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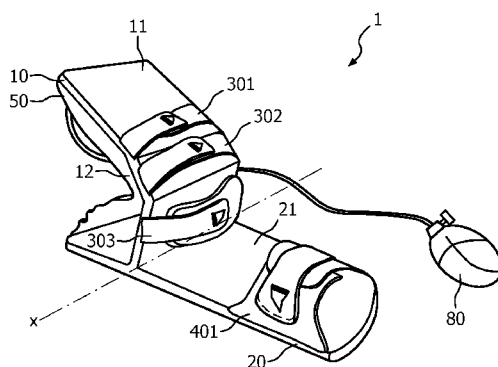


FIG. 1

(57) Abstract: This invention provides a device for hand rehabilitation of a user. The device comprises: a first board configured as a multi-piece foldable board; a hand fixing means for fixing a hand of the user to a first surface of the first board; and an inflatable air bag attached to a second surface of the first board, the second surface being opposite to the first surface. The air bag causes the first board to fold when the airbag is deflated and causes the first board to unfold when the airbag is inflated. In this manner, the pressure exerted on the hand is relatively uniform, since all pieces of the first board have a constant shape and will not deform when the air bag is inflated. Preferably, the device further comprises a second board, wherein an end of the first board is pivotally connected to a surface of the second board, the air bag is further attached to the surface of the second board to cause the first board to pivot with respect to the second board when the airbag is inflated. In this way, the device can be used to concurrently exercise the hand and wrist of the user. Moreover, the device is portable and the user can easily put it on to do his exercises, irrespective of the user's posture.





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DEVICE FOR HAND REHABILITATION

FIELD OF THE INVENTION

5 The invention relates to hand rehabilitation, in particular to an inflatable device for hand rehabilitation.

BACKGROUND OF THE INVENTION

10 Hand dysfunction is a common symptom that can be caused by many conditions, such as neurological problems due to cerebrovascular accidents or other trauma resulting in brain injury with hand dysfunctions, and problems with bones, joints and/or muscles. A lot of patients suffer from this, and it seriously affects their professional and personal life.

15 Hand rehabilitation devices are frequently used to exercise a paralyzed hand, including, for example, opening a clenched hand, also referred to as hand extension, and closing a straight hand, also referred to as hand flexion.

 An inflatable hand rehabilitation device may be any hand rehabilitation device comprising an air bag, also called air bladder. Typically, the air bag is configured so as to
20 open the hand upon being inflated. For most inflatable hand rehabilitation devices currently available, the air bag present therein is in direct contact with the palm of the patient's hand.

 For example, US Patent No. 5020515 discloses an inflatable hand splint. The inflatable hand splint employs a soft two-ply sheet enclosing, at a first end, an air bladder.
25 The air bladder is inserted under the patient's finger tips and inflated to move the fingers away from the palm region.

SUMMARY OF THE INVENTION

 The inventor of the present invention has recognized that the inflatable hand
30 rehabilitation devices described above have a number of drawbacks.

Firstly, when the air bag is in the process of being inflated, it generally exerts different pressures on different positions of the palm due to its varying and uncontrollable deformation. Such non-uniform pressure on the palm makes the patient feel uncomfortable, and tends to cause hand spasms. This could impact the restorative effects of the exercise or even lead to a risk of exercise-induced injuries.

Secondly, in the case that the air bag is in direct contact with the hand of the patient, the hand could be badly injured if the air bag, in operation, is accidentally broken.

Thirdly, some patients suffer from wrist dysfunction in addition to hand dysfunction, but the inflatable hand rehabilitation device described above only provides exercises and treatment for the hand. Thus, those patients have to use an additional rehabilitation device especially for the wrist. Furthermore, for some patients, it is not sufficient to do hand exercises and wrist exercises separately. Taking stroke survivors as an example, they have difficulty controlling the cooperation of the hand muscles and wrist muscles as well as the cooperation of the wrist joint and the finger joints, but many hand motions require such cooperation.

Based on the understanding of the technical problems and the prior art described above, it would be desirable to reduce or eliminate the risk of exercise-induced injuries. It would also be desirable to enhance the safety of the inflatable hand rehabilitation device. It would further be desirable to enable the inflatable hand rehabilitation device to be used to exercise the hand and the wrist together.

To better address one or more of the above concerns, according to an embodiment of an aspect of the present invention, a device for hand rehabilitation of a user is provided. The device comprises:

- a first board configured as a multi-piece foldable board;
- a hand fixing means for fixing a hand of the user to a first surface of the first board; and
- an inflatable air bag attached to a second surface of the first board, the second surface being opposite to the first surface.

In this way, the air bag causes the first board to fold when the airbag is deflated and to unfold when the airbag is inflated.

When the user uses such a device, his hand will not be in direct contact with the air bag, because the first board is situated between them. When the air bag is being inflated, this causes the first board to unfold, and the first board in turn acts on the hand such that the fingers move away from the palm and the hand is gradually opened. When
5 the air bag is being deflated, this causes the first board to fold such that the hand is gradually closed. In this manner, the press exerted on the hand is relatively uniform, since all pieces of the first board have a constant shape and will not deform when the air bag is inflated. Furthermore, the first board can protect the hand from any injury caused by accidents such as a broken air bag, and the safety of using such a device is thereby
10 improved.

In another embodiment, the device further comprises:

a second board, an end of the first board being pivotally connected to a surface of the second board, the air bag being further attached to the surface of the second board to cause the first board to pivot with respect to the second board when the airbag is inflated;
15 and

an arm fixing means for fixing an arm of the user to the surface of the second board.

