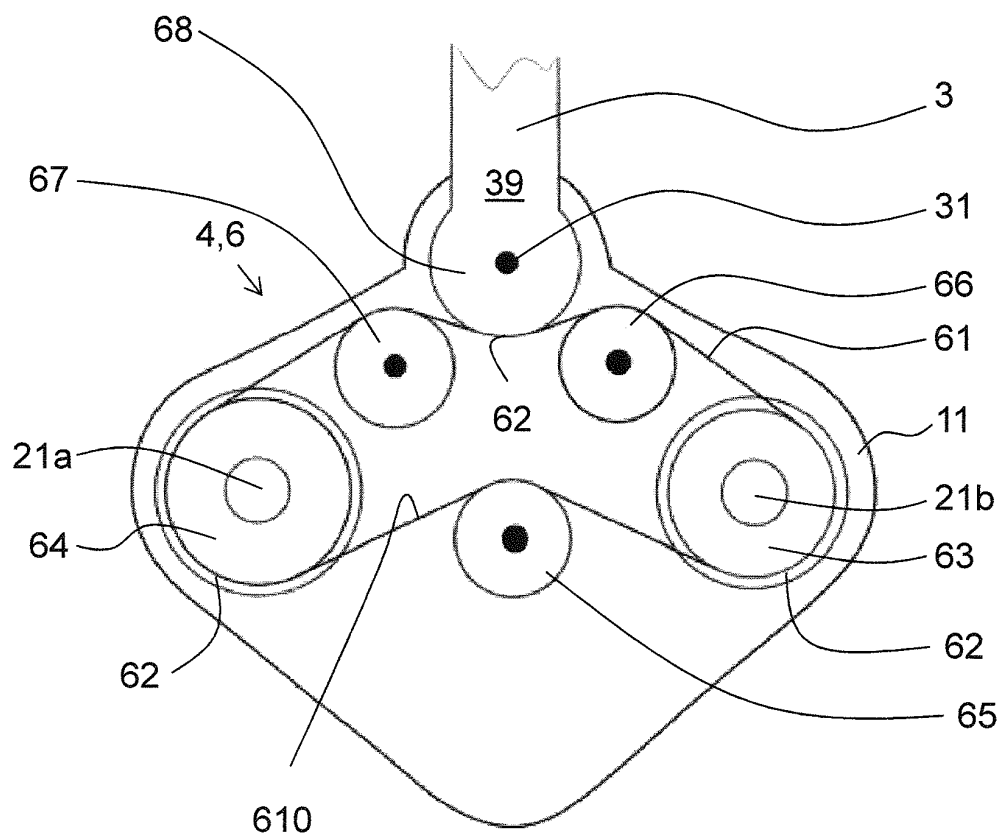


FIG. 8

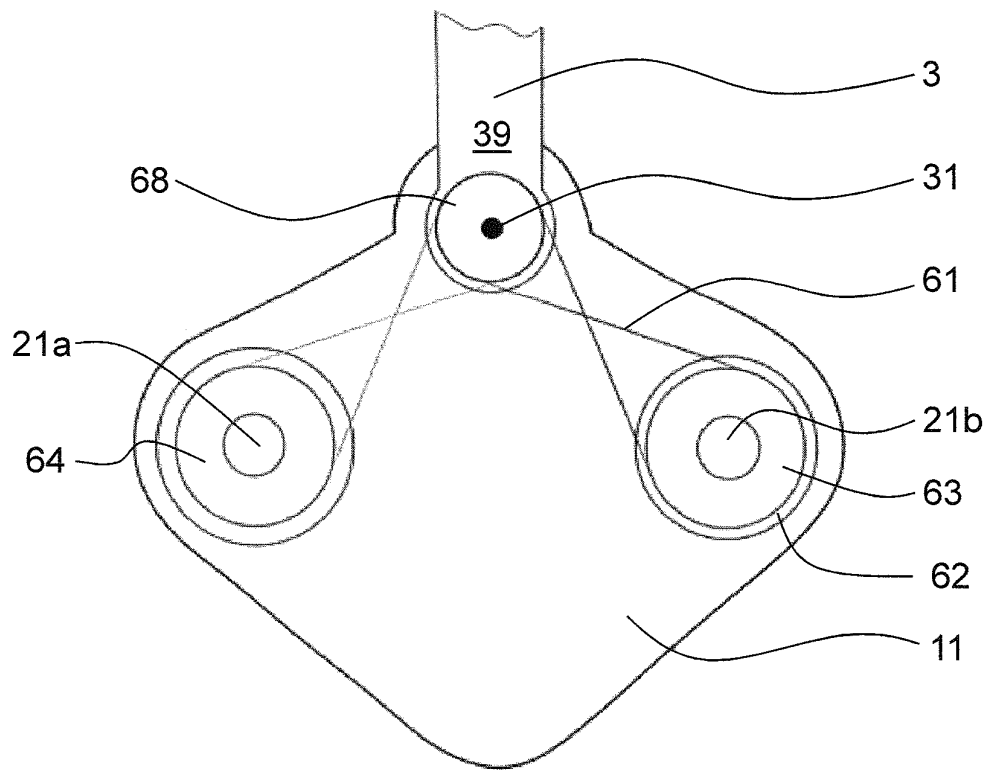


FIG. 9

