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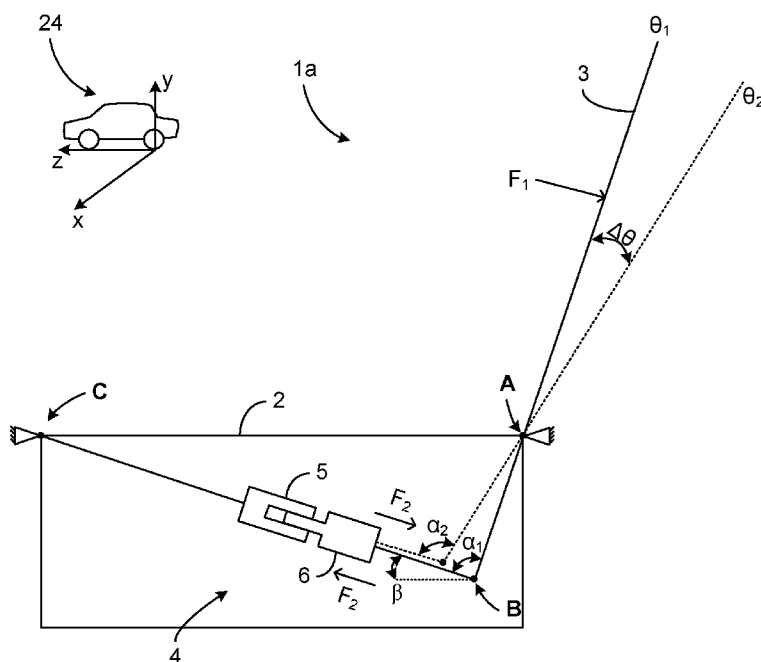


Fig. 1

(57) Abstract: The invention relates to an energy absorbing chair with a purpose to reduce the risk of injury, especially in accidents where the torso of the chair occupant is pressed against the backrest. This is accomplished by allowing a limited rotation of the backrest, transforming the rotary motion into a rectilinear motion, which together with an associated force in the direction of motion defines the energy that can be transferred to an energy absorbing element. By means of energy thus being transferred from the chair occupant accelerations and forces on the head and cervical spine of the chair occupant will be reduced, which reduces the risk of injury.

ENERGY ABSORBING CHAIR

TECHNICAL FIELD

The present invention relates to a chair with an energy absorbing function for use preferably in vehicles. The purpose of the chair is to reduce the risk of injury in an accident where the torso of the chair occupant is pressed against the backrest of the chair.

BACKGROUND

A common cause of whiplash injury is in car crashes when a motorist is hit from behind. A motorist will hereinafter also be called the chair occupant. An example of this situation is, therefore, when an overtaking vehicle collides with a vehicle ahead. Another example is frontal collision where the chair occupant is pressed against the backrest by an expanding airbag. A third example is frontal collision where the chair occupant is a child sitting in a child's seat facing the opposite direction of the car's direction of travel.

Many different types of symptoms of injury may occur as a result of violence to the motorist's head and spine in connection with the accident. In the literature, neck pain, headaches, visual disturbances, balance problems, dizziness, vertigo, tinnitus, concentration problems and nerve damage are mentioned. A likely explanation for these symptoms is injuries to joints, bleeding and nerve injuries caused by the violence. Even after relatively minor violence (e.g., when being hit at 10-15 km/h), the symptoms may occur.

The costs for whiplash-related injuries are globally very large. In Europe, they have been estimated to 10 billion Euro annually, in which a large proportion is related to car accidents and rear-end collisions. Women are affected more often than men. Other data suggest that the annual costs for whiplash-related injuries in the United States are estimated at USD 8.2 billion and in the UK at USD 1.2 billion.

The highest risk of suffering from whiplash injury in car crashes occurs at rear collisions. The collision process for rear-end collisions can be described in a number of phases (as exemplified by the following disclosed phase 1, phase 2, phase 3 and phase 4), which together last for a short time, typically
5 around 0.5 seconds.

Phase 1: In the first phase (0-0.1 seconds) the vehicle in front will accelerate forward, which means that each backrest will push its occupant forward, wherein first the torso is accelerated (in the latter part of phase 1), which causes the spine to be extended and compressed. As a consequence thereof
10 pressure gradients in chair occupant's brain occur. High pressure occurs in the back of the brain and low pressures in the front part. Shear forces occur in the brain stem.

Phase 2: In the second phase (0.1 to 0.25 seconds), the spine is further stretched out. The head is accelerated and pushed back at or above the neck
15 support. This can cause temporomandibular disorders (TMJ or TMD).

Phase 3: The third phase (from 0.25 to 0.4 seconds) achieves maximum head acceleration, the torso sinks back down into the seat and the head rotates forward. The backrest springs back and increases the speed of the chair occupant significantly.

20 Phase 4: In the fourth phase (0.4-0.5 seconds) the head, neck and torso are decelerated. High tensile and shear forces occur in the spine. High tensile forces also occur in the brain stem and the spinal cord.

The publication Energy-Absorbing Car Seat Designs for Reducing Whiplash, Traffic Injury Prevention, 9:6, 583-591, 2008, by S. Himmetoglu, M. Acar, K.
25 Bouazza-Marouf and A.J. Taylor discusses a number of different designs for car seats with the aim of reducing whiplash injuries; RO (Recliner Only): In this embodiment the backrest is pivotally mounted on the seat. During collision energy is collected by a coil spring coupled to the backrest's axis of rotation. SPO (Seat Span Only): In this example, the seat is allowed to be
30 translated backward relative to the vehicle's direction of travel. The energy is

collected by a spring-damper elements horizontally arranged in the seat. WMS: It combines RO and SPO. Energy is collected partly by a rotation of the backrest in a spiral spring, and partly by a translation of the seat in a horizontally positioned spring-damper element in the seat. DWMS: This solution is similar WMS but with the difference that the spring-damper element is inclined 30 degrees to the horizontal plane. RFWMS: This solution is based on WMS. In addition to WMS the backrest consists of an inner and outer frame where the inner frame is allowed to rotate in the opposite direction to the outer, which is said to have advantages in severe collisions. DRFWS: This solution, in turn resembles RFWMS, but with the difference that the spring-damper element is inclined 30 degrees to the horizontal plane as in DWMS.

Another example based on a gear that transmits rotation of the backrest into a linear movement of a toothed plate is described in the Japanese document JP2000280805. The linear motion is transmitted to an energy-absorbing spring. The invention is also said to protect the chair occupant during frontal collisions, for example during expansion of an airbag. The device is further provided with a locking function that is controlled by sensors and which engages mechanism at the moment of collision.

A practical limitation of this solution is that the gear wheel diameter has to be relatively large in order to transform a permitted limited rotation. The mechanism further includes a large number of parts which makes it complicated and expensive to realize and also to service.

In light of the foregoing, there is thus a need for an improved chair to reduce the appearance of, or at least reduce the effect of, whiplash injuries.

SUMMARY

An object of the present invention is thus to provide an improved chair to reduce the appearance of, or at least reduce the effect of, whiplash injuries.

Different types of headrests and energy absorbing materials in the chair helps to reduce the risk of injury. The inventors of the present invention have come

to the realization that if a larger share of the energy can be transferred from the chair occupant during the first phase of the above disclosed process, the risk of injury can be significantly reduced.

5 A particular object of the present invention is thus to reduce the injury risk of whiplash injuries and the associated very high costs, by providing an appropriate energy-absorbing function in the chair. This is accomplished by providing a chair according to the independent claims of the present invention. Such a chair is thus arranged to, when the chair occupant's torso is pressed against the seat, transform a limited rotation of the backrest to a
10 rectilinear motion. The operating distance of the motion may in one embodiment be shifted up and used for energy transfer to an energy absorbing element adapted for the task. The energy-absorbing element is thus adapted to store or accumulate energy in a harmless way (i.e., so that the risk of injury to the chair occupant is reduced). This reduces the accelerations
15 and forces in the chair occupant's head and cervical spine, thereby significantly reducing the risk of injury.

There is thus provided an energy absorbing chair consisting of a seat, a backrest and an energy transferring device disposed in the chair, the energy transferring device comprising an energy absorbing element. During collision
20 energy is transferred from the seat occupant to the energy absorbing element. This reduces the accelerations and forces on the seat occupant's head and spine, thereby reducing the risk of whiplash-related injuries. Specifically, the backrest is pivotally connected with the seat around an axis parallel to the vehicle's transverse direction and as well as with the
25 energy transferring device also around an axis parallel to the chair's transverse direction (i.e. about an axis parallel to the vehicle's transverse direction when the seat is installed in the correct direction in a car). The energy transferring device is in turn pivotally connected to the seat around an axis parallel to the transverse direction of the chair. This enables the
30 rotational movement of the backrest to be transformed into a rectilinear motion, which is utilized to transfer kinetic energy from the chair occupant to said energy absorbing element.

At rear collisions kinetic energy is transferred from the colliding car to the run-into car, which in turn through its backrest transfers it to the chair occupant. Thus, the kinetic energy may thereby be transferred to an energy absorbing element via rotation of the backrest. To accomplish this rotation of the backrest is transformed into a rectilinear motion, which is used for energy transfer to the energy absorbing element.

Thus, there is provided a chair whose function is based on translational motion and which enables the energy transmission rotation may be severely limited in order not to risk injuring passengers in the back seat (where the chair is used in the front seat). Similarly, there is provided a chair whose function enables a limitation of rotational movements and that despite these limitations provides an energy transfer at a large enough distance in order to obtain the desired effect, i.e. to reduce the appearance of, or at least reduce the effect of, whiplash injuries.

The energy transferring device is suitably fixed to the seat, pivotably about the third axis. Alternatively, the energy transferring device may be fixable at a part, disposed outside of the chair, of the vehicle in which the chair is mounted, pivotably about the third axis.

