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(71) Applicant *(for all designated States except US)*: **PR Sella B.V.** [NL/NL]; Ainsworthstraat 21B, NL-7575 BS Oldenzaal (NL).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: **HUTTENHUIS, Alouisius Gerardus** [NL/NL]; Knik 16, NL-7591 PZ Denekamp (NL).

(74) Agent: **SCHUMANN, Bernard Herman Johan**; Schumann Patent Consultancy B.V., Kerkedennen 43, NL-7621 EB Borne (NL).

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(54) **Title:** PIVOTABLE SEAT

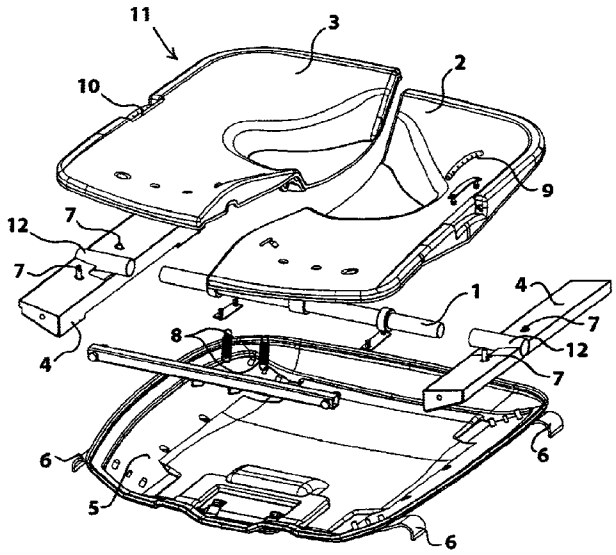

FIG. 2

(57) **Abstract:** A seat for supporting the bottom area of a seated person, which seat is intended and adapted to form part of an article of seating furniture, such as a chair or a couch, a seat for a means of transport such as a car, a bus or an aircraft, or a wheelchair, has the feature that the seat consists of two parts, i.e. a left-hand seat part and a right-hand seat part, which seat parts are separated from each other along the nominal median plane of a user, each of the seat parts is pivotable around a pivot zone extending at least roughly perpendicularly of said median plane; and the projected position of the pivot zone lies in front of the tubera.

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PIVOTABLE SEAT

The invention relates to a seat for supporting the bottom area of a seated person, which seat is intended and adapted to form part of an article of seating furniture, such as a chair or a couch, a seat for a means of transport such as a car, a bus or an aircraft, or a wheelchair.

Such a seat is known in many embodiments and is usually applied in combination with a backrest.

The invention has for its object to embody a known seat such that the shear forces on the upper legs and buttocks are reduced and the pressure on the left and right tubera is decreased.

As a result of a non-uniform pressure distribution on the bottom area there occurs more load at some locations on this bottom area and less load at other locations. Seated persons who are more or less forced to sit for long periods hereby experience problems related to this sitting.

Sitting-related problems manifest themselves in, among other ways, pain in the bottom area, this sometimes even resulting in death of tissue or decubitus. Decubitus is the death of tissue due to poor blood circulation. The poor blood circulation is caused, among other reasons, by the fact that a relatively high pressure locally on and in the tissue reduces the flow through the blood vessels. Decubitus ulcers occur at those locations where bone structures lie close to the surface of the skin, such as in the case of the two left and right seat bones (tubera ischiadica) and the tail bone (os coccyx).

Unfortunately, existing products such as special cushions, so-called anti-decubitus cushions, still provide little or no improvement for such patients.

The invention has for its object to provide a solution for people affected by sitting problems, including decubitus.

The invention is based on the insight that a uniform load provides for a lower peak load, which in turn ensures less discomfort.

The seat according to the invention has for this purpose the feature that

the seat consists of two parts, i.e. a left-hand seat part and a right-hand seat part, which seat parts are separated from each other along the nominal median plane of a user,

each of the seat parts is pivotable around a pivot zone extending at least roughly perpendicularly of said median plane; and

the projected position of the pivot zone lies in front of the tubera.

The seat according to the invention ensures that the upper legs and buttocks on the left and right are supported individually in uniform manner in accordance with a natural balance. The left-hand seat part and the right-hand seat part are each supported for individual pivoting by a pivot construction. This can for instance be a single pivot shaft shared by both seat parts, although other pivot constructions can also be used, for instance rod mechanisms or the like. It is not possible in the case of such mechanisms to refer to a single pivot axis, but there is a region around which the pivoting movement takes place. This region is referred to in this specification as "pivot zone".

The description of the accompanying figures is now anticipated in the following.

The biomechanical model (figure 3b) of the seated human body assumed in the research by dr. ir. H.A.M. Staarink (page 31 of the book "Zo zit het!" ISBN 978 90 232 4341) teaches that a frictionless bottom area support is created at a seat angle φ of a minimum of 12° (figure 4). The position of the pivot shaft or pivot

shafts respectively pivot zone or pivot zones is important for the distribution of the forces on the bottom area of the seated person. The seat angle φ is important in minimizing friction and shear forces. A support with low friction and shear forces is desirable. This can only be achieved with a correct choice of the seat angle.

A uniform load has a positive effect on the pressure-distributing properties of the seat. The seat parts can be freely movable and have for instance a rest position in which the front side of each of the seat parts occupies a highest position and the rear side a lowest position. Such a rest position can for instance be realized with suitable spring means. Use can also be made for this purpose of a specific location of the mass centre of the upper body of the seated person relative to each seat part.

According to an important aspect of the invention, the seat has the special feature that an angle measuring device is added to each of the seat parts with which the pivot positions of the seat parts can be measured and read, for instance a spirit level.

The seat can further be provided with pivot position adjusting means for adjusting the pivot positions of the seat parts.

According to yet another aspect of the invention, the seat has the special feature that the pivot position adjusting means are of mechanical, pneumatic or electrical type. Use can for instance be made of an electrical actuator.

The two latter variants have the advantage that they can be provided with fixation means for fixing at least one of the two seat parts, preferably both seat parts, in an adjusted pivot position.

In order to realize the best possible pressure distribution, the seat according to the invention can advantageously have the special feature that both seat parts have an anatomical form.

According to an important aspect of the invention, which also aims at a good pressure distribution, the seat has the special feature that both seat parts are provided with a pressure-distributing upper layer.