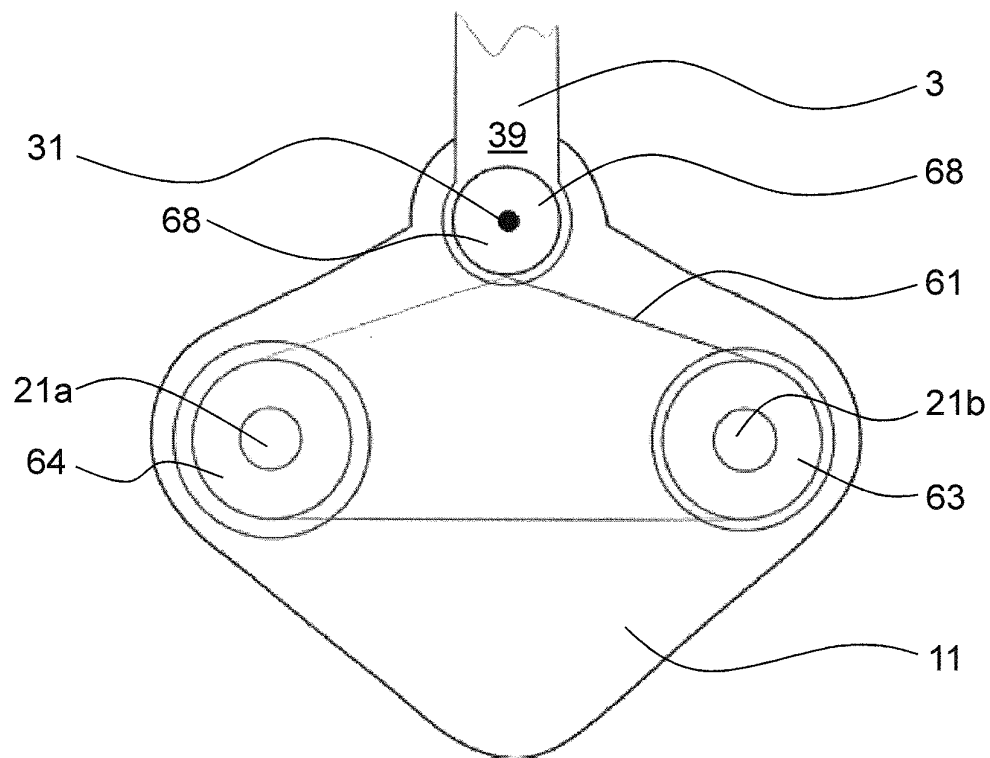


FIG. 10

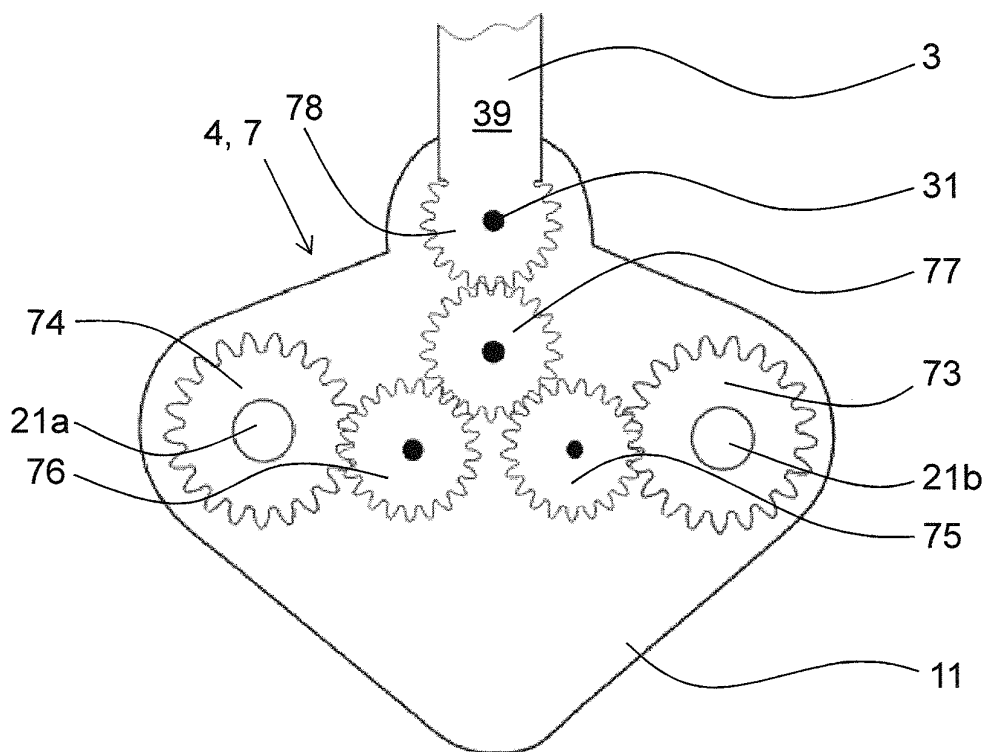


FIG. 11

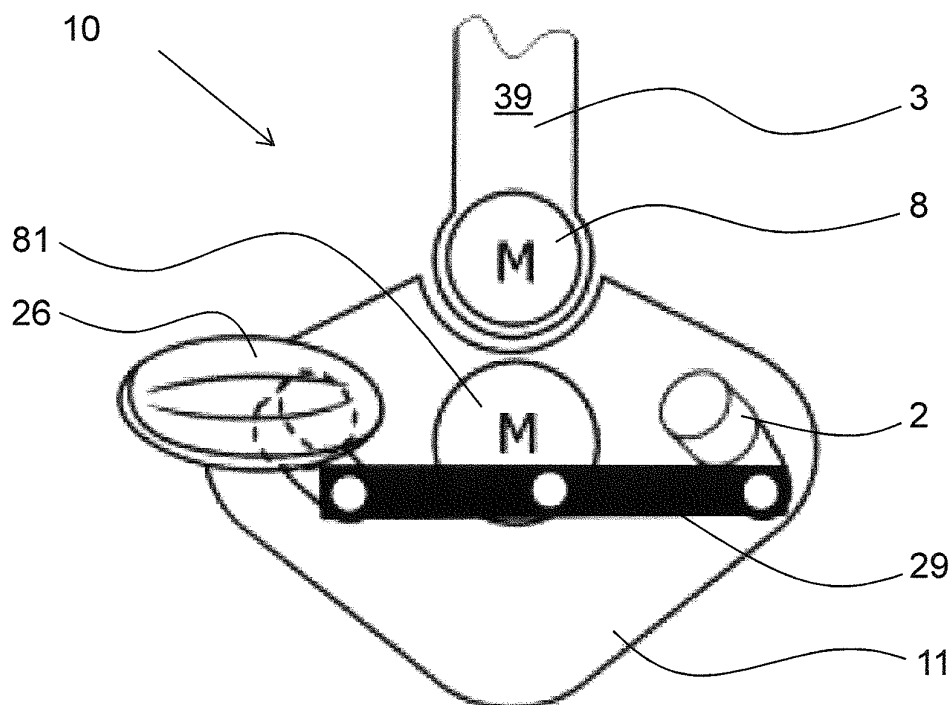