Said energy transferring device may according to an embodiment comprise an upshifting mechanism, arranged for upshifting the distance of said rectilinear movement, yielding constructive advantages.

The chair may according to an embodiment be arranged such that the angle between a line between the backrest's both rotation points and a line between the energy transferring device's both points of rotation, seen in a plane whose normal is parallel to the vehicle's transverse direction, increases as the backrest rotates due to the torso of the chair occupant being pressed against the backrest during collision from behind.

The chair may according to an embodiment be arranged such that the energy absorbing element is disposed and oriented to enable the distance between the first axis and the second axis to become as large as possible. Thereby the

length of the lever arm formed between the first and the second axes is maximized, whereby also the resulting linear movement of the energy transferring device is maximized with respect to the rotational movement about the first axis.

- 5 The kinetic energy from the chair occupant may according to an embodiment be transferred during said rectilinear motion to the energy absorbing element by means of a pushing force.

- The kinetic energy from the chair occupant may according to an embodiment be transferred during said rectilinear motion to the energy absorbing element
10 by means of a tensile force transferring element, which makes it possible to use simple structural elements for the energy transfer.

Said energy transferring device may according to an embodiment comprise a plate which is arranged in the seat and pivotally arranged in the same, which is simple to arrange and which does not require so much space.

- 15 Said energy transferring device may according to an embodiment comprise a slidably mounted member disposed in the longitudinal direction of the device, seen in a view along the vehicle.

The backrest may according to an embodiment be provided with a latch mechanism which is released at the initial phase of the moment of collision.

- 20 Said latch mechanism may according to an embodiment receive a signal from one or more sensors to be disengaged at a certain time after the moment of impact. The energy absorbing function is thus not activated under normal circumstances.

- Said latch mechanism and the energy transmitting device may according to
25 one embodiment be decoupled when the chair occupant wishes to set the seat for reasons of comfort, and that said rotary movement has a limited impact. There no active action (such as setting or turning on) of the chair occupant is thus required.

Said energy absorbing elements may be a band, a strap, a line, a rope, a wire, a solid material, a spring, a hydraulic damper, a gas spring or a flywheel; or combinations thereof.

5 Preferably the energy transferring devices enables the rotation of the backrest to be transformed into a linear movement, whose distance can be shifted up, yielding design benefits.

10 Preferably, the energy absorbing function is in the chair disposed in a practical and cost effective manner through its compact, flat design, and use of simple construction elements. The energy transferring device therefore does not affect the vehicle's structural performance in any substantial way, which also facilitates maintenance or replacement after activation. The device is thus easy to maintain and can be replaced without the whole chair needing to be replaced.

15 Preferably the energy transferring device enables the kinetic energy of chair occupant to be transmitted to the energy absorbing element via a down-shifted traction force. This enables the use of an easy and cost effective traction force transmitting elements for energy transfer.

20 Generally, all terms used in the claims are to be interpreted according to their ordinary meaning in the technical field, unless explicitly defined otherwise herein. All references to "a/an/the element, apparatus, component, means, step, etc." are to be interpreted openly as referring to at least one instance of the element, apparatus, component, means, step, etc., unless explicitly stated otherwise. The steps of any method disclosed herein do not have to be performed in the exact order disclosed, unless explicitly stated.

25 **BRIEF DESCRIPTION OF THE DRAWINGS**

The invention is now described, by way of example, with reference to the accompanying drawings, in which:

Figures 1-6 are various views of a chair comprising an energy transferring device, and

Figures 7-10 illustrate an energy transferring device according to different embodiments for integration in a chair according to Figures 1-6.

DETAILED DESCRIPTION

The invention will now be described more fully hereinafter with reference to the accompanying drawings, in which certain embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided by way of example so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Like numbers refer to like elements throughout the description.

Figure 1 shows a principled and stylized view of a chair 1a seen in a longitudinal view (the *yz* plane). Figure 1 also shows a coordinate system based on the assembly of the chair 1a in a car 24. The chair 1a comprises an energy transferring device 4 arranged in the seat 2 of the chair 1a. The chair 1a thus comprises the following principle components, referring initially to Figure 1: a seat 2, i.e., the seat load bearing structure, a backrest 3, i.e., the back load bearing structure; as well as an energy transferring device 4, which is arranged in the seat 2 with the purpose of transferring kinetic energy from an imagined chair occupant (not illustrated), that in use is placed in the chair 1a, to an energy absorbing element 5 by a linear displacement during mechanical resistance.

The energy transferring device 4 thus comprises an energy absorbing element 5 (only schematically shown in Figure 1), i.e., the elements of the energy transferring device 4 that, in use, primarily accumulates or converts the kinetic energy transmitted from the chair occupant. The energy absorbing element 5 is connected to a slidable element 6 which will be described below.

In the initial phase of the collision (Phase 1 above) the torso of the chair occupant is pressed against the backrest 3. The force arising between the backrest and the chair occupant can perform mechanical work, if the chair at

this stage is allowed to translate, or if the backrest is allowed to rotate, in the presence of resistance. This mechanical work can be transferred and accumulated. For example, the mechanical work may be accumulated in a spiral spring, hydraulic cylinder, pneumatic cylinder, flywheel or in a solid or porous material. This type of construction element is what it is referred to herein as "energy absorbing elements."

If the backrest is allowed to rotate during mechanical resistance, the forces on the head and cervical spine will be reduced.

Examples of energy absorbing element 5 are a solid or porous material, which collects the strain energy; a spring element, a hydraulic damper, a gas spring; a flywheel. These examples will be described in more detail below. Combinations of the above are, of course, also possible. Which element that eventually is realized depends on several factors; biomechanical as well as technical, economical and purely practical.

The backrest 3 is pivotally connected with the seat 2 in point A about an axis parallel to the transverse direction (x direction) of the chair 1a (and thus also the car 24) as well as with the energy transferring device 4 around point B about an axis parallel to the transverse direction of the chair. The device 4 is in turn pivotally arranged to the seat about a point C about an axis parallel with the transverse direction of the chair.

The energy transferring device 4 further comprises a slidably mounted element 6 (shown schematically in Figure 1) arranged in the longitudinal direction of the device 4 as seen in said yz plane. During collision from the behind the torso of the chair occupant is initially pushed towards the backrest 3. The backrest 3 is allowed to rotate during mechanical resistance from the energy absorbing element at an angle $\Delta\theta$ by the impact of a resultant force F_1 , see Figure 1, which is time dependent. When the backrest 3 thus rotates as a result of the torso of a chair occupant is pressed against the backrest and gives rise to the force F_1 towards the same due to the collision, the rotational movement is transformed into a rectilinear movement in the

energy transferring device 4. If said slidable element 6 is connected to an energy absorbing element 5, the energy can be transferred, which reduces the forces and accelerations of the head and the cervical spine of the chair occupant.

- 5 As the backrest 3 is rotatably disposed in the seat 2 at point **A** as well as in the energy transmission device 4 at point **B** at the same time as the device is rotatably fixed at point **C** and comprises a slidable element 6, the rotational movement of the backrest 3 will be transformed into a rectilinear movement whose distance is dependent on the distance between the rotation
- 10 points **A** and **B** and the angle change $\Delta\theta$ of the backrest 3 from the starting position. The rotation $\Delta\theta$ depends on the mechanical resistance in the energy absorbing element 4 and the amount of energy transmitted.

- The energy transferring device is disposed and oriented to maximize the length of the lever arm formed between the points **A** and **B**. In Figure 1 this is
- 15 illustrated by an angle β between a straight line passing through points **B** and **C** and a straight line parallel with the **z** direction being greater than zero in the clockwise direction according to the figure, where the **z** direction is parallel to the longitudinal direction of the chair 1a.

- An angle α between a straight line through the points **A** and **B** and a straight
- 20 line between points **B** and **C** increases (i.e., $\alpha_2 > \alpha_1$) when the backrest 3 rotates an angle $\Delta\theta$ due to the torso of the chair occupant is pressed against the backrest 2 during collision whilst said element 6 is displaced.

- According to embodiments, said linear displacement is shifted up in order to provide constructive flexibility in terms of characteristics and dimensions of
- 25 the energy absorbing element. This means that the transfer of energy from the chair occupant to the energy transferring element occurs at a longer distance. Several alternatives to the energy absorbing element 5 above are thus made possible whilst it may be easier to incorporate a preferred characteristic in the energy transfer, which can reduce the risk of injury even
- 30 further.

Figure 2 shows a principled and stylized view of a chair 1b seen in a longitudinal view (the yz plane). Figure 2 also shows a coordinate system based on the assembly of the chair 1b in a car 24. The chair 1b is in many respects similar to the chair 1a in Figure 1. The chair 1b thus comprises an energy transferring device 4 arranged in the seat 2 of the chair 1b. The chair 1a thus comprises the following principle components, referring initially to Figure 1: a seat 2, i.e., the seat load bearing structure, a backrest 3, i.e., the back load bearing structure; as well as an energy transferring device 4, which is arranged in the seat 2 with the purpose of transferring kinetic energy from an imagined chair occupant (not illustrated), that in use is placed in the chair 1a, to an energy absorbing element 5 by a linear displacement during mechanical resistance. The energy transferring device 4 thus comprises an energy absorbing element 5 (only schematically shown in Figure 2), i.e., the elements of the energy transferring device 4 that, in use, primarily accumulates or converts the kinetic energy transmitted from the chair occupant. The energy absorbing element 5 is connected to a slidable element 6 which will be described below.