When the user uses such a device, his hand is fixed to the first board and his arm is fixed to the second board such that his wrist is at the position where the first board is connected to the second board. When the air bag is being inflated, the first board rotates
20 with respect to the second board, and the first board in turn causes the wrist to hinge in a direction such that the palm gradually moves away from the inner side of the arm. In this way, both inflation and deflation of the air bag cause hand motion, namely opening and closing of the hand, respectively, as well as wrist motion. Therefore, the user can
25 concurrently exercise his hand and wrist, for example in a sequence from wrist to finger joints.

Moreover, conventional wrist rehabilitation devices, when being used, are generally required to be placed on an operating surface such as a table surface, so that the user has to assume a particular posture, namely he must put his hand and forearm above
30 the operating surface. The rehabilitation device of this embodiment, by contrast, does not require any operating surface, because while part of the surface of the second board is

used to receive the forearm of the user, the other part of the surface of the second board is attached to the airbag and serves as an operating surface. Thus, the user can put on and use such a rehabilitation device irrespective of the posture he assumes.

5 Additionally, the device further comprises a spring means for accelerating the speed of deflation of the air bag when the air bag is being deflated.

In this way, the speed of the closing of the hand can be accelerated accordingly. On the one hand, the spring means can force the user to close his hand at a rate the user cannot achieve by himself, thereby providing passive exercise. On the other hand, the spring means inherently will not prohibit the user from closing his hand at a rate faster
10 than that brought about by the spring means, thereby allowing voluntary hand movement and providing active exercise. Thus, the spring means enables a good combination of passive exercise and active exercise in a very simple way.

Additionally, the device further comprises a restriction means for limiting the angle between the first surface of the first board and the surface of the second board to a
15 threshold.

In this way, the maximum range of the wrist motion can be limited so as to prevent any unnecessary injury. Preferably, the threshold can be adjusted to meet various conditions of individual users.

These and other aspects of the invention will be apparent from and elucidated
20 with reference to the embodiments described hereinafter.

DESCRIPTION OF THE DRAWINGS

The above and other objects and features of the present invention will become
25 more apparent from the following detailed description considered in connection with the accompanying drawings, in which:

Fig.1 depicts a perspective view of a hand rehabilitation device in accordance with an embodiment of the present invention;

Fig.2 depicts a schematic view of the position of a hand of a user with respect to a
30 hand rehabilitation device in accordance with an embodiment of the present invention;

Figs.3A-3C depict an inflation sequence of a hand rehabilitation device in accordance with an embodiment of the present invention;

Fig.4 depicts a side view of a hand rehabilitation device in accordance with an embodiment of the present invention;

5 Figs.5A-5D each depict a perspective view of an air bag used in a hand rehabilitation device in accordance with an embodiment of the present invention;

Fig.6 depicts a perspective view of a hand rehabilitation device including an elastic band as a spring means in accordance with an embodiment of the present invention;

10 Fig.7A depicts a perspective view of a hand rehabilitation device including a spring shaft as a spring means in accordance with an embodiment of the present invention, and Fig.7B depicts a perspective view of an embodiment of the spring shaft;

Fig.8 depicts a side view of a hand rehabilitation device including a strap as a restriction means in accordance with an embodiment of the present invention; and

15 Fig.9 depicts a schematic graph of a hand rehabilitation device in accordance with an embodiment of the present invention.

The same reference signs are used to denote similar parts throughout the figures. In some figures, parts that are identical/similar to those used in previous embodiments and that are not relevant to the description of the embodiment in a figure are not shown
20 for brevity.

DETAILED DESCRIPTION

A detailed description of the present invention is given below in connection with
25 the accompanying drawings.

Fig.1 depicts a perspective view of a hand rehabilitation device in accordance with an embodiment of the present invention.

According to an embodiment of the present invention, a device for hand rehabilitation of a user, also called hand rehabilitation device, is provided.

30 The hand rehabilitation device is configured to rehabilitate hand and/or wrist mobility of a person, who uses it to exercise with his hand fixed to the device. The hand

rehabilitation device can be used for any person who intends to recover or enhance the ability of hand and/or wrist motion.

Referring to Fig.1, the hand rehabilitation device 1 comprises a first board 10 configured as a multi-piece foldable board and a second board 20. The first board 10 is pivotally connected to the upper surface 21 of the second board 20 such that the first board 10 is pivotable with respect to the second board 20, namely rotates through a pivotal axis x. The implementation of such a pivotal connection will be elaborated on later, with reference to Fig.4.

Each piece of the first board 10 and the second board 20 is rigid and may be made of steel, plastic or other proper materials.

As a multi-piece foldable board, the first board 10 can be embodied in many ways. For example, the first board 10 may comprise multiple, separate pieces, and every pair of mutually foldable pieces may be connected together by means of a hinge. Alternatively, the first board 10 may be formed by attaching multiple, separate, rigid pieces on a flexible piece made of materials such as cloth and plastic. In another example, the first board 10 may be integrally formed by means of molding.

The hand rehabilitation device 1 further comprises a hand fixing means 30 and an arm fixing means 40 configured to fix, respectively, the hand and the arm of the user to the device 1 in such a way that the palm is kept in contact with a first surface 11 of the first board 10 and the inner side of the arm is kept in contact with the upper surface 21 of the second board 20. In particular, the hand fixing means 30 comprises distal finger fixing strap 301, proximal finger fixing strap 302 and palm fixing strap 303 attached to the first board 10. The arm fixing means 40 comprises at least one fixing strap 401 attached to the second board 20.