A further improvement in a uniform pressure distribution and an improvement in the sitting comfort is realized with an embodiment in which the pressure-distributing upper layer is air-permeable, is covered by a cover layer provided with perforations, and air pressure means, for instance fan means, are present which feed air under a certain pressure to the pressure-distributing upper layer, this air leaving the upper layer via the perforations present in the cover layer. This embodiment has the further advantage of realizing a certain ventilation and cooling of the skin and the tissues thereunder.

According to yet another aspect of the invention, the seat can comprise: control means for controlling the pivot position adjusting means such that the pivot positions of the seat parts vary through time such that the pressure loads on the tubera vary through time.

It can be of great importance that the left-hand seat part can be adjusted independently of the right-hand seat part. A difference in lower leg length or differences in thickness of for instance shoe soles on the left and right adversely affect the pressure-distributing results in the case where the seat, other than in the invention, were not divided.

In the case a footrest is set too high (figure 3c) the upper leg will be supported less, or even not be supported, and the buttock must absorb the sitting load, whereby the danger of decubitus will increase. If the footrest is adjusted too low (figure 3a) the upper leg, and particularly the part behind the knee, is loaded too much, resulting in an increased risk of restriction of blood vessels and nerve-paths, with all the adverse consequences this entails. The invention evens out the possible difference between left and right almost

completely, and therefore causes considerably less high sitting load peaks (figure 3b). The pivoting of the seat parts (figure 6) is essential in providing a correct support and guaranteeing a balanced pressure distribution. The operation of the seat parts could be compared to the operation of a pair of scales.

Adjustment of the seat angles φ_L (left) and φ_R (right) (see figure 6) is brought about by adjusting the heights of the left and right-hand footrests. Integrated seat angle measuring devices measure the φ_L and the φ_R relative to the horizontal plane and give qualitative and/or quantitative feedback to the seated person and/or to the therapist.

Many seat cushions are known which claim to cause no friction or shear forces but, if there is no relation between a seat cushion and the seat angle (φ) and the functional backrest angle ($\forall + \varphi$) (see figure 4), friction and shear forces cannot be precluded.

During use the seat according to the invention forms part of a full seat support comprising the seat and a backrest, and optionally a footrest.

The seat according to the invention can be applied as replacement for an existing seat or be applied integrally in combination with a back support in for instance a car seat, office chair, garden seat or a wheelchair.

Seat which may or may not be embodied with a backrest are per se known. Also known are seats which can pivot in different ways.

Described in WO-A-1995/015101 is a total seat support comprising a seat wherein the seat can pivot as a whole. A similar structure is specified in WO-A-2005/0116527, although here the seat cannot pivot around a fixed pivot axis.

Described in US-A-5 580 128 is a segmented seat wherein there are two pivot axes transversely of said median plane.

It is known from the literature that discomfort is also caused by friction forces on and shear forces in the tissue. Different researchers assume that the influence of friction and shear forces on discomfort, as manifested for instance in decubitus, could be greater than the influence resulting from perpendicular load. Friction and shear forces are caused largely by an incorrect value of the seat angle φ.

Research has shown that an anatomically correct torso support starts at a functional backrest angle ($\forall + \varphi$) of about 115° (figure 4) and ends at an angle of about 123°. At a larger angle ($\forall + \varphi$) the head must always be actively supported, and this is therefore no longer an active sitting posture, but the beginning of the lying posture.

If in the model of the human body of figure 5a masses are assigned in accordance with anthropometric data to the body parts assumed in the model, it then follows from a (bio)mechanical analysis that, at a functional backrest angle of ($\forall + \varphi$) of 115° and a seat angle φ of about 12°, no friction forces occur on the bottom area as a result of the external load.

If the seat angle ($\forall + \varphi$) increases, angle φ must also increase in order that no shear forces are caused in the seat as a result of the external load. There is a direct relation between a seat angle ($\forall + \varphi$) and seat angle φ. If both seat parts are provided with an angle indicator, the measured angles φ_L and φ_R are indicators of whether or not friction and shear forces occur on the seat parts.

It is important to stimulate awareness of posture through interaction of the seat and the user by means of said angle indicators added to both the left and the right-hand seat part. The user and/or the therapist can check the seat angle by reading the value of φ_L and φ_R from the integrated angle indicators.

People with sitting problems are often consciously involved in their rehabilitation. In order to stimulate

this process the invention provides users, by means of the seat angle indicator, with an aid allowing them to monitor their own sitting posture and, if necessary, to adjust it themselves if possible.

The seat does not require an actuator to position a user in the correct posture because the user balances him/herself using the balance in the support, provided the footrest is set to the correct height.

An actuator can however be added for a forced alternating load between the left, right, front and rear sides of the seat. This provides the option of varying the load on both tubera (figure 7).

By tilting the left-hand supporting surface further forward (reducing angle φ_L) the left tuber will be loaded more than the right tuber. By varying the left and right seat angle (respectively φ_L and φ_R) the loads on the tubera will begin to vary, this enhancing flow of blood and moisture in the surrounding tissue. The risk of decubitus can thus be reduced in preventive manner.

The transfer, i.e. sitting down in or standing up from the seat, is facilitated in that the seat parts pivot along with the displacement of the centre of gravity of the user.

In addition to posture and pressure distribution, temperature and moisture are also important factors in the development of decubitus or discomfort. In the invention the seat contact surfaces are provided with a cover and a pressure-distributing layer which are air and moisture-permeable so as to bring about a decrease in the air humidity and temperature on the seat surface, optionally brought about by a forced airflow. Figure 8 makes clear that forced ventilation in the pressure-distributing layers of the support is realized by means of an electrically driven fan.

The invention will now be elucidated with reference to the accompanying drawings. In the drawings:

figure 1 shows a perspective view of an exemplary embodiment of the seat according to the invention;

figure 2 shows an exploded view of the seat according to figure 1;

figures 3a, 3b and 3c show highly schematic side views of a seat according to the invention in combination with a footrest, wherein the footrest is set too low in figure 3a, set correctly in figure 3b and set too high in figure 3c;

figure 4 shows a schematic side view of a seat in combination with a backrest and a seated person for the purpose of elucidating the relevant angles;

figure 5a shows a model of the human body in the manner of figure 3 in accordance with the mentioned book "Zo zit het!" by dr. ir. H.A.M. Staarink, placed on the seat according to the invention and provided with the correct back, arm and foot supports;

figure 5b shows a side view of the seat according to figure 5a in which the relevant forces are drawn;

figure 6 shows a highly simplified, perspective view of the seat according to the invention, wherein the seat parts are provided with angle measuring devices and the chair comprises footrests and a back support;

figure 7a is a schematic top view of a seat according to the invention, wherein prominent zones of the seated person are drawn;

figure 7b is a rear view of the seat according to figure 7a;

figure 8 is a cut-away perspective view of a seat with a fan;

figure 9a is a schematic side view of a seat part which is pivotable by means of rods; and

figure 9b shows a view corresponding to figure 9a of a variant in which a seat part is guided along guide slots by means of pins, and is thus pivotable.