Figure 2 shows a principal embodiment where the energy absorbing element 5 absorbs energy during influence of a compressive force when the backrest rotates due to the chair occupant being pressed against the backrest. The slidable element 6 acts on the energy absorbing element 5, which in Figure 2 comprises a material 5b enclosed in a cylinder 5a. The energy absorbing element 5 could also for example be any of the above-mentioned elements: a hydraulic damper, a gas spring, a spring element or combinations of these. One or more energy transferring devices 4, each of which comprises an energy absorbing element 5, could then e.g. be placed in one or more tubes (or other hollow space) provided in the seat 2.

In Figure 2, the rotation points **B** and **C** are disposed such that the angle β between a straight line passing through points **B** and **C** and a straight line parallel to the z direction is zero (where the z direction is parallel to the longitudinal direction of the chair 1b), which may be an advantageous orientation for accommodation reasons (since the angle β is zero, it is not

depicted in Figure 2). It is advantageous to have the rotation point **B** positioned as low as possible so as to maximize the lever arm defined by the distance between **A** and **B**. Orientation of the device such that β is substantially zero thus defines a special case.

- 5 It is also advantageous if the angle α_1 between the lines **A** and **B** and between the lines **B** and **C** is substantially 90 degrees before the rotation of the backrest 3 because a rotation then yields maximum displacement in the element 6.

A number of embodiments will now be described.

- 10 Figure 3 is a perspective view of the chair 1a, 1b seen obliquely from above and from the front with the energy transferring device 4 indicated below the seat 2. Figure 4 shows the chair 1a, 1b and the device 4 in a view directly from behind (the **xy** plane). Figure 5 shows the chair and the energy transferring device 4 in a side view (the **yz** plane). It is indicated that the backrest 3 has
 15 rotated from an initial more upright position to a more inclined position. Figure 6 is a perspective view of the chair 1a, 1b seen obliquely from the front, essentially in the **xy** plane. The energy transferring device 4 is here seen rotatably provided in the front portion of the seat 2.

- The energy transferring device 4 preferably comprises a link arm 7 pivotally
 20 mounted in the backrest 3 at point **B**. The link arm can be bracket-shaped. The energy transferring device 4 preferably comprises a slidably mounted element 8 which is fixed in the link arm 7. The slidable element may be bifurcated. The slidable element is preferably slidably disposed in plane parallel tracks 9 in a plate 10. The plate 10 is pivotally mounted to the seat 2
 25 at point **C**. The backrest 3 can thereby be likened to a lever. A pressure force F_2 will act on the yoke 7 and the pressing fork 8, which is moved a distance **s** in the direction of the force.

- One can assume that the rotation $\Delta\theta$ which may be permitted is relatively limited with regards to any passengers in the back seat (i.e., when the chair
 30 1a, 1b is used as the front seat of the car 24) or with regards to any cargo

space behind (i.e., when the chair 1a, 1b is used as the back seat of the car 24). This has the consequence that the distance s will be relatively small. If the energy is transferred over a very short distance, it may be difficult to incorporate some form of characteristics of the energy transfer.

- 5 It may therefore be desirable to be able to shift up the distance s , as utilized in the transfer of energy to the energy absorbing element. It may further be desirable to transfer the kinetic energy to the energy absorbing element by a pulling force, which makes it possible to use simple and cost efficient construction elements, such as a strap, tape, rope, cord, wire or chain for the
10 energy transfer.

This may be achieved by providing rotatable elements 12, 13 as interface between the slidable fork 8 and the plate 10. The rotatable elements 12, 13 can thus be arranged in the slidable fork 8 as well as in the plate 10. A tensile load transmitting element 14 is disposed in the plate 10 at point D and runs
15 around the rotatable elements 12 and 13. By means of this constructive design the distance s the fork 8 travels due to the backrest 3 being rotated may be shifted up 4 times. According to basic mechanical principles, the tension in the tensile load transmitting element 14 will be shifted down proportionately to $F_2 / 4$.

- 20 Alternatively, the rotatable elements may be replaced with slidable bodies that are fixed to the plate 10 and the fork 8 or are provided as integral parts of the plate 10 and the fork 8. A tensile load transmitting element 14 may, analogously as described above, be fixed to the plate 10 and run along the fixed mounted or integrated elements' vertical sliding surfaces, which sliding
25 surfaces can be coated with a low friction material.

By means of being able to shift up the distance s and shift down the force F_1 favorable conditions for providing an energy transfer are created, which significantly reduces the forces and accelerations of the head and cervical spine of the chair occupant and thus reduce the risk of associated
30 injuries.

At the rods of the fork rod 11 may thus rotatable elements 12 be mounted with rotary axes that are orthogonal to the plan of the plate 10. These rotatable elements 12 are displaced when the fork 8 is displaced as a result of rotation of the backrest 3. The device 4 further comprises a number of elements 13
5 with axes of rotation orthogonal to the plane of plate 10 rotatably arranged in the plate 10. A tensile load transmitting element 14 is fixed to the plate in point D and runs in the rotatable elements 12 and 13. Examples of tensile load transmitting elements 4 are a strap, V-belt, belt, rope, wire, line, and ribbon. One can also imagine a chain. In that case the rotatable members
10 may be a sprocket wheel. If the tensile load transmitting elements 4 is a strap, the rotatable members are pulleys, which will be readily understood by the skilled person.

Since the transfer of energy to the energy absorbing element 5 occurs over a longer distance under the influence of a lower power, it means that the
15 dimensions of the energy absorbing element 5 can be reduced significantly, which also has practical importance because it thus becomes easier to integrate the energy transmitting device, including the energy absorbing element, in the chair.

Kinetic energy from the chair occupant may in fact be absorbed in many
20 different structural members simultaneously. A certain portion can be absorbed by the backrest 3 in the form of elastic strain energy, a certain portion as frictional energy (heat) in the joints and so on. Below a number of primary energy absorbers, i.e., examples of the primary absorbent which, in addition to other absorbents are supposed to absorb energy, will be
25 described.

Example 1 relates to a tensile load bearing element as energy absorbing element and is illustrated in Figure 8. Figure 8 shows an energy transferring device 4 which according to an embodiment disclosed below comprises a plate 10 adapted to be rotatably arranged in the seat 2. A fork shaped element
30 is slidably disposed in the plane of the plate. A shift comprises a number of rotatable elements and a traction force transmitting element, such as a belt,

running around the rotatable elements in order to shift up the displacement of the fork element. The energy absorbing element comprises the tensile load transmitting element itself, which is fixed to the plate at two points.

According to an embodiment, the symmetrically arranged rods 11 of the fork
5 are arranged to be displaced by a distance s as a result of the rotation $\Delta\theta$ of the backrest 3. The tensile load transmitting element 14 is here attached to the plate 10 at two points **D** and **E**. By means of this arrangement, the load F_2 will be distributed substantially symmetrically over both rods 11 of the fork such that that the power of each rod is essentially $F_2 / 2$. The force in
10 the tensile load transmitting element 14 is then essentially $F_2 / 4$. The tensile load transmitting element 14 will then stretch, whereby the strain energy, which can have both an elastic and a plastic component, is collected by the tensile load transmitting element 14. Strain energy will be collected by the tensile load transmitting element at a maximum distance of $4s$, depending
15 on the elasticity modulus, dimensions and yield stress limit, σ_s , of the element.

Example 2 relates to a tensile load transmitting element combined with a solid extensible material as the energy absorbing elements and is illustrated in Figure 9. Figure 9 shows an energy transferring device 4 according to an
20 embodiment described above in Example 1, but with the difference that the energy absorbing element comprises both the tensile load bearing element itself and a solid elastomeric material coupled to the tensile load transmitting element at one end and is fixed to the plate at the other end. The solid material may have variable cross sectional area along its longitudinal
25 direction in order to achieve a preferred mechanical resistance from a biomechanical point of view.

According to an embodiment the symmetrically arranged rods 11 or the fork are arranged to be displaced a distance s as a result of rotation by $\Delta\theta$ of the backrest rotation. The tensile load transmitting element 14 is fixed to the
30 plate in point **D** as well as to a solid elastomeric material 15 at point **E**. The solid elastomeric material 15 is, in turn, attached to the plate 4 at point **F**.

In analogy with the previous example, the load F_2 will be distributed symmetrically on the two rods of the fork such that the power of each rod is essentially $F_2 / 2$. The force acting on the tensile load transmitting element 14 and the solid elastomeric material 15 is then essentially $F_2 / 4$. Both the
5 tensile load transmitting element 14 and the solid elastomeric material 15 will then extend under the influence of the pulling force $F_2 / 4$. It follows that the strain energy is collected by the element 14 and the solid elastomeric material element 15 during a displacement which at its maximum is $4s$, depending on the elasticity modulus, dimensions and yield stress limit, σ_s , of the element
10 14 and the solid elastomeric material element 15, respectively.

Example 3 relates to a tensile load bearing element combined with a spring element as the energy absorbing element and is illustrated in Figure 10. Figure 10 shows an energy transmitting device according to an
15 embodiment similar to those described above in Examples 1 and 2 but with the difference that the energy absorbing element comprises the tensile load transmitting element itself and a spring, where the spring is coupled to the tensile load transmitting device at one end and to the plate at the other.

According to an embodiment, the symmetrically arranged rods 11 or the fork are arranged to be displaced a distance s as a result of rotation by $\Delta\theta$ of the
20 backrest rotation. The tensile load transmitting element 14 is fixed to the plate in point D as well as to a spring element 16 at point E. By means of this arrangement, the force F_2 will be distributed substantially symmetrically on the two rods 11 or the fork such that the power of each rod is essentially $F_2 / 2$. The force acting in the element 14 and the spring element 16 then becomes
25 essentially $F_2 / 4$. In analogy with the variable cross-sectional area of the solid material in the previous example the spring may have a progressive stiffness.