The fixing straps 301-303 and 401 can be embodied in many ways. As shown in Fig.1, each fixing strap may be a hook and loop strap. Alternatively, each fixing strap may comprise other kinds of fasteners, such as a buckle, a clasp, etc.

The hand rehabilitation device 1 further comprises an air bag 50, preferably a one-piece air bag. The air bag 50 is positioned between the first board 10 and the second board 20, and is attached to a second surface 12 of the first board 10, facing away from the first surface 11, and the upper surface 21 of the second board. Additionally, the air

bag 50 is further connected to an air pump 80 through an airhose so as to be inflatable or deflatable. The air pump 80 may be an electronic air pump or a self-controlled air pump with a balloon.

When the air bag 50 is being inflated, it causes the first board 10 to unfold and simultaneously rotate away from the upper surface 21 of the second board 20. When the air bag 50 is being deflated, it simultaneously causes the first board 10 to fold and rotate toward the upper surface 21 of the second board 20. This will be elaborated on later in connection with Figs.3A-3C.

Referring next to Fig.2, the position of the hand of a user with respect to a hand rehabilitation device in accordance with an embodiment of the invention is schematically shown.

The first board 10 and the second board 20 are configured according to the structure of the human hand and the process of hand flexion/extension.

For example, as shown in Fig. 2, the first board 10 comprises three pieces 101-103. The pieces 101 and 102 are foldable with respect to each other along a pivot axis x_1 , and the pieces 102 and 103 are foldable with respect to each other along a pivot axis x_2 . Further, the first board 10 is rotatable along the pivot axis x . The first board 10 and the second board 20 are configured so that the pivot axes x_1 , x_2 and x correspond to PIP (Proximal interphalangeal) finger joint, MIP (Metacarpophalangeal) finger joint and wrist joint, respectively. Accordingly, all the pivot axes are substantially parallel to each other.

In another example, the first board 10 may comprise only two pieces which are foldable with respect to each other, and the folding position corresponds to either PIP finger joint or MIP finger joint. In yet another example, the first board 10 may comprise multiple multi-piece foldable boards, each of which corresponds to one of the fingers.

Referring next to Figs.3A-3C, an inflation sequence of a hand rehabilitation device in accordance with an embodiment of the present invention is schematically shown.

Fig.3A shows the hand rehabilitation device 3 when the air bag 50 starts to inflate. At this stage, the air bag 50 starts to unfold the first board 10 and meanwhile moves the second surface 12 of the first board 10 away from the second board 20. Accordingly, the fingers are slightly pushed away from the palm.

Fig.3B shows the rehabilitation device 3 when the air bag 50 is further inflated. At this stage, the first board 10 is further unfolded and further pushed away from the second board 20 by the further inflated air bag 50. Accordingly, the hand has been partially extended, and the palm is also slightly raised with respect to the arm.

5 Fig.3C shows the rehabilitation device 3 when the air bag 50 is almost completely inflated. At this stage, the first board 10 is totally unfolded and all the pieces are substantially aligned in a straight line. Meanwhile, the first board 10 is approximately perpendicular to the second board 20. Accordingly, the hand has been almost completely extended, and the palm has been almost completely raised with respect to the arm.

10 The deflation of the hand rehabilitation device 3 is the opposite process of the inflation, and is therefore not described here.

As will be clear from the above, a hand rehabilitation device according to an embodiment of the present invention can provide an integrated exercise for both hand and wrist of a user. Further, it is easy for the user to put on the rehabilitation device on his
15 hand and arm. Moreover, the rehabilitation device can operate irrespective of the posture of the user.

The pivotal connection between the first board 10 and the second board 20 can be embodied in many ways, for example, by means of a hinge. In another example, the first board 10 can be connected to the second board 20 in the way shown in Fig.4.

20 Fig.4 depicts a side view of a hand rehabilitation device in an embodiment of the present invention.

Referring to Fig.4, the first board 10 is configured as a four-piece foldable board. While the three pieces 101-103 have the same functions as those described in the above, the fourth piece 104 is used to connect the first board 10 to the second board 20. In
25 particular, one surface of the further piece 104 is attached to the upper surface 21 of the second board 20 by means of gluing, screwing or other ways known in the art. Thus, the pivotal connection between the first board 10 and the second board 20 can be realized in a simply way.

The air bag 50 may have different shapes. Figs.5A-5D each depict a perspective
30 view of an air bag used in a hand rehabilitation device in accordance with an embodiment of the present invention.

Referring to Fig.5A, an air bag 51 is in the shape of a plate. The air bag 51 can be mounted to the hand rehabilitation device 1 by attaching the upper part 511 of a surface, for example a back surface, of the air bag 51 to the second surface 12 of the first board 10 and attaching the lower part 512 of the same surface to the upper surface 21 of the second board 20.

Referring to Fig.5B, an air bag 52 has a front surface 521, a back surface 522 and a bottom surface 523. The air bag 52 is configured so that, in the cross-sectional view, the front surface 521, the back surface 522 and the bottom surface 523 form a triangle. The air bag 52 is mounted to the hand rehabilitation device 1 by attaching the back surface 522 to the second surface 12 of the first board 10 and attaching the bottom surface 523 to the upper surface 21 of the second board. Further, the angle formed by the back surface 522 and the bottom surface 523 is not smaller than the required maximum angle between the first board 10 and the second board 20.