Figures 1 and 2 show a seat 11 according to the invention. Seat 11 comprises a profiled bottom plate or shell 5 of for instance a rigid plastic, a bearing construction 4 supported thereby, a pivot shaft 1 which is carried thereby via bushes 12 and to which a left-

hand seat part 2 and a right-hand seat part 3 are pivotally connected. In the shown situation the left-hand seat part 2 is pivoted further forward/downward than right-hand seat part 3.

The upper surfaces of seat parts 2 and 3 have an anatomical form.

It is noted that the pressure-distributing layers and cover layer to be further described below are not shown in figures 1 and 2 for the sake of clarity.

Bottom plate 5 carries on its four corner points outward protruding hooks 6 for coupling to for instance the frame of a chair or a wheelchair.

In this exemplary embodiment frames 4 comprise adjustable fixation means 7 for securing or bounding the pivoting range of seat parts 2 and/or 3.

The sitting comfort of a seated person 19 depends, among other factors, on the height adjustment of footrests 13, 14, of which only the left-hand footrest 13 is drawn in figure 3. Referring to figure 6, it is noted here that, as well as seat parts 2, 3, footrests 13, 14 are also separated from each other in this exemplary embodiment. The right-hand footrest is designated with reference numeral 14.

In the situation according to figure 3a footrest 13 is set too low, which has the result that the pressure on the front side of the upper leg indicated with an arrow 15 is concentrated locally and is relatively great.

In the situation according to figure 3c footrest 13" is set too high, which has the result that the pressure is concentrated as according to arrow 16 in the vicinity of the relevant tuber 24.

In the intermediate position according to figure 3b, in which the footrest is set correctly, the pressure forces indicated symbolically with arrows 17, 18 are properly distributed over the whole supporting length of the upper leg and the buttocks.

Figures 3a and 3c show only a part of the seated person 19, while figure 3b shows the whole person 19, albeit very schematically. Attention is also drawn to the fact that in the situation shown in figure 3b (which corresponds to that according to figures 3a and 3c) the person 19 is supported in the back by a backrest 20, and can rest his left lower arm on a left-hand armrest 21.

The situations according to figures 3a and 3c can result in discomfort, restriction and even decubitus. The correct foot support according to figure 3b provides for a correct distribution of forces and correspondingly small pressure on the bottom area of user 19, and thereby reduces the peak pressures, whereby discomfort is reduced substantially and the risk of decubitus accordingly reduced.

Figure 4 shows a seated person 19, wherein relevant measurable postural angles are shown on the human body. Particularly important in the context of the invention is the seat angle φ, which can be measured on the left with the left-hand angle measuring device 9 and on the right can be measured with the right-hand angle measuring device 10.

Backrest 20 has in figure 4, as also in figures 5a and 5b, a form differing from backrest 20 according to figure 3b, although this aspect is not relevant within the context of the present invention.

Figure 5a shows a model of the human body as developed by dr. ir. H.A.M. Staarink in his above discussed book "Zo zit het!". The model is chosen such that feet, lower legs, upper legs, pelvis, torso, head, upper arms, lower arms and hands are represented as non-deformable elements with respective mass centres m1-m9. The body parts of the model are connected to each other by means of hinges. In the view of figure 5a the seated person 19 is supported by seat 2, backrest 20, footrest 13 and armrest 21. Said mass centres m1-m9 each have their own resultant gravitational force.

Two draw springs 8 (see also figure 2) pull the front sides of left-hand seat part 2 and right-hand seat part 3 downward to a rest position.

Figure 5b shows the forces exerted on seat part 2 by the seated person 19. The forces F-LEG and F-TUBER are at least substantially frictionless in that the seat angle φ has a value of about 12°. This has been demonstrated experimentally in a study reported in the above cited reference by dr. ir. H.A.M. Staarink. The force on the F-AXIS is the resultant normal force. The total of the forces and the moments of force will be in equilibrium if no angular rotation and no angular acceleration take place.

As already described, in non-loaded situation the force F-SPRING exerted by spring 8 will cause seat part 2 to pivot forward/downward.

It will be apparent that seat 2, 3 according to the invention has a symmetrical structure and that the descriptions given on the basis of left-hand seat part 2 therefore also apply to right-hand seat part 3.

Figure 6 shows that a change in the height of left-hand footrest 13 and right-hand footrest 14 causes a change in φ_L and/or φ_R, and thus also a change in F-TUBER, L and F-TUBER, R. An individual optimal adjustment can be realized by adjusting footrests 13, 14. These adjustments can differ from each other as a result of anthropometric and individual size differences.

Angle measuring devices 9 and 10 give user 19 and/or the therapist information relating to the current seat angles φ_L and/or φ_R.

The force F-LEG, L exerted by the left leg is designated with the reference numeral 57, the force F-LEG, R exerted by the right leg with 58, the force F-FEET, L exerted by the left foot with 59 and the force F-FEET, R exerted by the right foot with 60. L means "left" and R means "right'.

Figure 7a shows that the force F-TUBER, R on the right-hand tuber is decreased by pivoting right-hand seat part 3 further backward than left-hand seat part 2 while increasing φ_R.

In figure 7a the pivot axis defined by pivot shaft 1 is designated with reference numeral 22. In this embodiment this axis is collinear for both seat parts 2 and 3.

In figure 7a the centre of pressure is designated 23, left-hand tuber 24 and right-hand tuber 25.

Figure 7b shows the effect of the mutually differing pivot positions of seat parts 2 and 3.

It will be apparent that the tissue under left-hand tuber 24 is further compressed than the tissue under right-hand tuber 25. Given a specific condition of the person 19, this may be a desired setting of seat parts 2 and 3.

Figure 8 shows a seat part 26 to which a fan 27 is added. A pressure-distributing upper layer 28 is air-permeable and is covered by a breathing cover layer 29. The fan carries air under a certain pressure toward pressure-distributing upper layer 28, this air leaving upper layer 28 via perforations 30 present in the breathing cover layer 29.