The tensile load transmitting element 14 and the spring 16 will then be extend whereby mechanical energy is absorbed in the tensile load transmitting
30 element 14 and the spring 16, respectively, at a maximum distance

of $4s$, depending on the elasticity modulus, dimensions and yield stress limit of the band as well as the stiffness of the spring.

It will be appreciated by the skilled person how the spring element 16 in the embodiment described above in Example 3 (i.e., Figure 10) can be replaced
 5 with a hydraulic damper (not shown), alternatively a gas spring (not shown), for energy absorption. It also follows that the above energy-absorbing elements can be combined in various ways to achieve advantageous characteristics for the absorption of energy in order to reduce accelerations and forces to the head and the cervical spine.

10 Example 6 relates to a tensile load transmitting element combined with a flywheel as an energy absorbing element. Figure 7 shows a energy transmitting device according to an embodiment comprising two joined plates where one plate is arranged to be rotatably fixed in the seat. A fork shaped element is slidably disposed in the plane of the plate. The energy
 15 transmitting device comprises a shift comprising a number of rotatable members and a tensile load transmitting element, such as a belt, running around the discs in order to shift up the displacement of the fork element. The energy absorbing element, in the form of a flywheel 23 (not visible in Figure 7 but indicated in Figure 6), is positioned in the gap between
 20 the plates. The tensile load transmitting element is in this case coupled to a disc whose axis of rotation is connected to a freewheel and a flywheel.

According to an embodiment, the symmetrically arranged rods 11 or the fork are arranged to be displaced a distance s as a result of rotation of the backrest rotation. The element 14 is fixed to the plate in point D as well as to a disc 19
 25 pivotably arranged in the plate at point E. By means of this arrangement, the force F_2 will be distributed substantially symmetrically on the two rods 11 or the fork such that the power of each rod is essentially $F_2 / 2$. The force acting in the element 14 then becomes essentially $F_2 / 4$.

According to this embodiment the energy transmission device 4 is
 30 complemented with a further plate, a bottom plate 21, which is secured to the

plate 10 by a number of spacers 22 such that a gap between the two plates is formed. A freewheel 20 coupled to a flywheel 23 is disposed in the gap between the two plates. The axis **G** is thus rotatably connected to the flywheel 23. The force of the element 14 will thus create a torque acting on the
5 flywheel 23 during the maximum distance **4s**. The flywheel will thus be accelerated and collect kinetic energy. The disc may have a rotational non-symmetric design to achieve a favorable energy transfer from the biomechanical point of view.

Some principal practical aspects of the invention, which is not illustrated in
10 further detail in this description, is that the energy transmitting device 4 may have to be disengaged from the backrest when the seat is adjusted for reasons of comfort. A locking mechanism can be arranged in the connection between the yoke 7 and the fork 8. This locking mechanism is thus arranged to release the backrest from the energy transferring device when the chair is adjusted
15 for reasons of comfort.

The permitted rotational movement $\Delta\theta$ may, as mentioned above, also need to be limited such that, for example, the rear passengers will not be injured. One way to achieve this is to adapt the length of the tracks 9 in the plate 10 and a shock absorbing function may be provided in the end position.

20 The allowable rotation could be allowed to be greater in the absence of passengers in the back seat, which could be determined by sensors. One would in this case for example be able to imagine that the tracks 9 are arranged with some type of mechanical barrier that stops the movement at different angular displacements depending on whether there are passengers
25 in the back seat or not.

The chair may comprise a latch mechanism releasing the backrest for rotation according to a given condition, e.g. that the power of any structural component exceeds a certain value. For that reason, the chair may comprise any type of actuator, which, at a given signal from a sensor, disengages the

backrest 3 for rotation, wherein the energy transmission function 4 is activated.

- The invention has as its starting point taking a car chair and has been focused primarily on collisions from behind. It will be appreciated by the skilled
5 person that the present invention also may be used for a collision from the front where e.g. an expanding airbag presses the driver against the backrest.

The present invention is also applicable to other types of chairs in order to transfer kinetic energy from the chair occupant. An obvious example is child seats intended to be installed in cars.

- 10 The invention has mainly been described above with reference to a few embodiments. However, as is readily appreciated by a person skilled in the art, other embodiments than the ones disclosed above are equally possible within the scope of the invention, as defined by the appended patent claims.

CLAIMS

1. Mechanically energy absorbing seat (1a, 1b) comprising a seat (2) and a backrest (3),
further comprising an energy transmitting device (4) disposed in the
5 mechanically energy absorbing chair (1a, 1b) and comprising an energy absorbing elements (5),
wherein the backrest is pivotally connected with the seat around a first axis (A) parallel to the transverse direction of the mechanically energy absorbing chair (1a, 1b) and as well with the energy transferring device
10 around a second axis (B) parallel to the transverse direction of the mechanically energy absorbing chair (1a, 1b), wherein the energy transferring device is rotatably fixable around a third axis (C) parallel to the transverse direction of the mechanically energy absorbing chair (1a, 1b), such that a rotational movement of the backrest thereby is to be
15 transformed to a rectilinear movement in said energy transmitting device, and
wherein the rotational movement and the force in the direction of the rotational movement defines the energy that in use during said rotational movement is transferred from a chair occupant placed in said chair to said
20 energy absorbing element 5, and
characterized in that the mechanically energy absorbing chair (1a, 1b) is arranged such that an angle (α) between a line between said first axis (A) and said second axis (B) and a line between said second axis (B) and said third axis (C), seen in a plane whose normal is parallel to the
25 transversal direction of the mechanically energy absorbing chair (1a, 1b) in use increases when the backrest (3) rotates due to the torso of the chair occupant being pressed towards the backrest (3) when the mechanically energy absorbing chair (1a, 1b) is subjected to a force from behind, such as during collision from behind, and in that an angle (β) between a straight
30 line between said second axis (B) and said third axis (C) and a straight line parallel to the longitudinal direction of the chair (1a, 1b) is non-negative.

2. Mechanically energy absorbing chair (1a, 1b) according to claim 1, wherein the angle (β) between a straight line between said second axis (B) and said third axis (C) and a straight line parallel to the longitudinal direction of the chair (1a, 1b) is larger than zero.
- 5 3. Mechanically energy absorbing chair (1a, 1b) according to claim 1, wherein the energy transferring device is fixed to the seat, pivotable around the third axis (C).
4. Mechanically energy absorbing chair (1a, 1b) according to claim 1, wherein the energy transferring device is fixable to a vehicle, pivotable around the
10 third axis (C).
5. Mechanically energy absorbing chair (1a, 1b) according to any one of claims 1 to 4, wherein the energy transferring device (4) comprises a shift up mechanism for shifting up the distance of said rectilinear movement.
6. Mechanically energy absorbing chair (1a, 1b) according to any one of the
15 preceding claims, wherein the mechanically energy absorbing chair (1a, 1b) is arranged such that in use kinetic energy from the chair occupant is transferred during said rectilinear movement to the energy absorbing element (5) by means of a tensile load transmitting element (14).
7. Mechanically energy absorbing chair (1a, 1b) according to claim 6,
20 wherein said tensile load transmitting element also is energy absorbing.
8. Mechanically energy absorbing chair (1a, 1b) according to claim 6, wherein said tensile load transmitting element is a band, strap, V-belt, belt, rope, wire, line, or chain.
9. Mechanically energy absorbing chair (1a, 1b) according to any one of the
25 preceding claims, wherein said energy transmitting device (4) comprises a plate (10).
10. Mechanically energy absorbing chair (1a, 1b) according to claim 9, wherein a plurality of rotatable elements (13) is provided on said plate (10) and arranged such that their axes of rotation are parallel to the
30 normal direction of the plate (10).
11. Mechanically energy absorbing chair (1a, 1b) according to any one of the preceding claims, wherein said energy transmitting device (4) comprises a

- slidably mounted element (6) arranged in the longitudinal direction of the mechanically energy absorbing chair (1a, 1b).
12. Mechanically energy absorbing chair (1a, 1b) according to claim 11, wherein said slidably mounted element (6) is fork shaped.
- 5 13. Mechanically energy absorbing chair (1a, 1b) according to claim 9 and 11, wherein at least one rotatable element (12) is arranged on the slidably mounted element and oriented such that its axis of rotation is orthogonal to the plane of the plate (10).
14. Mechanically energy absorbing chair (1a, 1b) according to claim 9 and 11, 10 wherein said plate (10) comprises tracks, and wherein said slidably mounted element (6) is disposed to run in said tracks.
15. Mechanically energy absorbing chair (1a, 1b) according to claim 6, 10 and 13, wherein a tensile load transmitting element (14) is fixed to the plate (10) and arranged to run around said rotatable element (12, 13).
- 15 16. Mechanically energy absorbing chair (1a, 1b) according to any one of the preceding claims, wherein said mechanically energy absorbing chair (1a, 1b) comprises a latch mechanism arranged to, at a given signal from a sensor, disengage the backrest (3) for rotation, whereby the energy transferring function is activated.
- 20 17. Mechanically energy absorbing chair (1a, 1b) according to any one of the preceding claims, wherein said mechanically energy absorbing chair (1a, 1b) comprises a latch mechanism arranged to disengage the backrest (3) from said energy transfer in order to facilitate adjustment of the mechanically energy absorbing chair (1a, 1b) for reasons of comfort.
- 25 18. Mechanically energy absorbing chair (1a, 1b) according to any one of the preceding claims, wherein said rotational movement has a limited stroke.
19. Mechanically energy absorbing chair (1a, 1b) according to claim 1, wherein said energy absorbing element (5) comprises at least one of a solid elastomeric material (15), a flywheel (23), a hydraulic damper, a spring 30 element (16), and a gas spring.
20. Mechanically energy absorbing chair (1a, 1b) according to claim 19, comprising a flywheel, wherein said energy transferring device (4) comprises two plates separated by a number of spacers (22) wherein one

of said plates comprises a rotatable disc (19) whose axis of rotation (G) is coupled to said flywheel (23).