FIG. 12

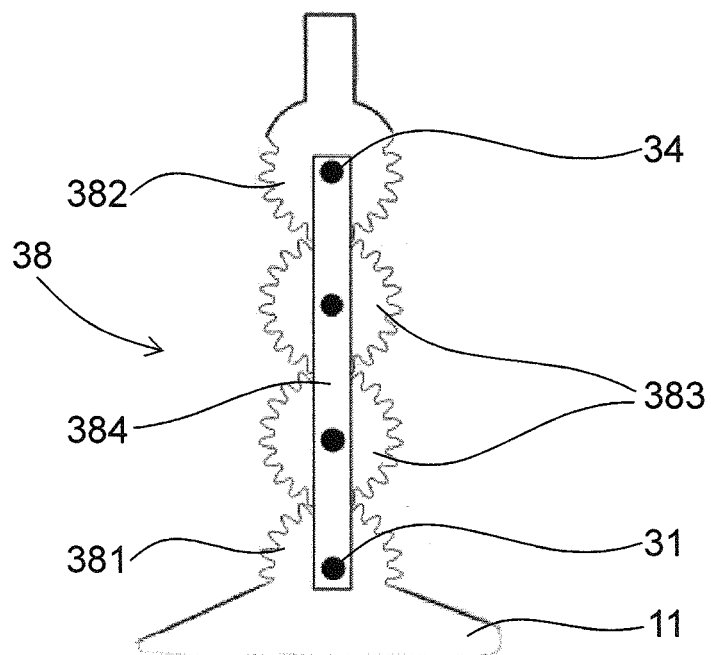


FIG. 13

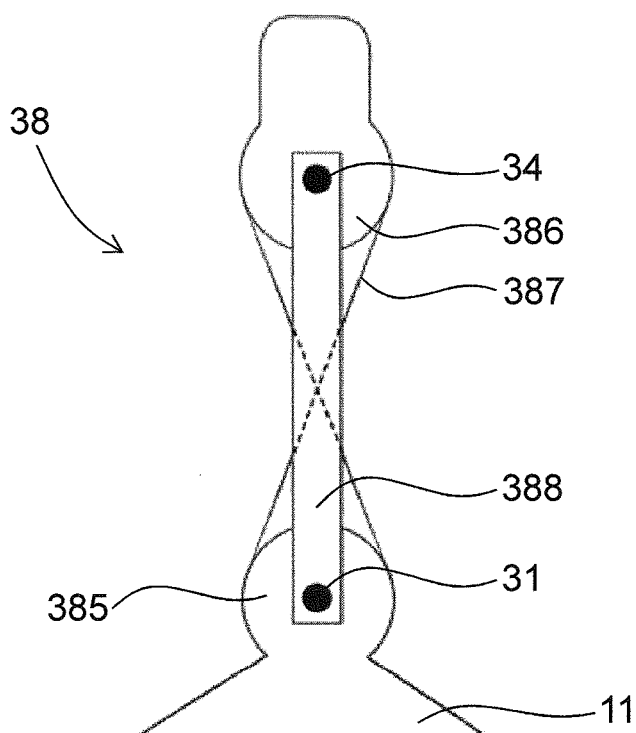