Fig.5C and Fig.5D show an air bag 53 and an air bag 54, respectively. The air bags 53 and 54 are similar to the air bag 52 in Fig.5B, except that part of the front surface 531 of the air bag 53 is in a corrugated shape, and part of the front surface 541 of the air bag 54 is a curved surface.

In another embodiment of the present invention, there is provided a hand rehabilitation device comprising a spring means for accelerating the speed of deflation of the air bag when the air bag is deflated.

The spring means can be embodied in many ways. Two examples are described with respect to Fig.6 and Figs.7A-7B in the following paragraphs.

Fig.6 depicts a perspective view of a hand rehabilitation device including an elastic band as a spring means in accordance with an embodiment of the present invention.

Referring to Fig.6, the spring means 61 of the hand rehabilitation 6 comprises two elastic bands 611. It is noted that alternatively a larger or smaller number of elastic bands may be used. Each elastic band 611 has one end attached to piece 101 of the first board 10, which is most remote from the second board 20, and the other end attached to the second board 20 such that the elastic force generated by the elastic bands 611 urges the first board 10 to fold and rotate toward the second board 20.

The elastic bands 611 are attached to the first board 10 and the second board 20 at fixing spot 612. Alternatively, the elastic bands 611 may be glued to the boards or attached to the boards in other different ways known in the art.

5 Additionally, multiple fixing loops 613 may be provided on the first surface 11 of the first board 10 and the upper surface 21 of the second board 20, particularly adjacent to positions where the individual pieces can be folded and rotated with respect to each other. The elastic bands 611 are always kept close to the surfaces of the boards by passing them through the fixing loops 613.

10 Fig.7A depicts a perspective view of a hand rehabilitation device including a spring shaft as a spring means in accordance with an embodiment of the present invention, and Fig.7B depicts a perspective view of an embodiment of the spring shaft.

Referring to Fig.7A, the spring means 62 of the hand rehabilitation device 7 comprises three spring shafts 621-623. The spring shafts 621 and 622 are located along the folding positions of the first board 10 for causing the first board 10 to fold. The spring shaft 623 is located along the connection between the first board 10 and the second board 20 for causing the first board 10 to move toward the second board.

20 Referring to Fig.7B, a spring shaft 620 comprises a shaft 6201 and at least one pair of plates 6202 (two pairs of plates are shown). The plates 6203 can pivot about the shaft 6201, and the two plates of each pair of plates 6202 are clamped together without the application of external force. When the two plates of the pair of plates 6202 are separated by a certain angle, the spring shaft 620 will generate elastic forces in the direction denoted by arrows 6203, causing the pair of plates 6202 to become clamped together.

25 Referring back to Fig.7A, each pair of plates of the spring shaft 621 is fixed to the first piece 101 of the first board 10 at one side and to the adjacent piece, namely the second piece 102, of the first board 10 at the other side. Thus, the spring shaft 621 exerts corresponding elastic forces on the first piece 101 and the second piece 102 of the first board 10 so as to fold the first piece 101 and the second piece 102. Likely, the spring shaft 622 exerts corresponding elastic forces on the second piece 102 and the third piece 103 of the first board 10 so as to fold the second piece 102 and the third piece 103; and 30 the spring shaft 623 exerts corresponding elastic forces on the third piece 103 of the first

board 10 and the second board 20 so as to move the third piece 103 and hence the whole first board 10 toward the second board.

As shown in Fig.7A, the spring shafts 621-623 are integrated so as to form a single element, i.e. such that every two adjacent spring shafts share one side of each pair
5 of plates. Alternatively, the spring shafts 621-623 may simply be elements separated from each other.

As will be clear from the above, a spring means in a hand rehabilitation device can apply a spring force to the first board of the second board to cause the first board to fold and rotate toward the second board, thereby exerting pressure on the air bag. Thus,
10 the speed of deflation of the air bag can be accelerated by the spring means. Accordingly, the speed of the closing of the hand can be accelerated. On the one hand, the spring means can force the user to close his hand at a speed that he cannot achieve by himself, thereby providing passive exercise. On the other hand, the spring means inherently will not prohibit the user from closing his hand at a speed faster than that caused by the spring
15 means, thereby allowing voluntary hand movement and providing active exercise. In other words, the spring means enables a good combination of passive exercise and active exercise in a very simple way.

Additionally, the spring means may be configured so as to be replaceable, allowing spring means having a different specification to be used to adjust and change the
20 speed of deflation of the air bag.

In yet another embodiment of the present invention, there is provided a hand rehabilitation device comprising a restriction means for limiting the angle between the second surface of the first board and the surface of the second board to a threshold.

Fig.8 depicts a side view of a hand rehabilitation device including a strap as a
25 restriction means in accordance with an embodiment of the present invention.

Referring to Fig.8, the hand rehabilitation device 8 comprises a non-elastic strap 70 connecting the first board 10 and the second board 20 to limit the relative movement between the first board 10 and the second board 20. In particular, the non-elastic strap 70 limits the angle between the second surface 12 of the first board 10 and the surface 21 of
30 the second board 20 to a threshold Max.

In this way, the maximum range of the wrist motion can be limited so as to prevent unnecessary injury. Preferably, the threshold can be adjusted to meet various conditions of individual users, for example on the suggestion of doctors or physical therapists.

5 Different thresholds can be set in many ways. For example, the strap 70 is replaceable, and therefore, different thresholds can be obtained by replacing it with a strap of a corresponding length. In another example, the position where the strap 70 is attached to the first board 10 and/or the position where the strap 70 is attached to the second board 20 are variable, and therefore, a different threshold can be obtained by
10 changing the place of attachment at the first board 10 or the place of attachment at the second board 20 or both.