21. Mechanically energy absorbing chair (1a, 1b) according to claim 20,
wherein said energy transferring device (4) comprises a slidably arranged
5 element (6) disposed in the longitudinal direction of the energy
transferring device as viewed along the mechanically energy absorbing
chair (1a, 1b), wherein the mechanically energy absorbing chair (1a, 1b)
further comprises a tensile load transmitting element (14) disposed in the
plate (10) and arranged to run around said rotatable elements (12, 13),
10 and wherein the length of the tensile load transmitting element (14) is
provided so as for the tensile load transmitting element (14) to disengage
from the rotatable disc (19) when the slidably arranged element (6) is
maximally displaced.
22. Mechanically energy absorbing chair (1a, 1b) according to claim 20 or 21,
15 wherein said axis (G) is coupled to a freewheel (20) which in turn is
coupled to the flywheel (23).
23. Mechanically energy absorbing chair (1a, 1b) according to claim 9,
wherein a plurality of slidable members oriented such that their slidable
surfaces are parallel to the normal direction of the plate (10).
- 20 24. Mechanically energy absorbing chair (1a, 1b) according to claim 1, wherein
said angle (α) between said line between said first axis (A) and said
second axis (B) and said line between said second axis (B) and said third
axis (C), seen in said plane whose normal is parallel to the transversal
direction of the mechanically energy absorbing chair (1a, 1b), is essentially
25 90 degrees before rotation of the backrest (3).