FIG. 14

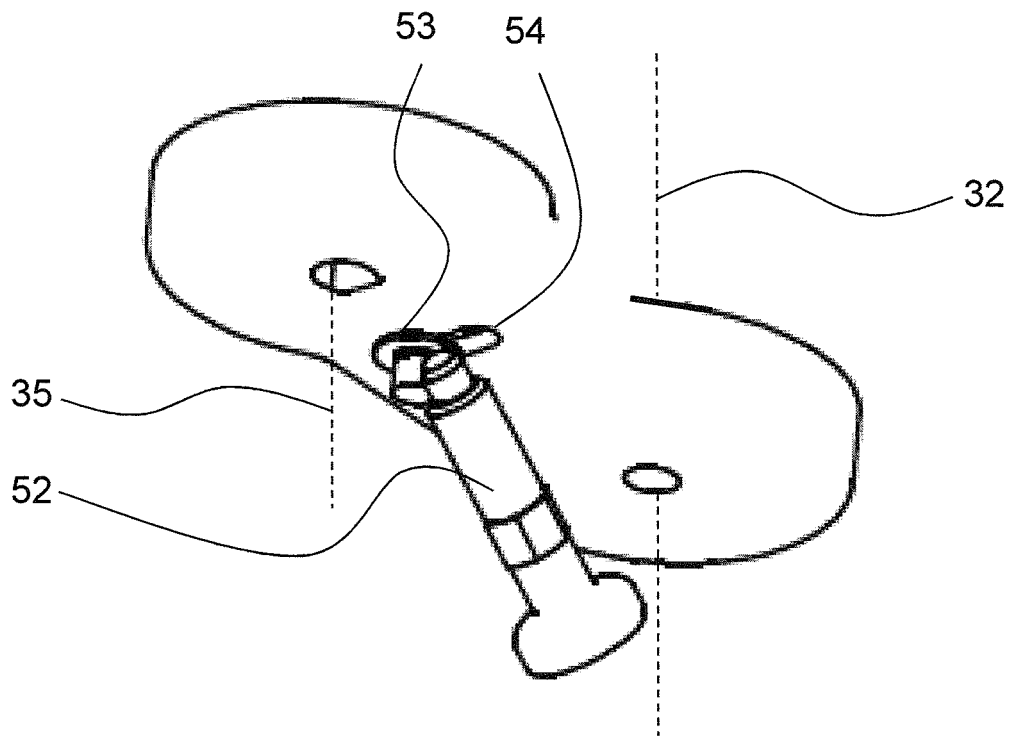


FIG. 15

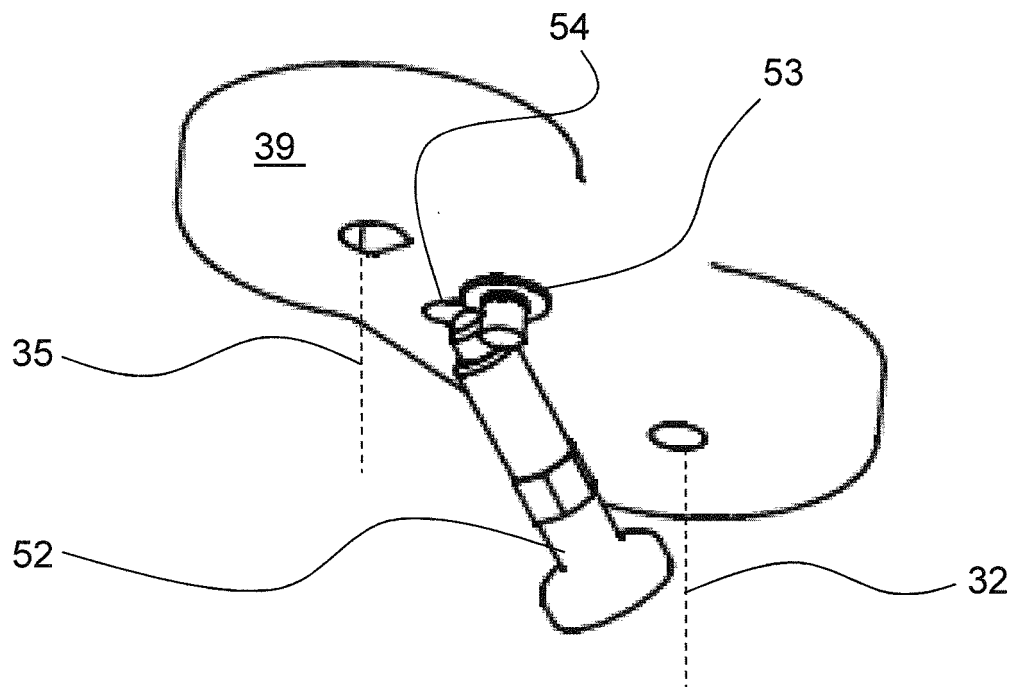


FIG. 16