Figures 9a and 9b show that the pivoting of a seat part can take place in a manner other than via a pure and simple hinge displacement.

Figure 9a shows that a seat part 2 can pivot to for instance position 2' in the manner according to the invention by means of a rod mechanism.

Figure 9b shows that the pivoting can also take place by having a seat part 2 guided to position 2 in two paths by pins in guide slots.

LITERATURE

* "Zo zit het!", dr. ir. H.A.M. Staarink, ISBN 978 90 232 4341

* WO-A-1995/015101
* WO-A-2005/0116527
* US-A-5 580 128

Claims

1. Seat for supporting the bottom area of a seated person, which seat is intended and adapted to form part of an article of seating furniture, such as a chair or a couch, a seat for a means of transport such as a car, a bus or an aircraft, or a wheelchair,

characterized in that

the seat consists of two parts, i.e. a left-hand seat part and a right-hand seat part, which seat parts are separated from each other along the nominal median plane of a user,

each of the seat parts is pivotable around a pivot zone extending at least roughly perpendicularly of said median plane; and

the projected position of the pivot zone lies in front of the tubera.

2. Seat as claimed in claim 1, wherein an angle measuring device is added to each of the seat parts with which the pivot positions of the seat parts can be measured and read, for instance a spirit level.

3. Seat as claimed in any of the foregoing claims, comprising pivot position adjusting means for adjusting the pivot positions of the seat parts.

4. Seat as claimed in claim 3, wherein the pivot position adjusting means are of mechanical, pneumatic or electrical type.

5. Seat as claimed in either of the claims 3 and 4, comprising fixation means for fixing at least one of the two seat parts in an adjusted pivot position.

6. Seat as claimed in any of the foregoing claims, wherein both seat parts have an anatomical form.

7. Seat as claimed in any of the foregoing claims, wherein both seat parts are provided with a pressure-distributing upper layer.

8. Seat as claimed in claim 7, wherein the pressure-distributing upper layer is air-permeable, is covered by a cover layer provided with perforations, and air pressure means, for instance fan means, are present which feed air under a certain pressure to the pressure-distributing upper layer, this air leaving the upper layer via the perforations present in the cover layer.

9. Seat as claimed in claim 4, comprising control means for controlling the pivot position adjusting means such that the pivot positions of the seat parts vary through time such that the pressure loads on the tubera vary through time.