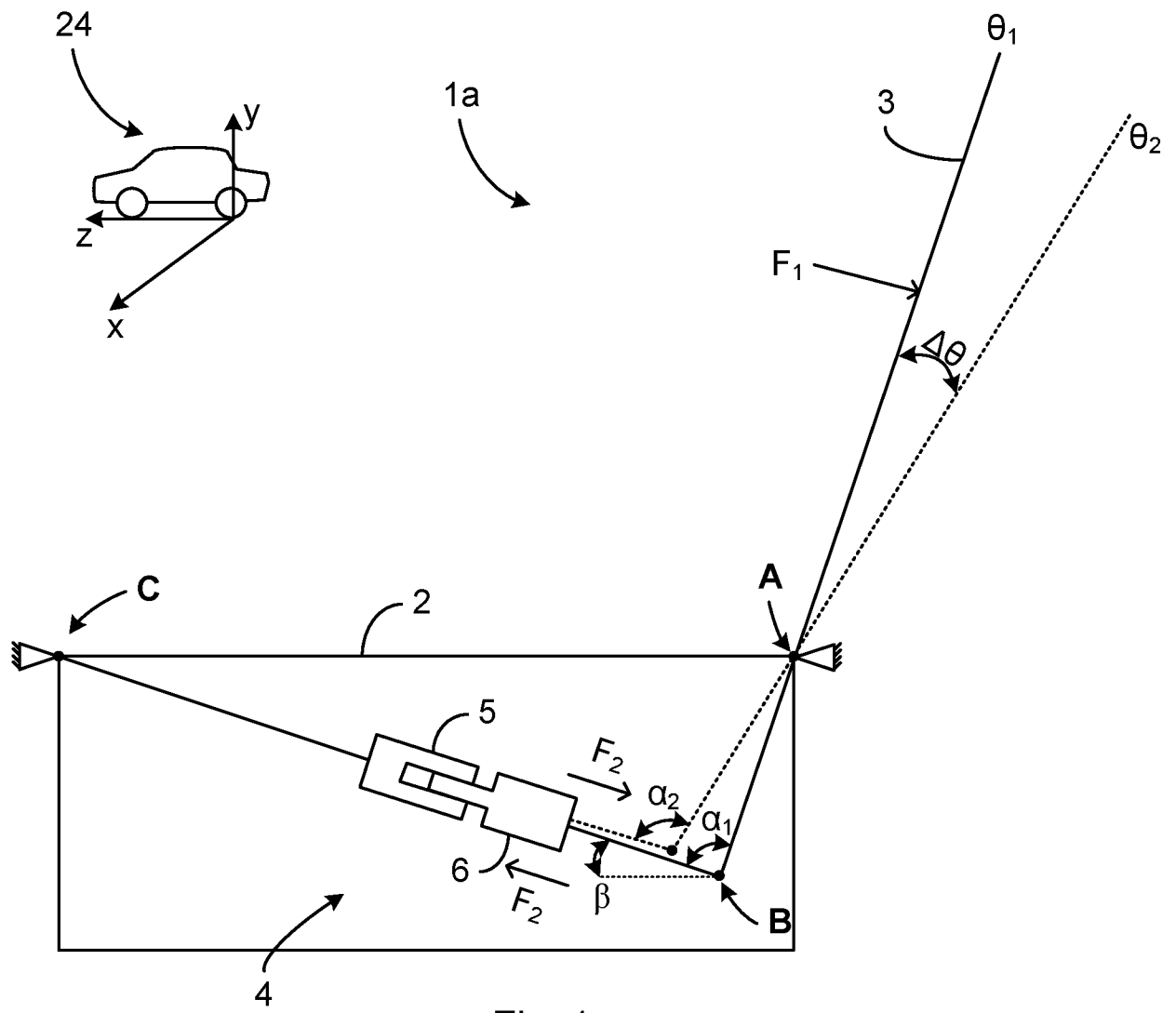


Fig. 1

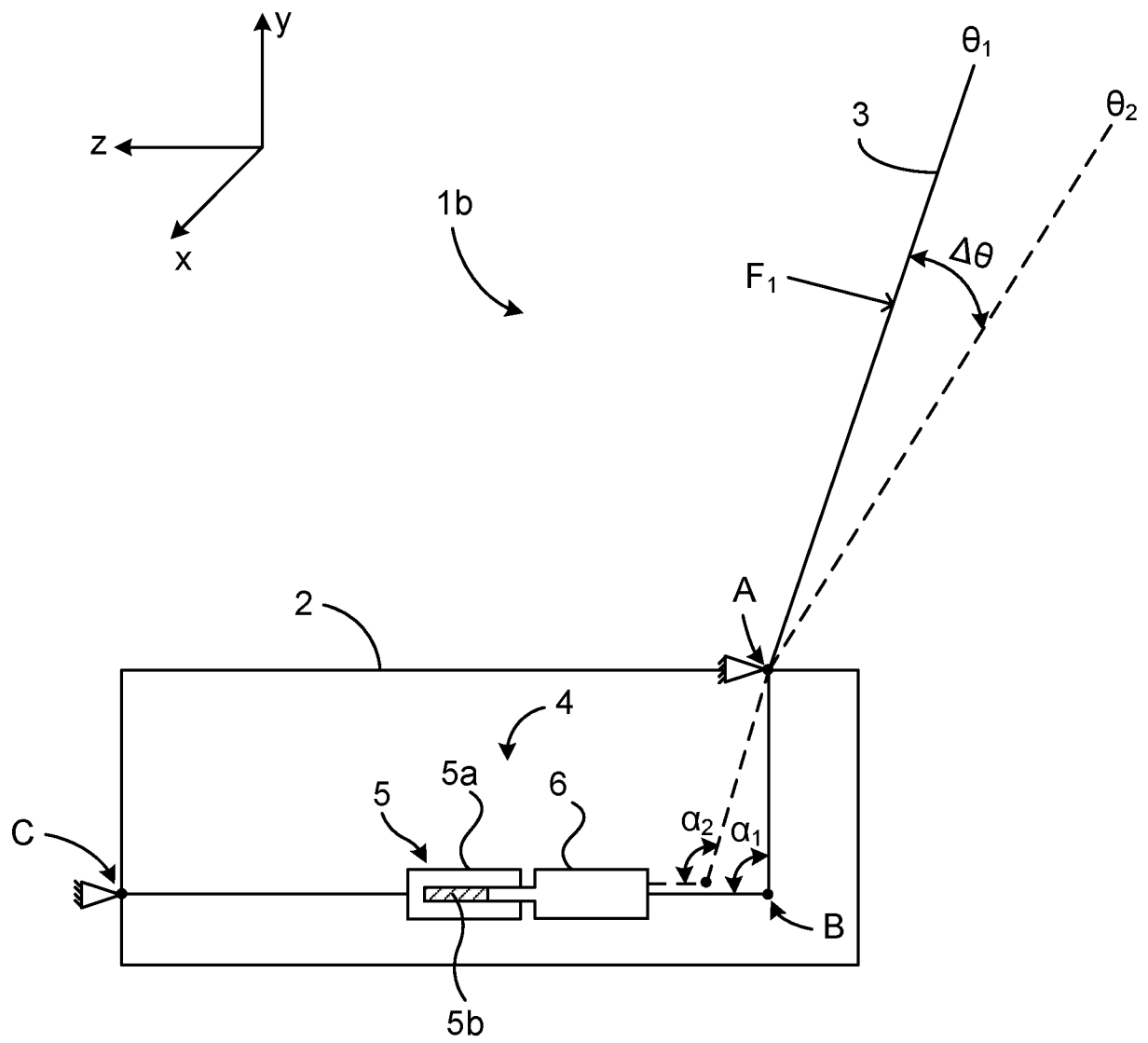


Fig. 2

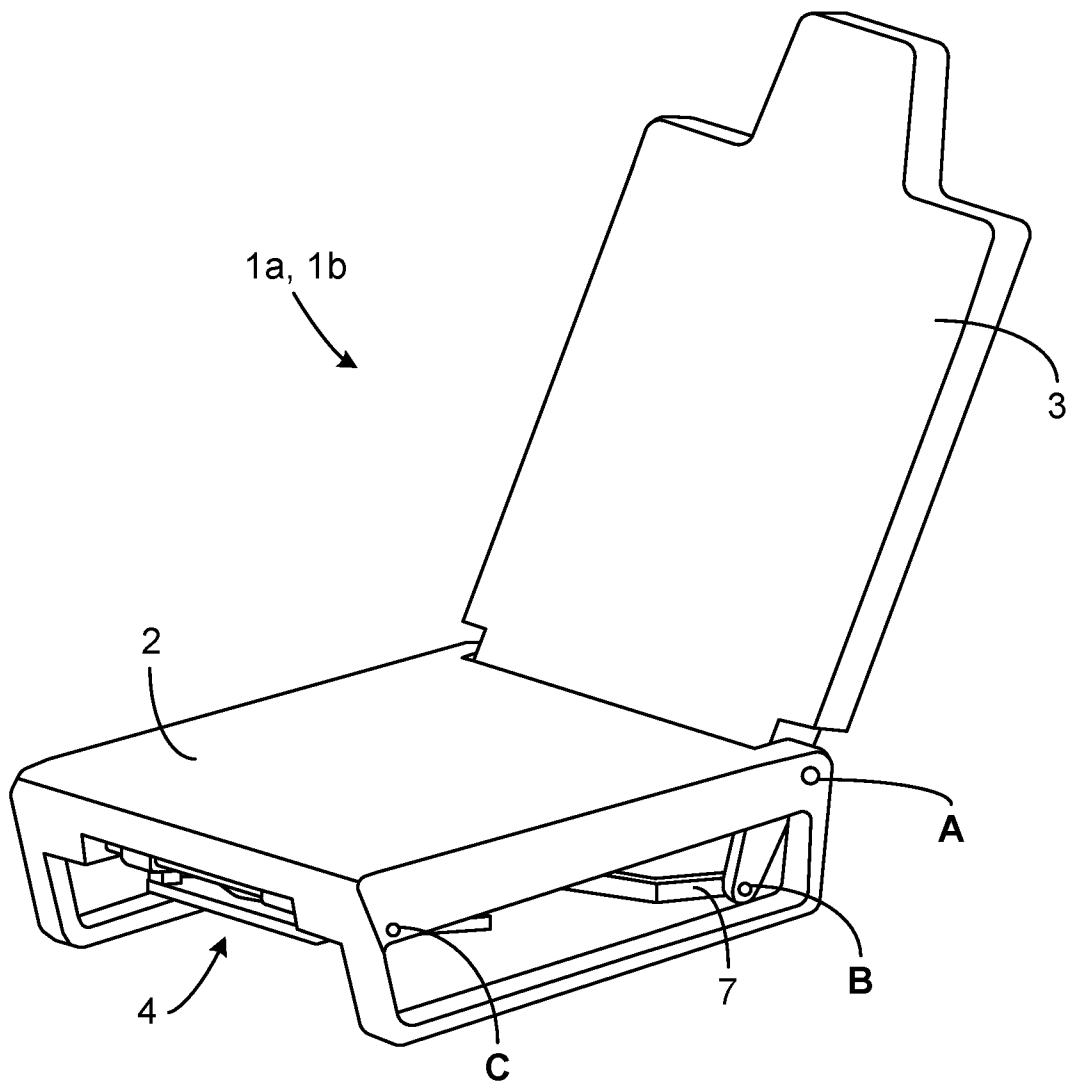