The restriction means 70 may also be implemented in other ways. For example, a protrusion on the upper surface 21 of the second board at a location close to the first board 10 and facing the second surface 12 of the first board 10 can limit the angle
15 between the second surface 12 of the first board 10 and the surface 21 of the second board 20.

Fig.9 depicts a schematic graph of a hand rehabilitation device in accordance with an embodiment of the present invention.

As shown in Fig.9, the second board 20 is curved to provide a comfortable fit for
20 the user's forearm when the hand rehabilitation device is being used.

Additionally, at least pairs of lateral boards 901 (three pairs shown Fig.9) are attached to both sides of the first board 10. Preferably, the distance between the two lateral boards of each pair is approximately equal to the width of the hand of the user, so that lateral movement of the hand, such as moving left or right, can be limited, and the
25 hand of the user can be held in proper position and orientation for proper use of the device.

Similarly, at least one pair of lateral boards 902 (one pair shown in Fig.9) is attached to the sides of the first board 10. Preferably, the distance between the two lateral boards of each pair is approximately equal to the width of the arm of the user, so that
30 lateral movement of the arm can be limited, and the arm of the user can be held in proper position and orientation for proper use of the device.

The lateral boards 901-902 can be separate elements attached to the sides of the first board 10 and/or the second board 20. Alternatively, the lateral boards 90 can be integrally formed with one of the first board 10 and the second board 20, as shown in Fig.9.

5 It should be noted that the above-mentioned embodiments illustrate rather than limit the invention and that those skilled in the art will be able to design alternative embodiments without departing from the scope of the appended claims. The embodiments are illustrative rather than restrictive. It is intended that all modifications and variations to the illustrated and described embodiments fall within the scope and
10 spirit of the invention. In the claims, any reference signs placed between parentheses shall not be construed as limiting the claim. The word “comprising” does not exclude the presence of elements or steps not listed in a claim or in the description. The word “a” or “an” preceding an element does not exclude the presence of a plurality of such elements. In the device claims enumerating several units, several of these units can be embodied by
15 one and the same item of hardware or software. The use of the words first, second and third, et cetera, does not indicate any ordering. These words are to be interpreted as names.

CLAIMS:

1. A device for hand rehabilitation of a user, comprising:

a first board (10) configured as a multi-piece foldable board;

5 a hand fixing means (30, 301-303) for fixing a hand of the user to a first surface (11) of the first board (10); and

an inflatable air bag (50) attached to a second surface (12) of the first board (10), the second surface (12) being opposite to the first surface (11).

2. The device according to claim 1, wherein the first board (10) comprises at least
10 three pieces (101-103), every two adjacent pieces of the at least three pieces (101-103) being foldable along a first pivot axis (x1, x2), and all the first pivot axes (x1, x2) being substantially parallel to each other.

3. The device according to claim 1, further comprising:

15 a second board (20), an end of the first board (10) being pivotally connected to a surface (21) of the second board (20), the air bag (50) being further attached to the surface (21) of the second board (20) to cause the first board (10) to pivot with respect to the second board (20) when the airbag (50) is inflated; and

20 an arm fixing means (40, 401) for fixing an arm of the user to the surface (21) of the second board (20).

4. The device according to claim 1 or 3, further comprising a spring means for accelerating the speed of deflation of the air bag when the air bag is being deflated.

25 5. The device according to claim 4, wherein the spring means (60) comprises at least one elastic band (611).

6. The device according to claim 4, wherein the spring means (60) comprises at least one spring shaft (621, 622, 623).

7. The device according to claim 3, further comprising a restriction means (70) for
5 limiting the angle between the second surface (12) of the first board (10) and the surface (21) of the second board (20) to a threshold (Max).

8. The device according to claim 7, wherein the restriction means (70) comprises a non-elastic strap (70) connecting the first board (10) and the second board (20).

10

9. The device according to claim 1, further comprising a first pair of lateral boards (901) for limiting lateral movement of the hand of the user and/or a second pair of lateral boards (902) for limiting lateral movement of the arm of the user.

15 10. The device according to claim 9, wherein the first pair of lateral boards (901) is integrally formed with the first board (10), and the second pair of lateral boards (902) is integrally formed with the second board (20).