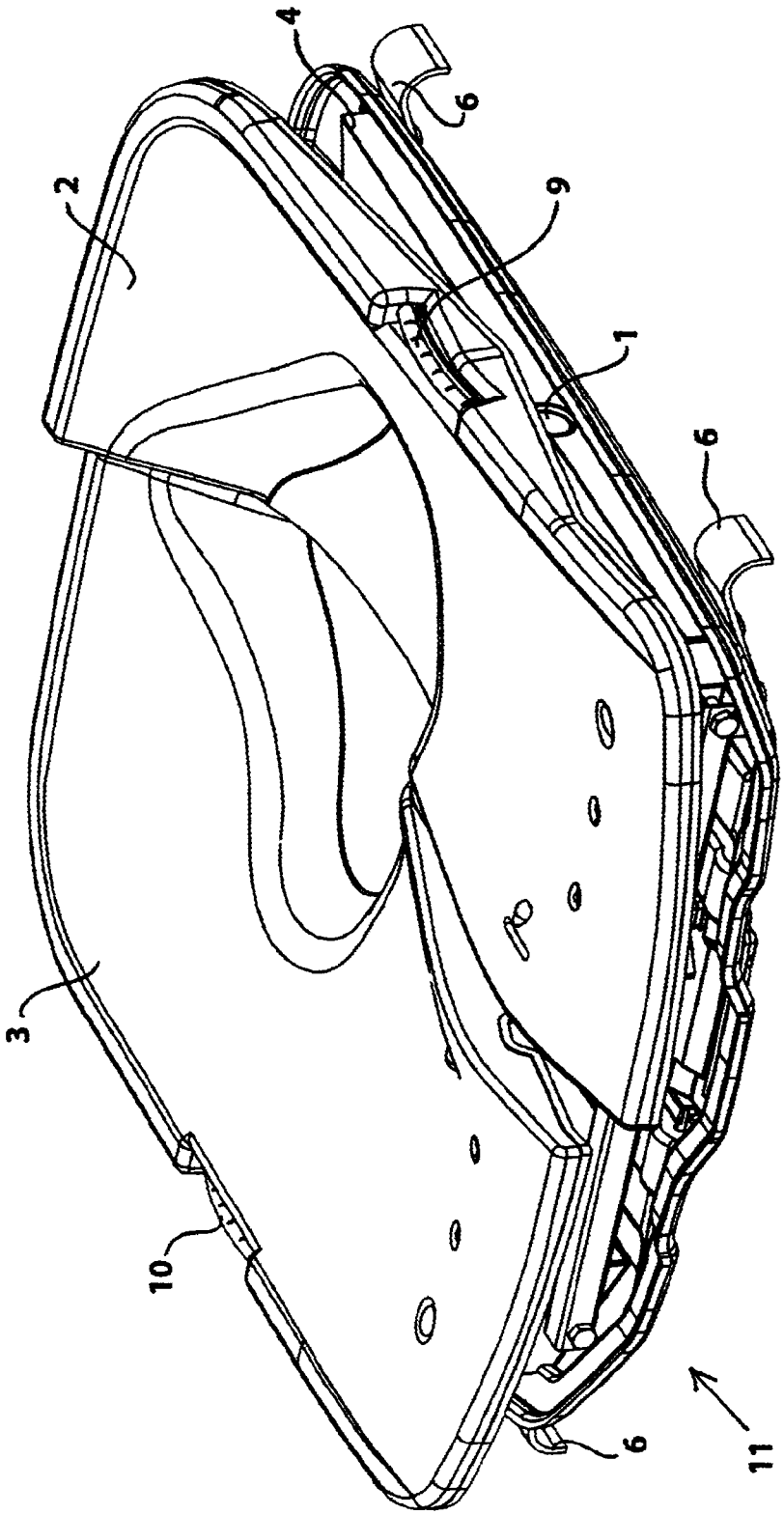

FIG. 1

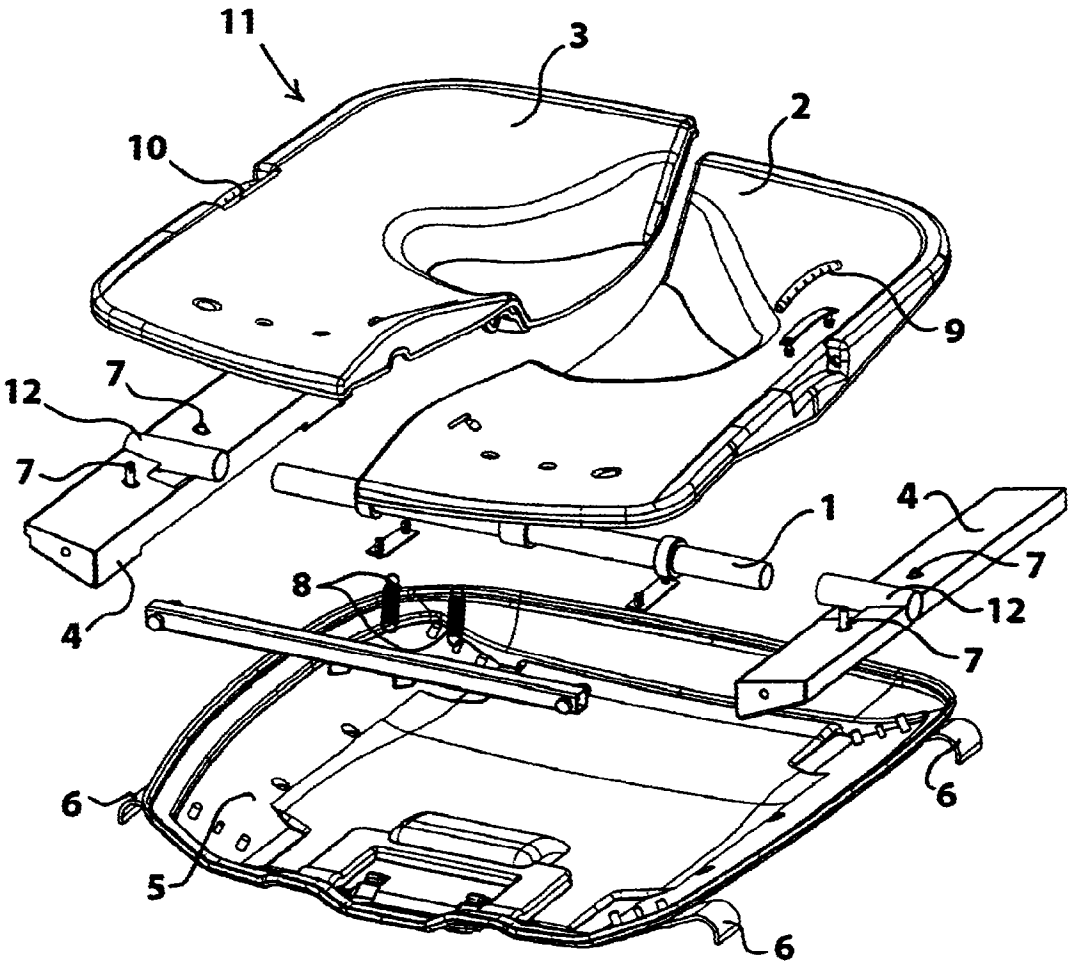

FIG. 2

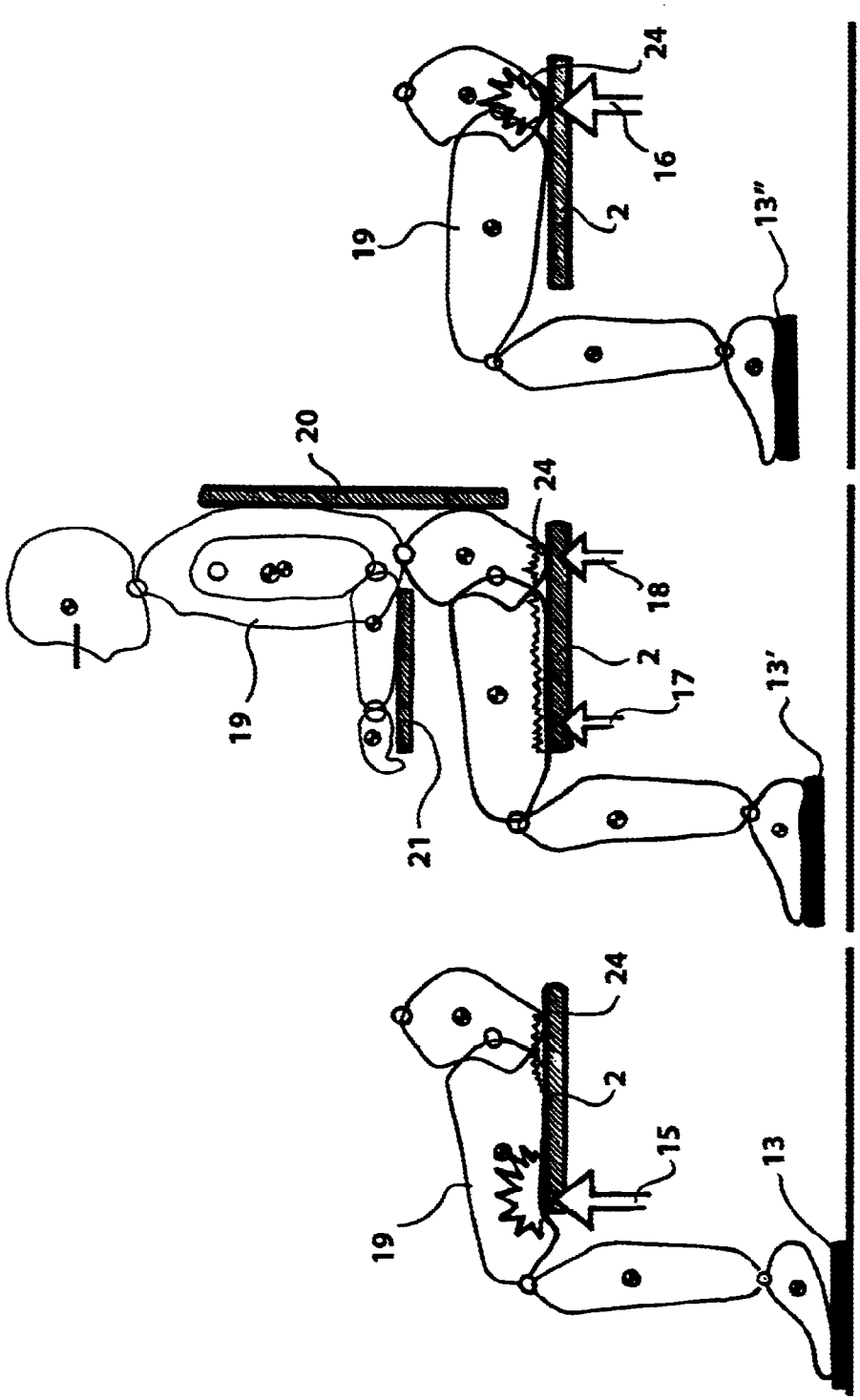

FIG. 3c

FIG. 3b

FIG. 3a

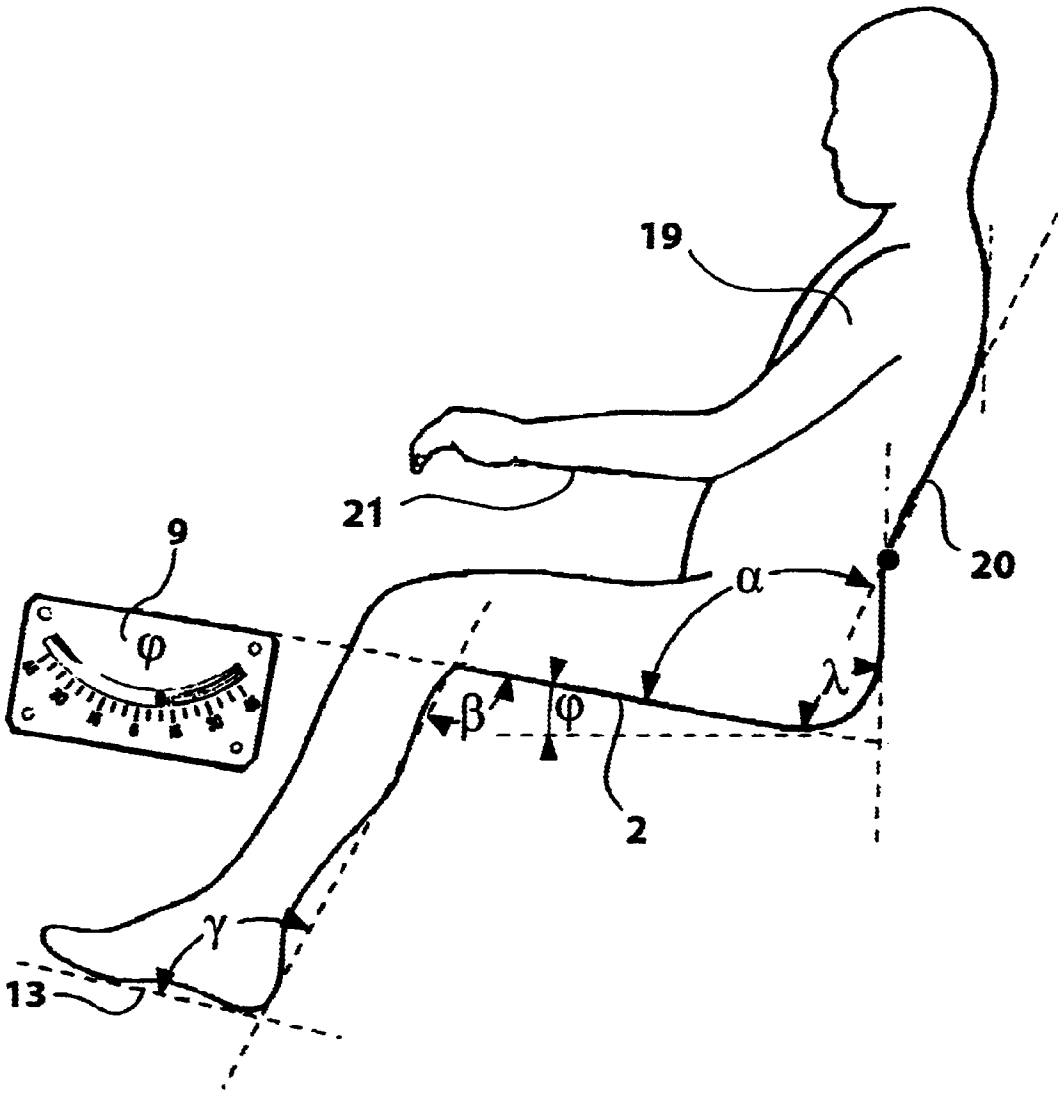

FIG. 4

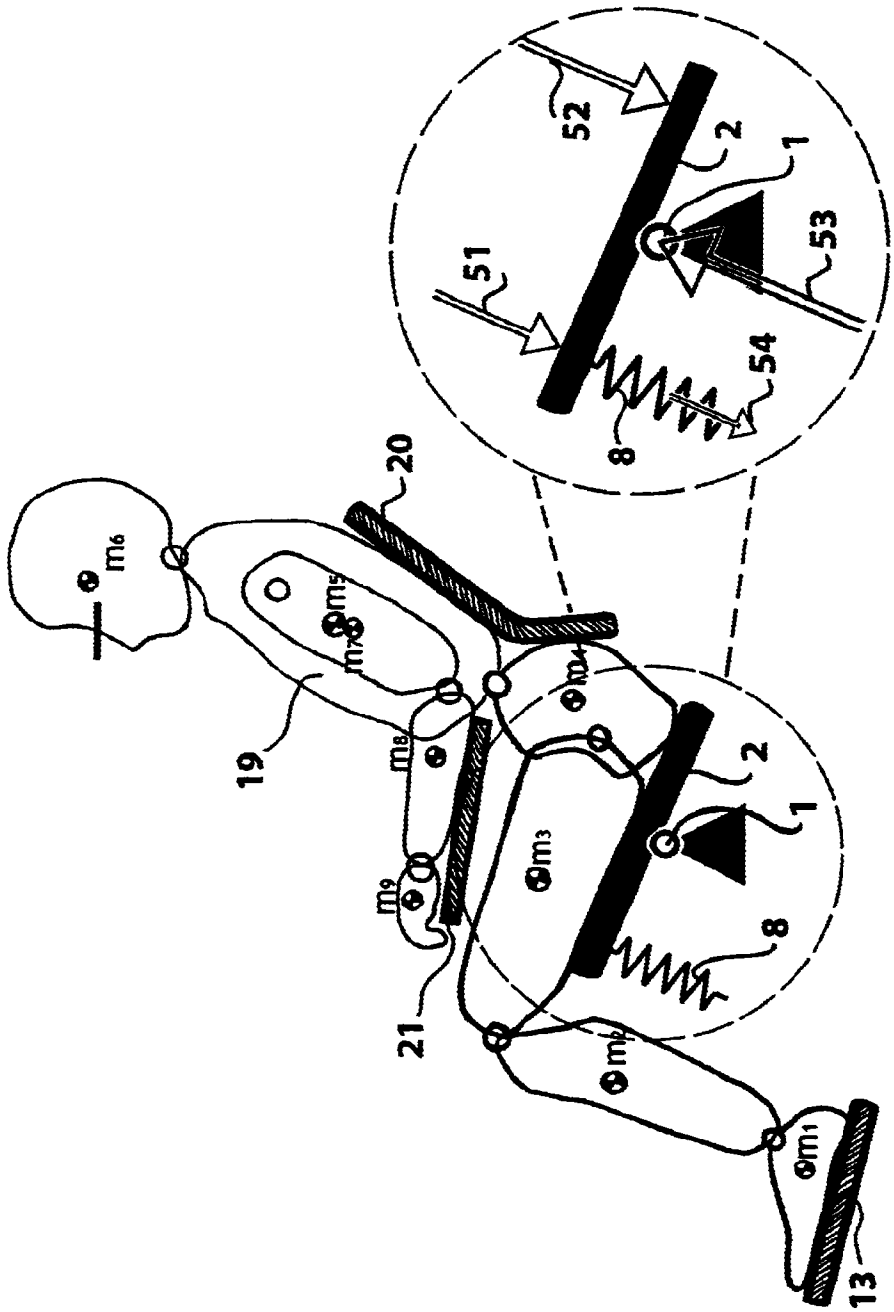

FIG. 5b

FIG. 5a

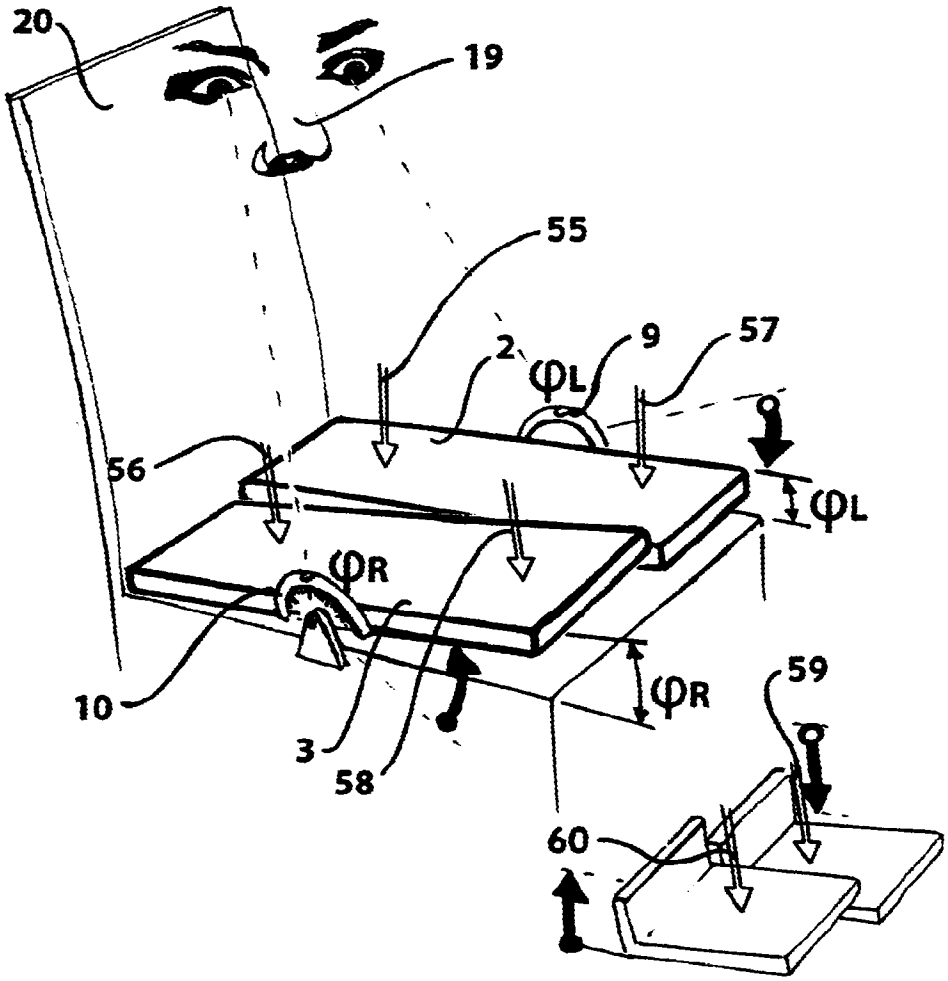