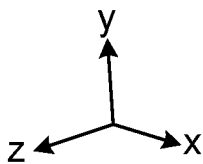
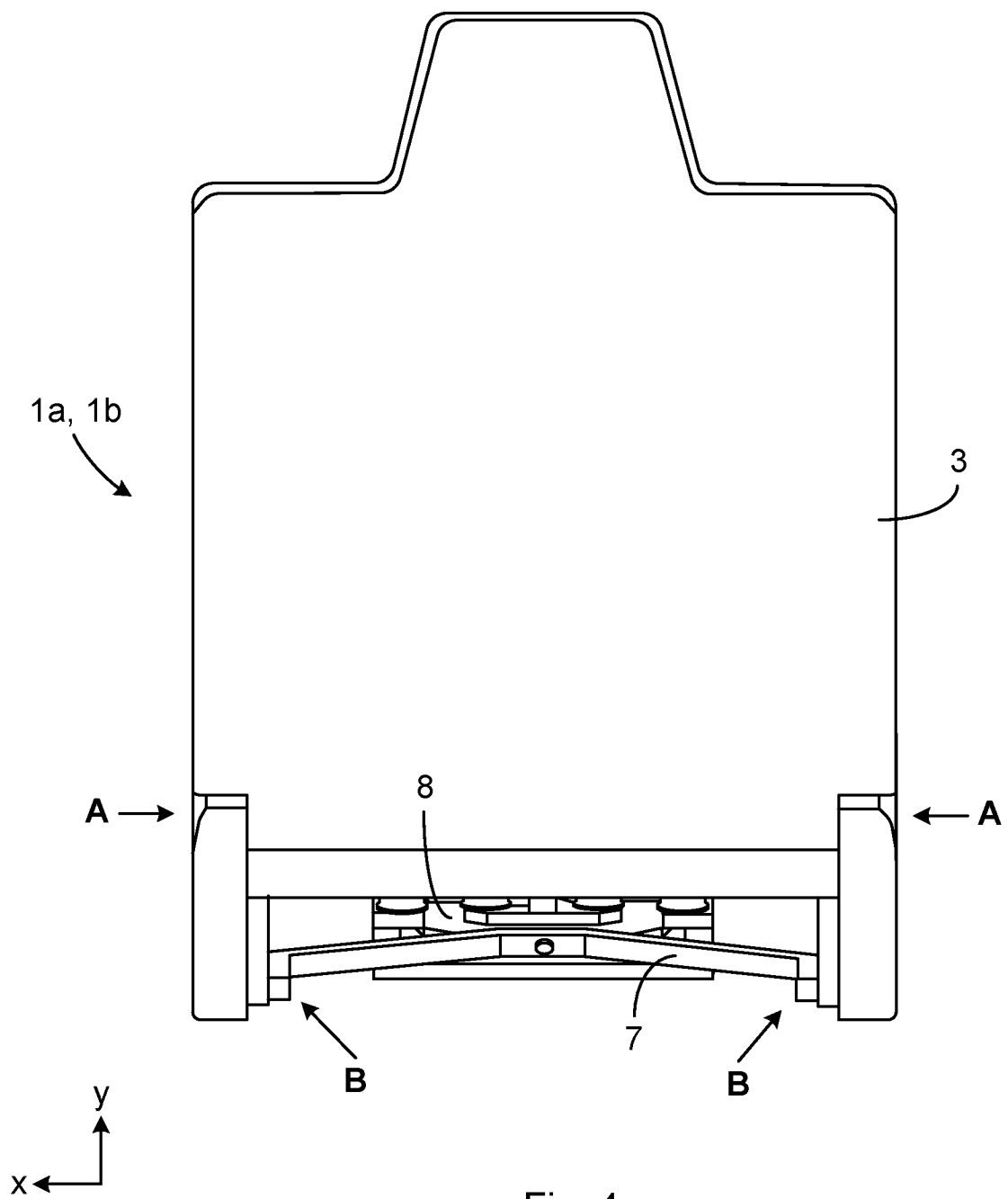
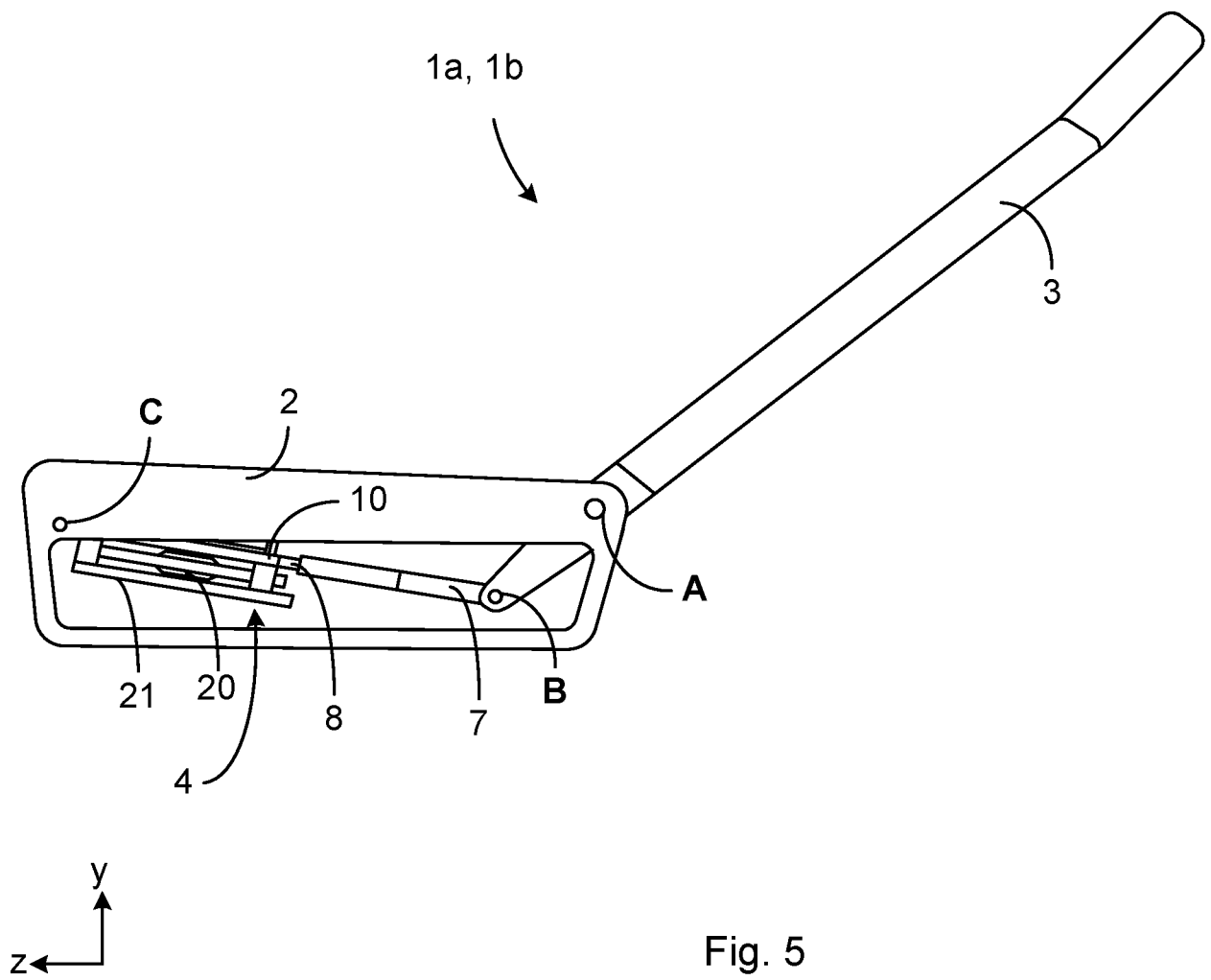