11. The device according to claim 1, further comprising an air pump (80) connected
20 to the air bag (50).

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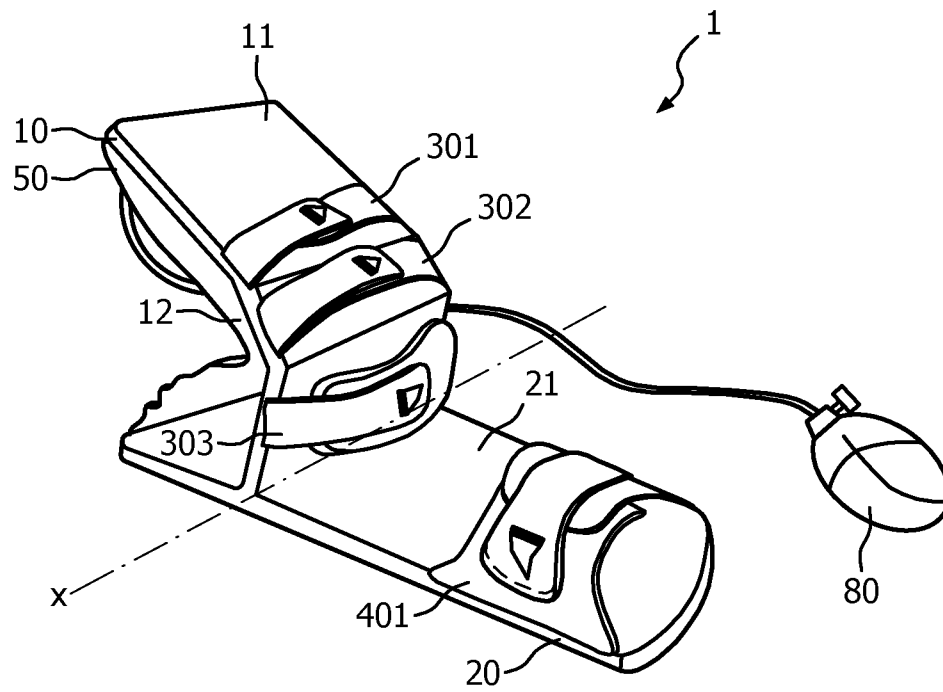


FIG. 1

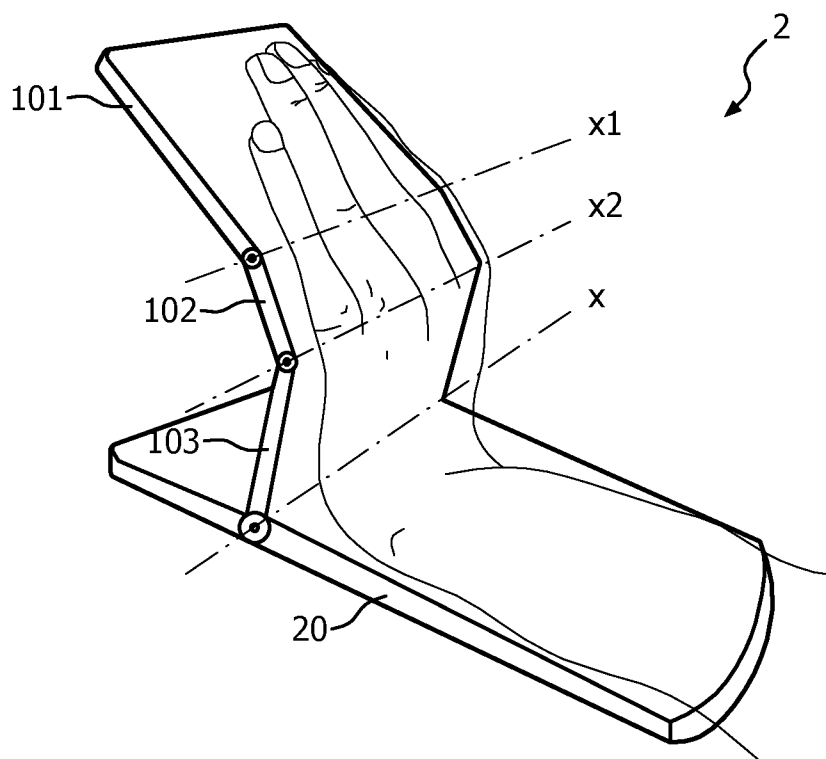
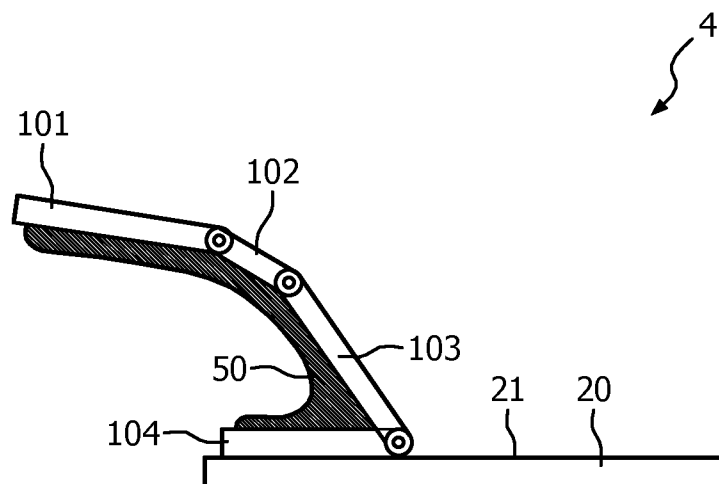
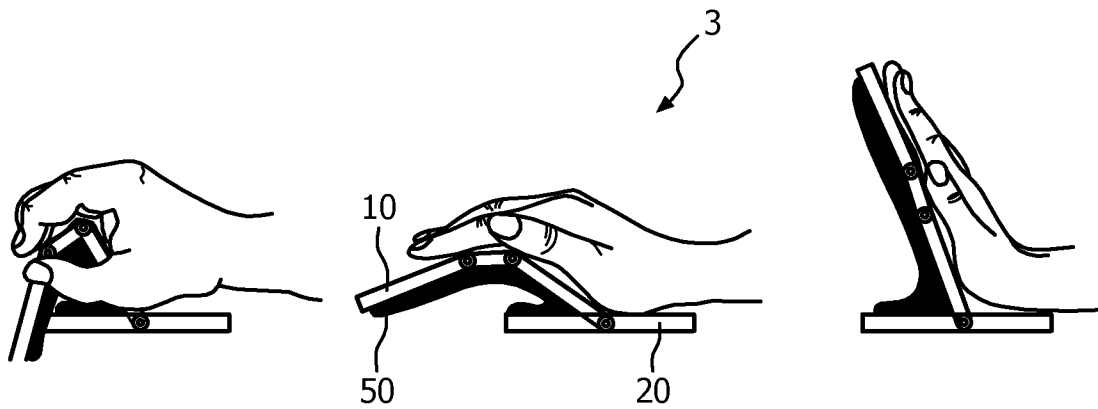