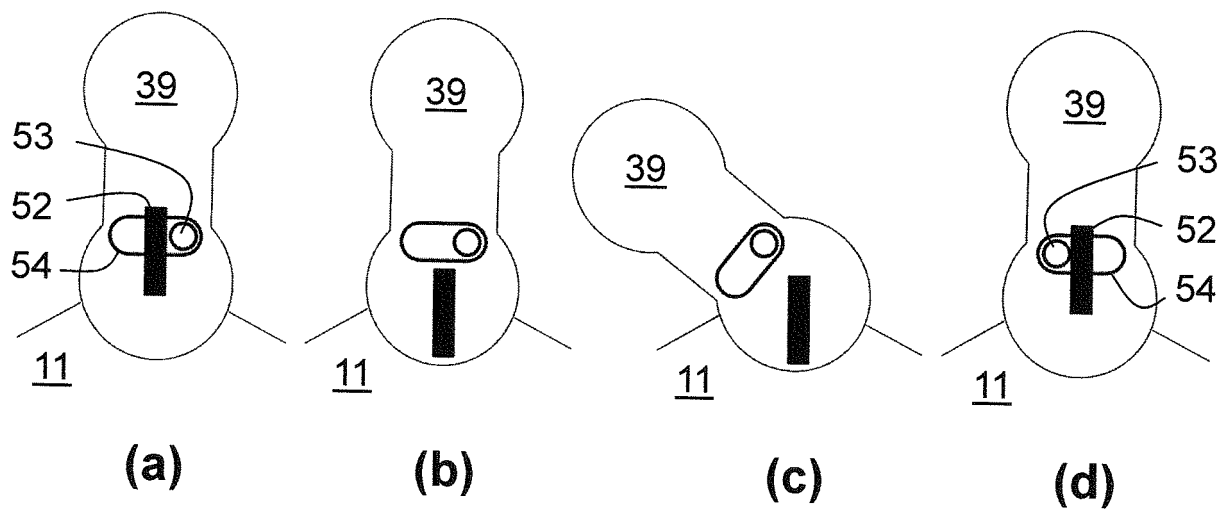


FIG. 17

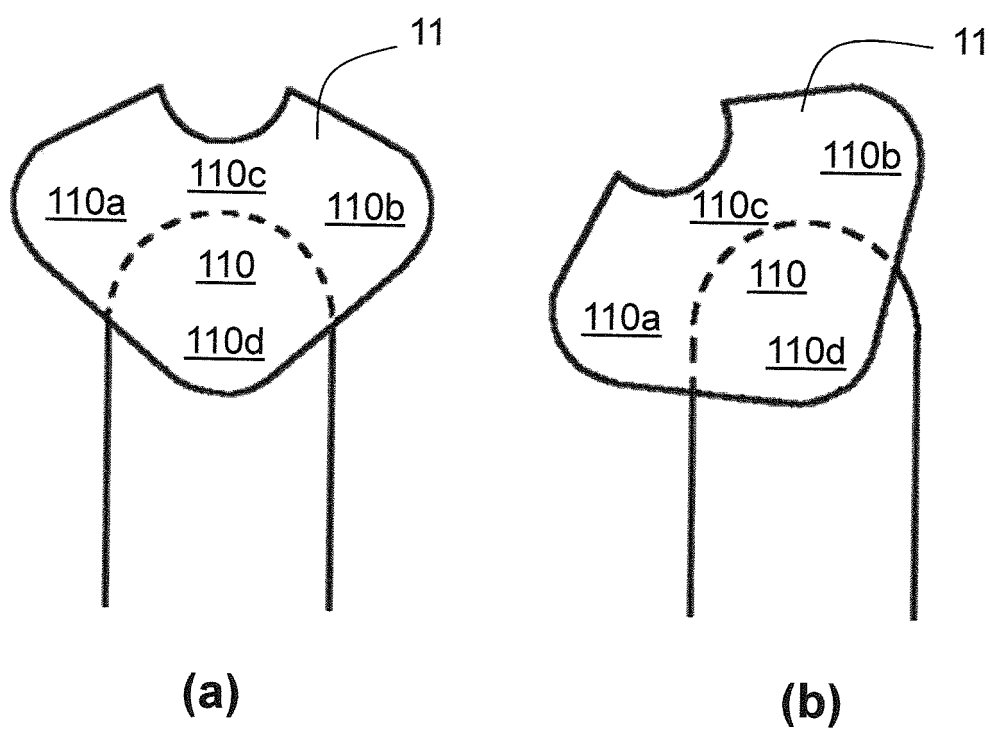


FIG. 18

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 9308882 A [0003]
- WO 2010140984 A1 [0005]
- US 5261393 A [0006]
- JP 2013106706 A [0007]