FIG. 6

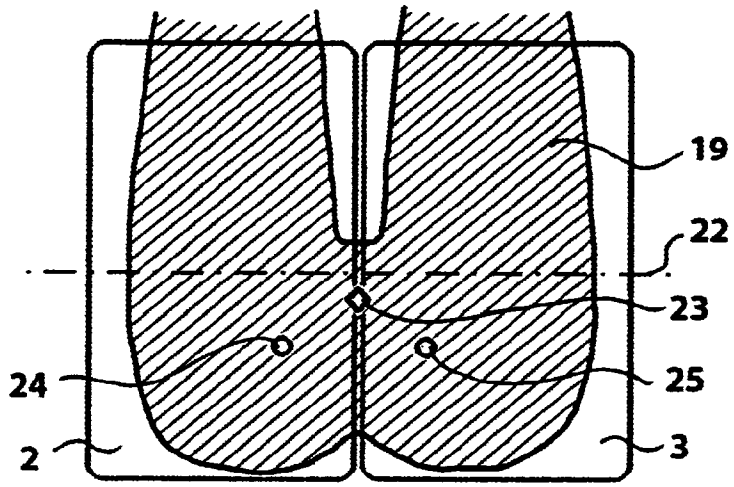

FIG . 7a

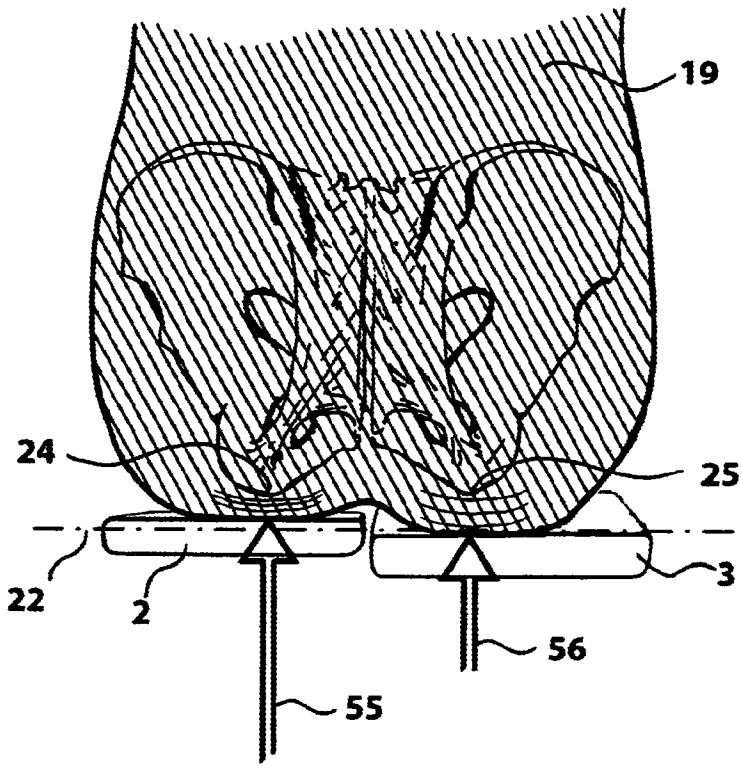

FIG . 7b

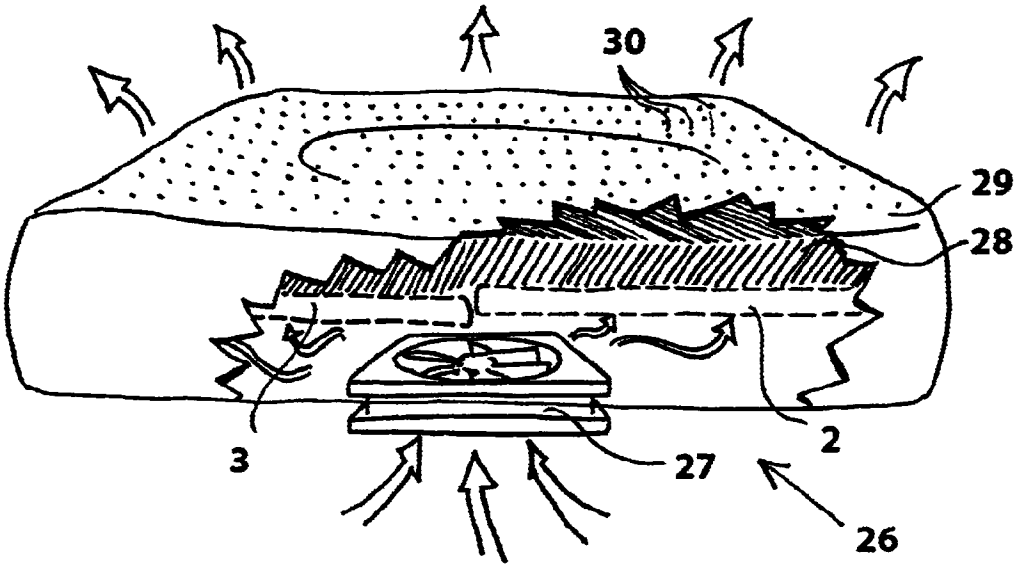

FIG. 8

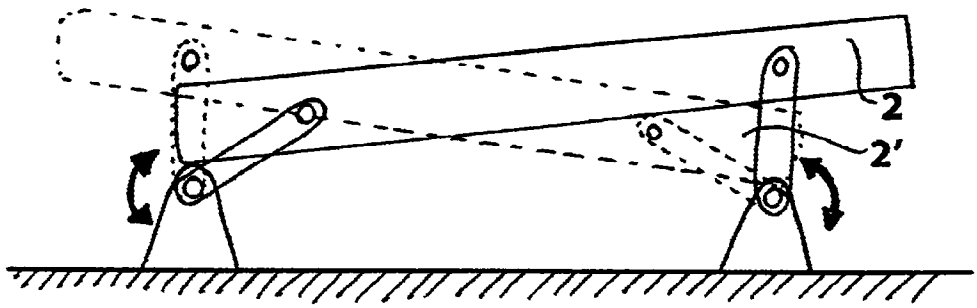

FIG. 9a

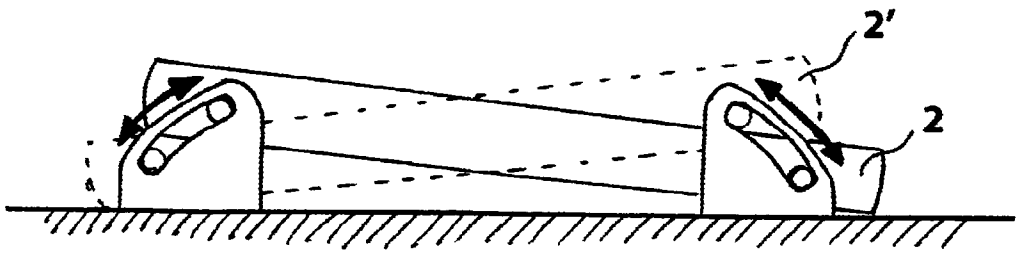

FIG. 9b

INTERNATIONAL SEARCH REPORT

International application No
PCT/NL2008/050861

A. CLASSIFICATION OF SUBJECT MATTER
INV. A47C7/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A47C A61G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 024 485 A (BERG JOSEPH A [US] ET AL) 18 June 1991 (1991-06-18) column 4, line 42 - column 6, line 5 figures 1-8	1,3-7
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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
12 March 2009	06/04/2009

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	MacCormick, Duncan

INTERNATIONAL SEARCH REPORT

International application No
PCT/NL2008/050861

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