FIG. 2

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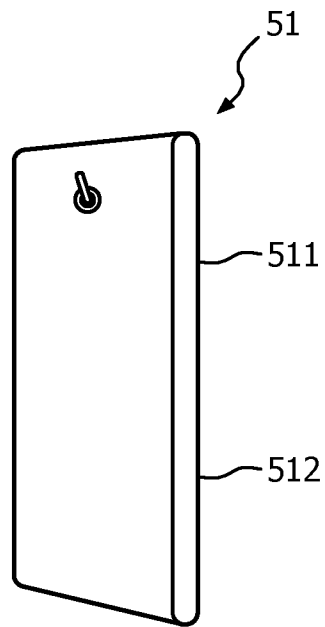


FIG. 5A

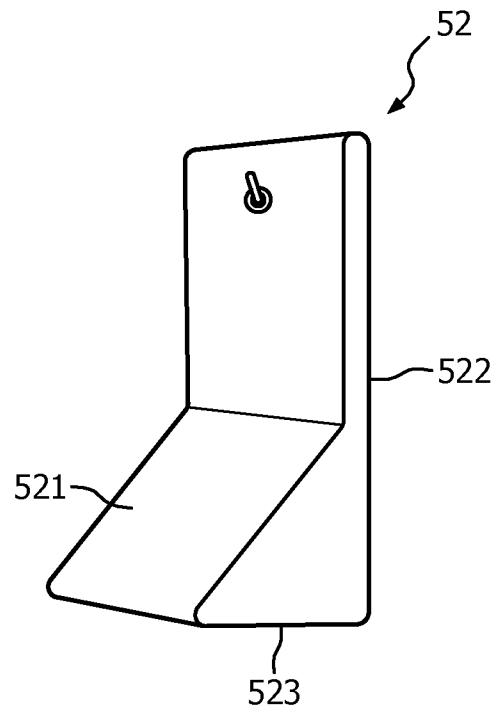


FIG. 5B

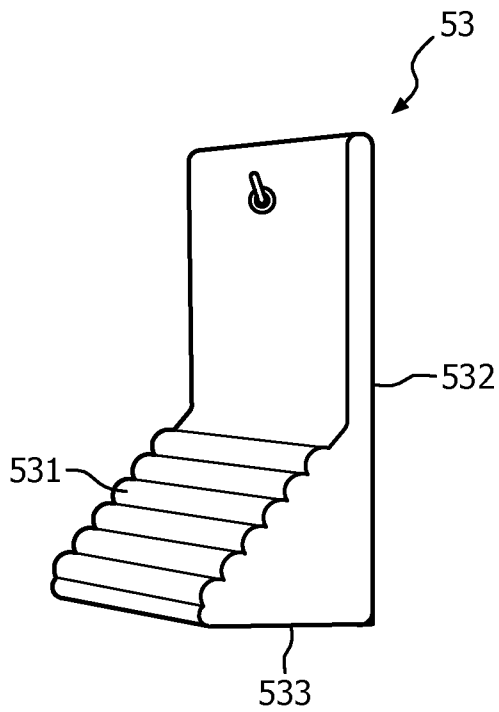


FIG. 5C

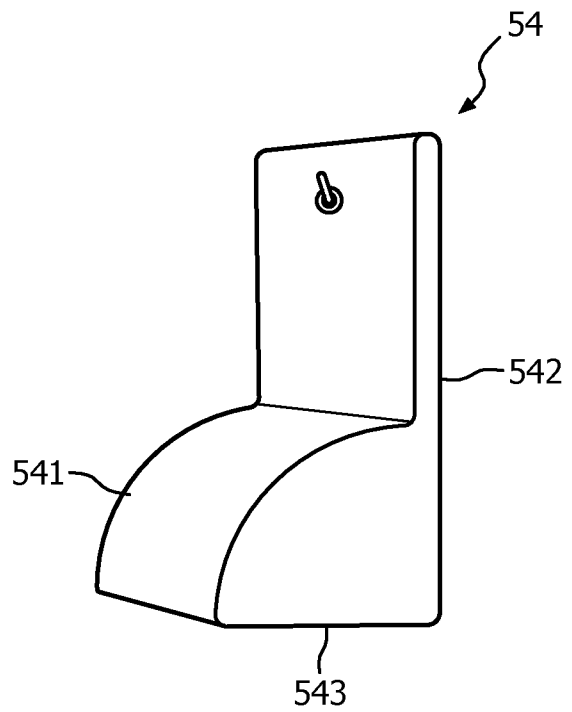


FIG. 5D

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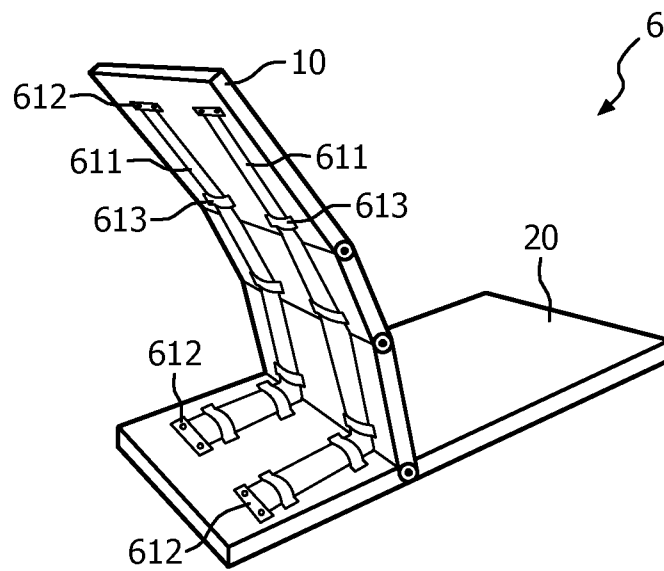