Fig. 3







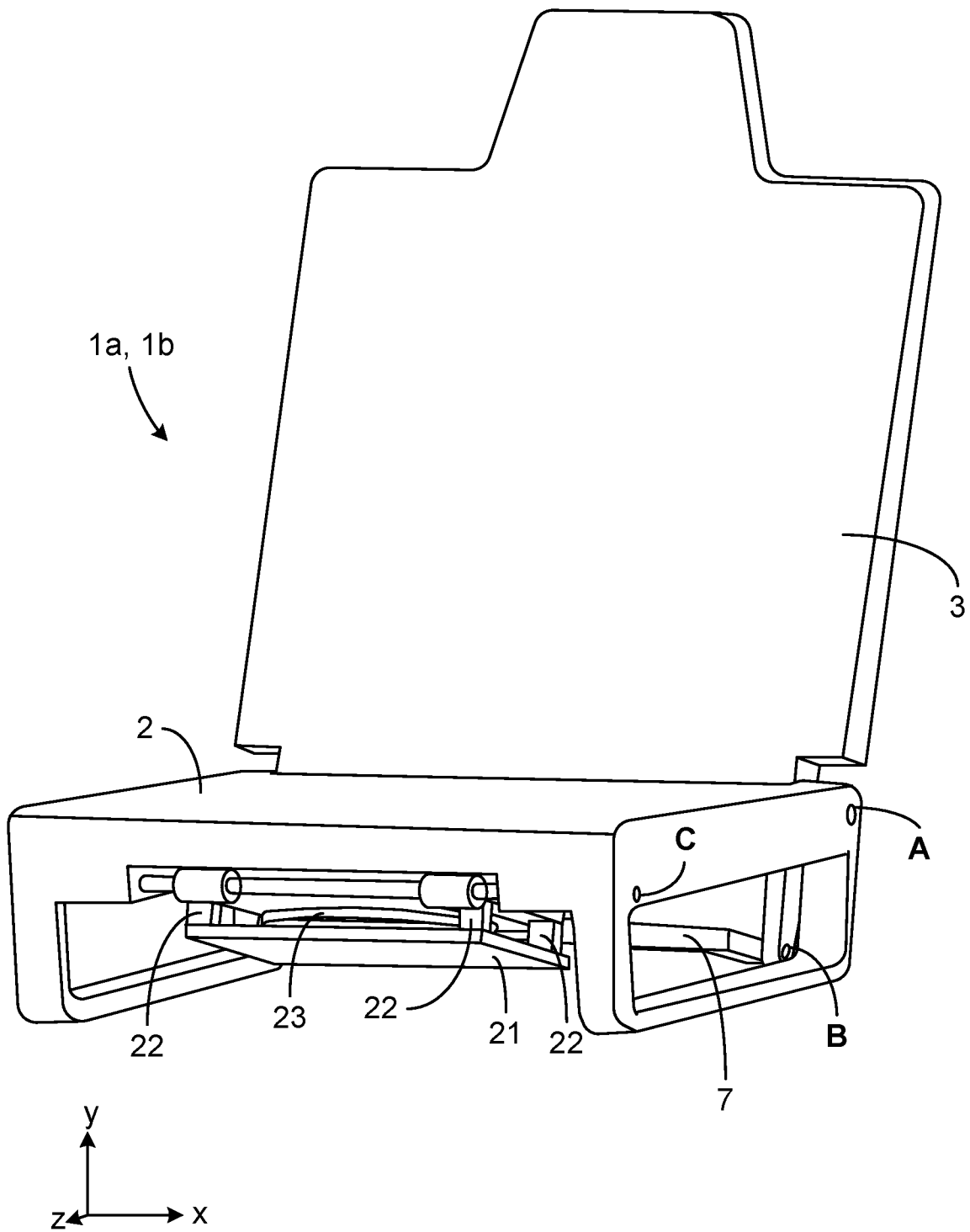


Fig. 6

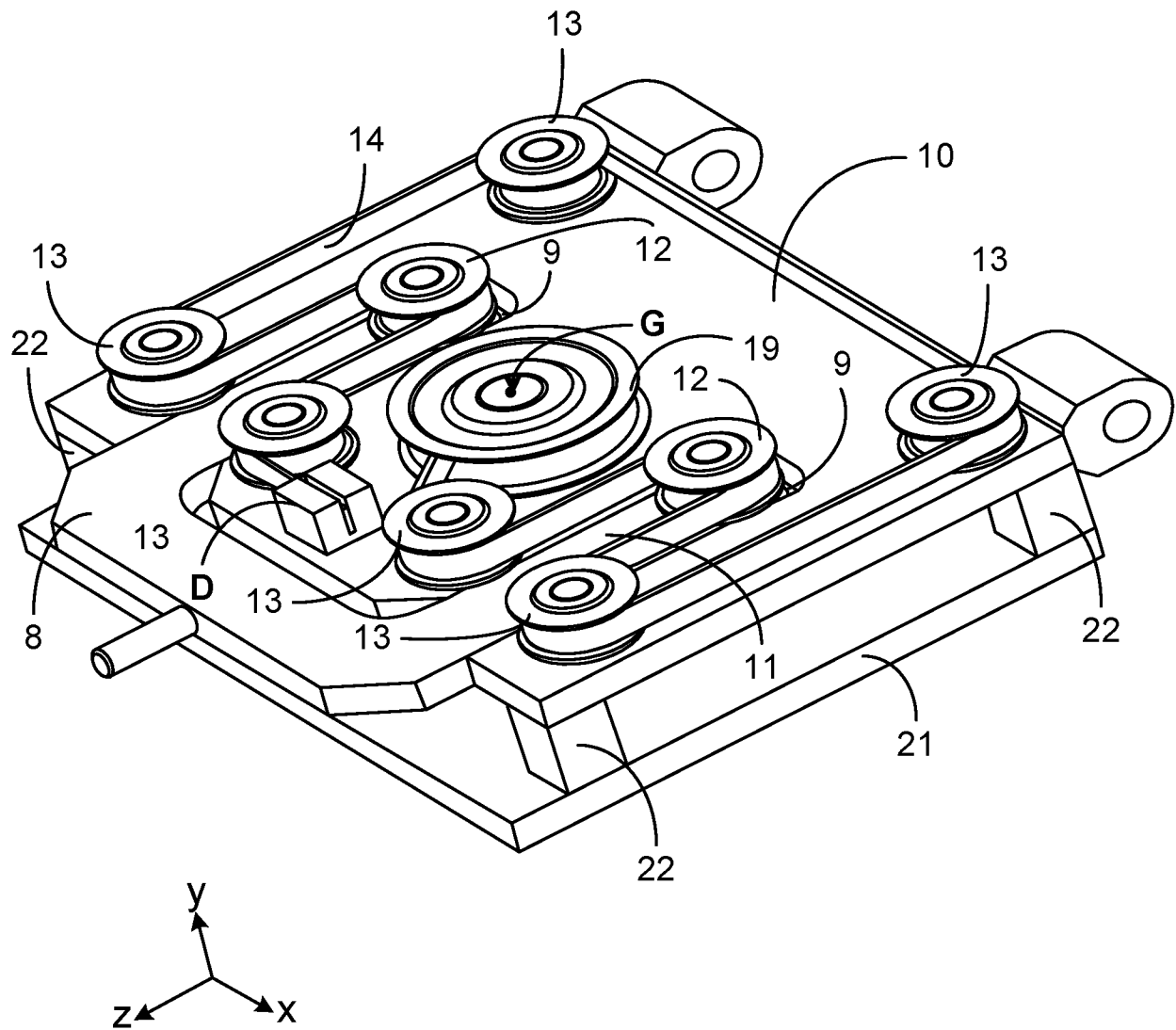


Fig. 7

8/9

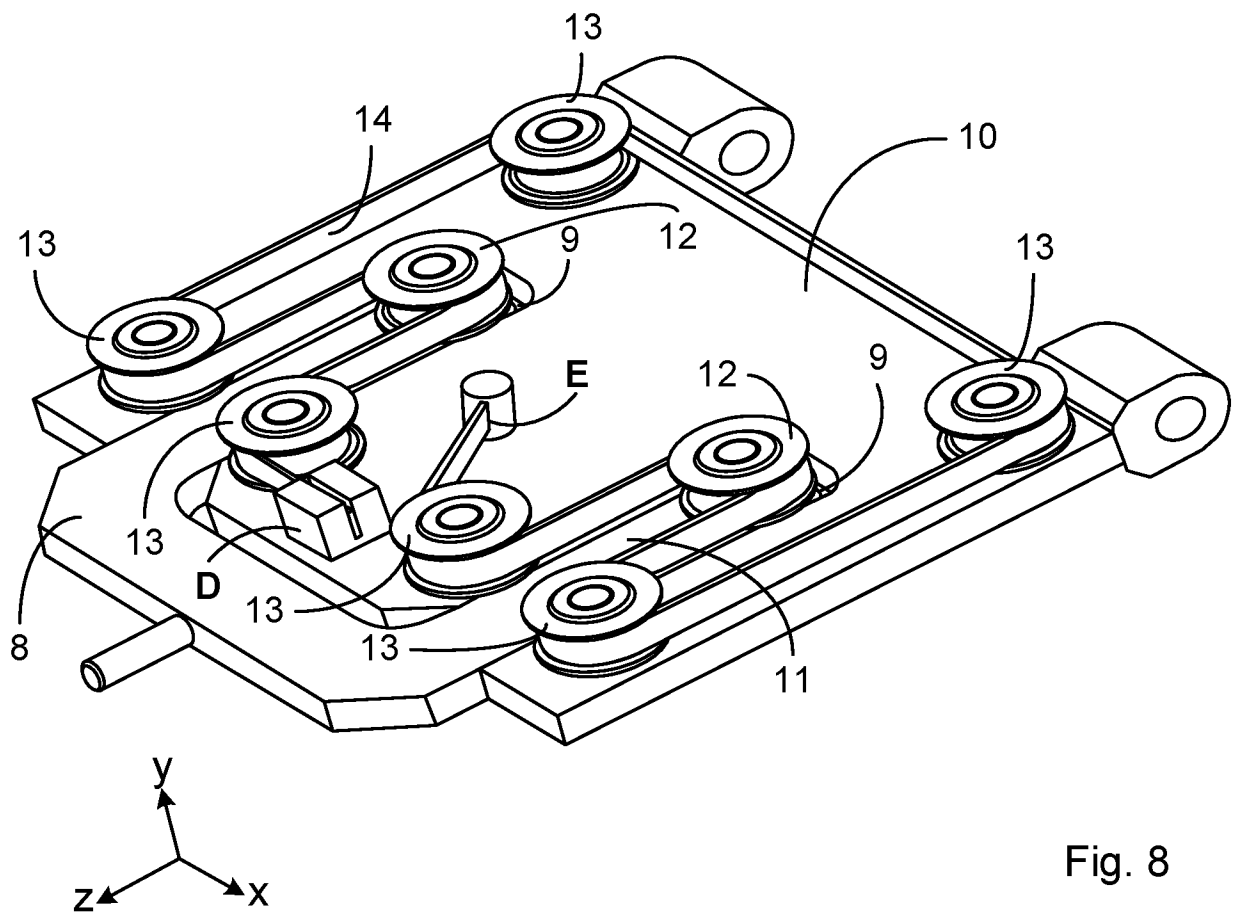


Fig. 8

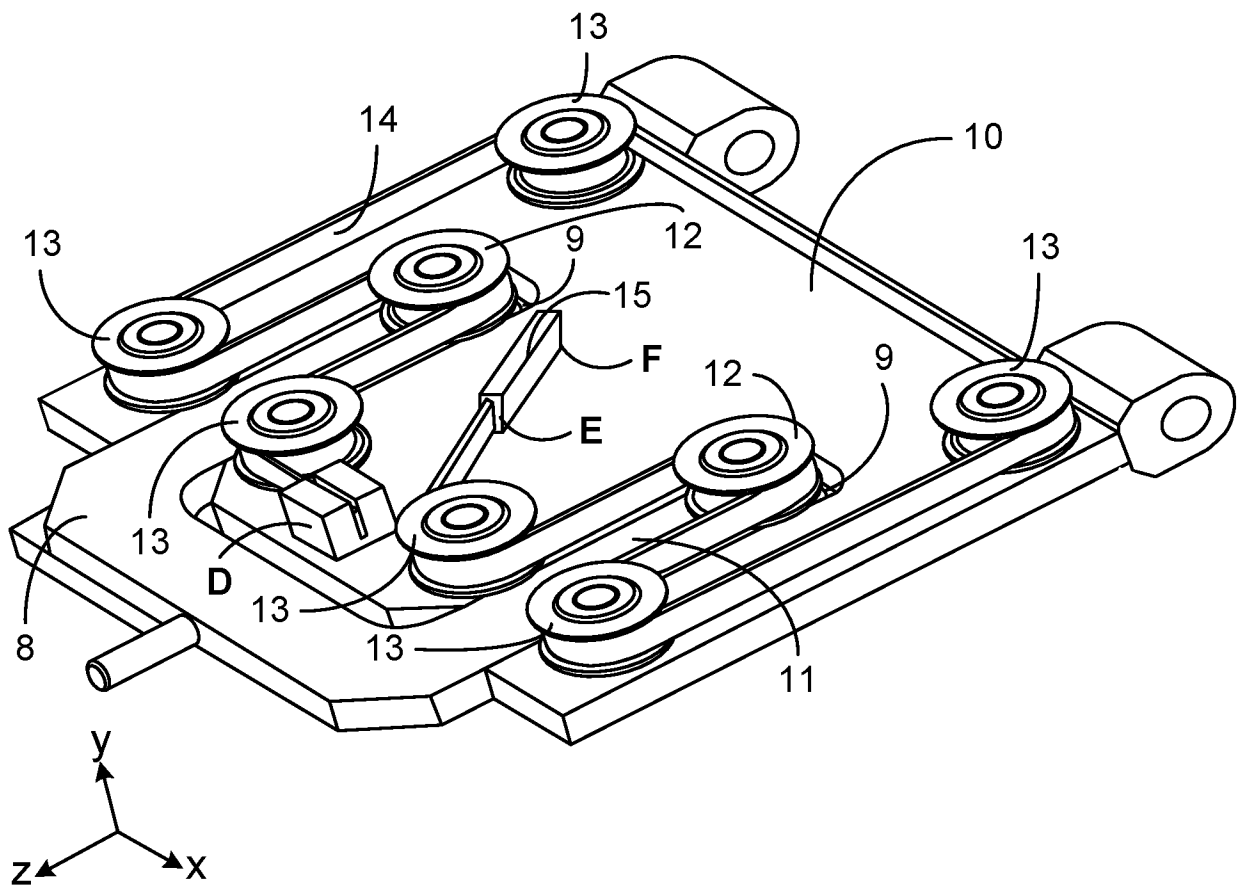


Fig. 9

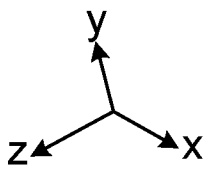
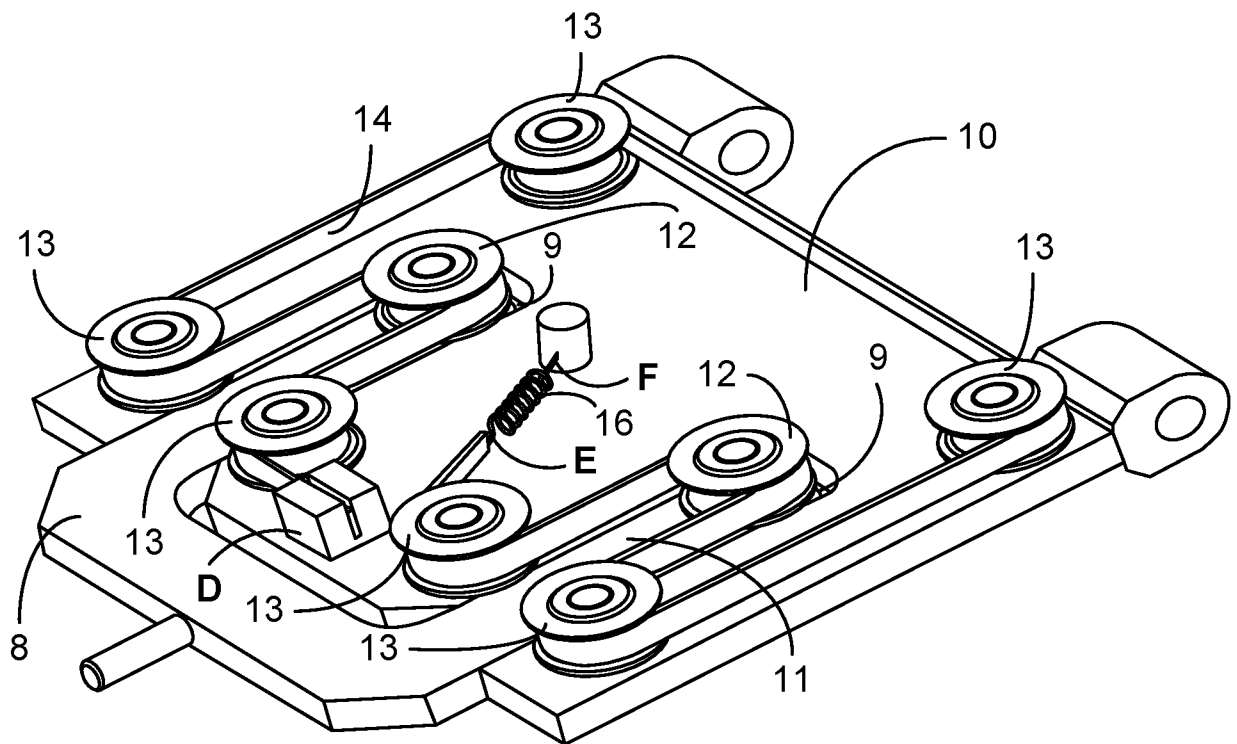


Fig. 10