FIG. 6

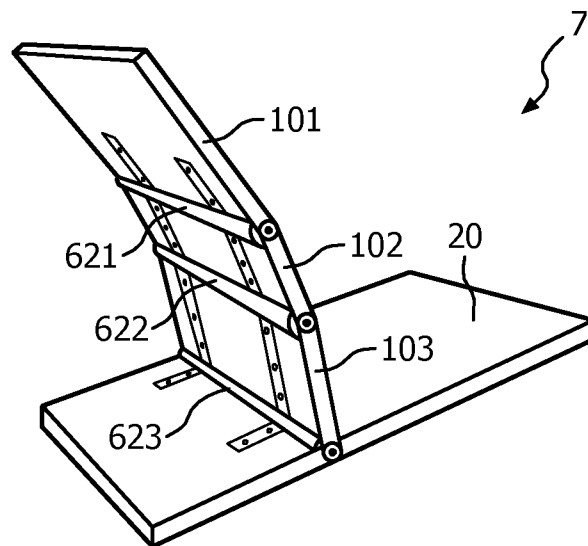


FIG. 7A

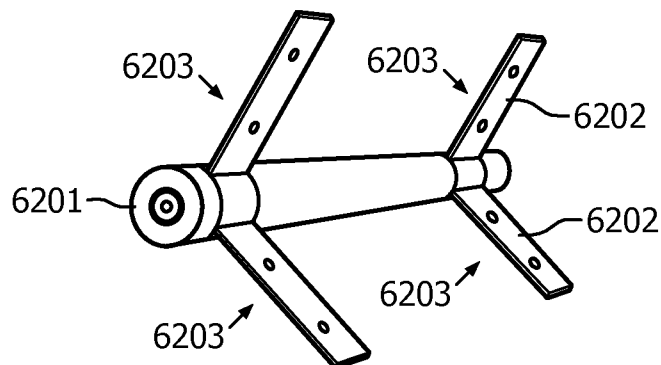


FIG. 7B

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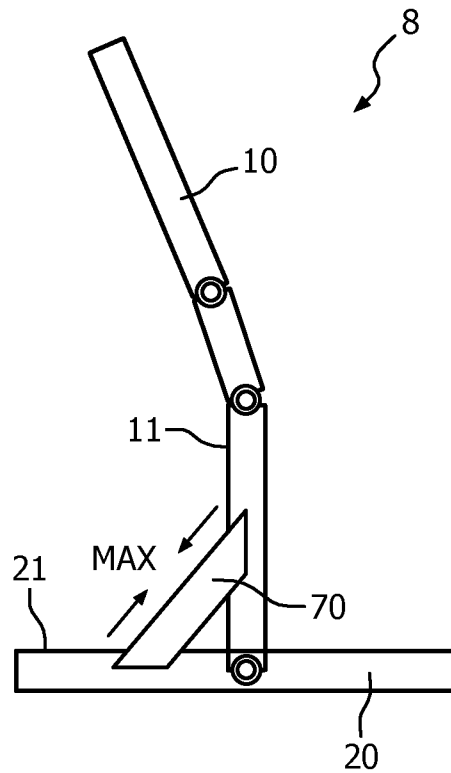


FIG. 8

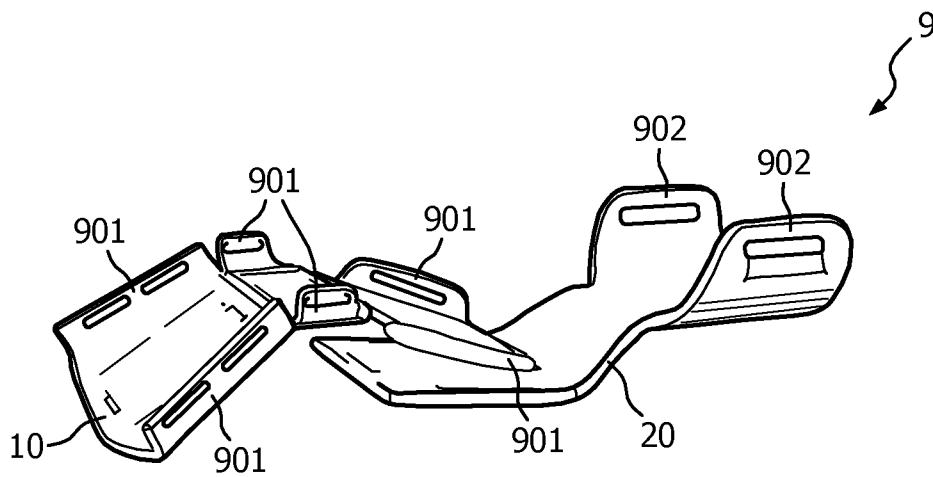


FIG. 9