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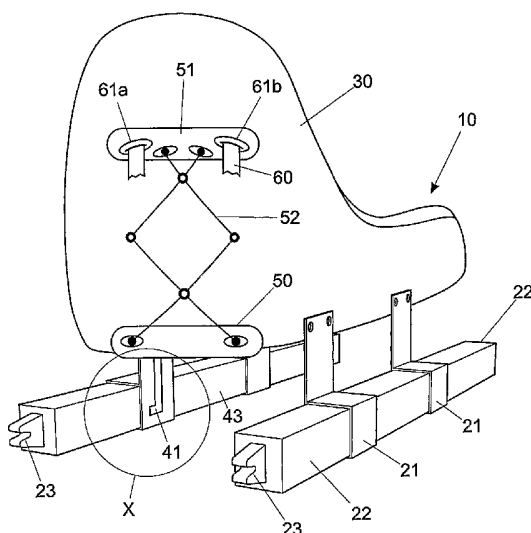
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(54) Title: ADAPTIVE VEHICLE CHILD RESTRAINT SYSTEM



(57) Abstract: A child restraint system (CRS) for a vehicle includes a body (10) having a base portion (20) and a seat portion (30), which comprises adjustable, restraining means (60) for securing a child passenger therein. The seat portion (30) is connected to the base portion (20) via seat mounting means (21) and is capable of movement relative to the base portion (20) in a direction that is consistent with the direction of vehicle travel. The base portion (20) includes anchor means (23) for fixing the body (10) to the interior of the vehicle, an energy absorbing apparatus (40) for absorbing some of the energy generated during a vehicle collision, and a regulator (50) coupled to the adjustable restraining means (60) such that adjustment of the adjustable restraining means (60) also results in adjustment of the amount of energy absorbed by the energy absorbing apparatus (40) during a vehicle collision.

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ADAPTIVE VEHICLE CHILD RESTRAINT SYSTEM

The invention relates to a child restraint system (CRS) that is suitable for restraining
5 infants and children in passenger vehicles. In particular, the invention concerns
CRSs that are capable of absorbing at least some of the forces of deceleration
experienced by a child passenger during a vehicle collision and thus reducing the
risk of injury to the child.

10 In recent years the safety of passengers during a collision has become an
increasingly important concern for the automotive industry and the national and
international authorities that regulate the industry. Much concern is focussed upon
the safety of child passengers, since the majority of passenger vehicles are designed
around the dimensions of the adult passenger. Hence, to ensure the safety and
15 comfort of an infant passenger child seats (or CRSs) are typically used until the child
is of an age that they can safely occupy the standard seating found in the vehicle.

In the year 2002, in the United Kingdom alone, almost 9000 child passengers were
injured in vehicle collisions. It is estimated that in a 30 mph (50 kph) crash, an
20 unrestrained child can be thrown forward with a force of over 30 times their body
weight. It is desirable, therefore, to provide improved CRSs that can manage the
forces experienced by the child passenger during a vehicle collision in such a way
that injury to the child is reduced.

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A number of current CRS designs allow for secure mounting to the vehicle either by
means of the vehicle's integral safety belts or by means of anchoring systems such as
ISOFIX or LATCH systems. A CRS is deemed correctly fitted when it is securely
coupled to the vehicle so that the CRS may not move independently of the vehicle,
30 especially in a crash. As modern vehicles are designed to meet increasingly tougher
safety standards, the vehicle body structures have tended to become stiffer, the

knock-on effect of this is to increase the mean acceleration levels of the passengers relative to the vehicle during a crash (i.e. the action of being thrown forward relative to the vehicle). This increase is managed for the adult passengers by use of safety belts and airbags to increase the time that the occupants are coupled to the vehicle and so decrease the peak acceleration experienced by the passengers. The same is true for children seated correctly in a CRS. However, a child's body is much more flexible than that of an adult, and this makes effective restraint more challenging. Ideally a child passenger seated in a CRS should start to accelerate as early as possible in the crash, and continue to do so until just after the vehicle has stopped moving. This preferred energy management profile provides the maximum possible time to decelerate from the original vehicle speed to rest, and so greatly reduces the potentially harmful peak acceleration levels. Increasing the duration of the acceleration/deceleration period sustained by a child in a crash will tend to decrease the peak acceleration level and so reduce the severity of the crash for the child.

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A child safety seat system is described in US-A-5664830. This system comprises a base having a pair of arcuate side rails and a seat having a pair of arcuate side rails that are engaged with the base arcuate side rails, and a collapsible energy absorber element positioned between the base and seat. During a collision, the seat rotates relative to the base and causes the energy absorber element to collapse, thereby absorbing some of the energy of the collision. A fundamental drawback of this system is that the centre of gravity of the child passenger and seat combination must be below the centre point of the arcuate rails. Hence, the seat is restricted to children of a certain age or size, since as the child grows the centre of gravity would tend to rise relative to the CRS. In addition, since the US-A-5664830 system relies on forward rotation of the seat in order to mitigate the collision forces, there must also be means provided for preventing the entire seat assembly from tipping forward.

US-A-5685603 describes a child seat located on slide rails. The slide rails are fixed at both ends to the body of the vehicle. The seat can slide along the rails during a collision and the force of the collision is separately absorbed by a variety of energy

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absorption means. However, the problem persists that the level of energy absorption cannot be adjusted in accordance with the growth of the child, or for children of different sizes.

- 5 Hence, there is a need for a CRS that provides a level of collision energy absorption (i.e. management of forces) that can be adjusted in accordance with the mass and size of the child passenger.

Thus, in a first aspect the invention provides a CRS suitable for use in a vehicle,
10 comprising:

a body that comprises a base portion and a seat portion;

15 the seat portion comprising adjustable restraining means for securing a child passenger in the seat portion, wherein the seat portion is connected to the base portion via seat mounting means, and is capable of movement relative to the base portion in a direction that is consistent with the direction of vehicle travel; and

20 the base portion comprising anchor means for fixing the CRS to the interior of a vehicle, EA means for absorbing at least a part of the energy during a vehicle collision, and EA regulator means for controlling the amount of energy absorbed by the EA means during a vehicle collision;

25 wherein the adjustable restraining means is coupled to the EA regulator means, such that adjustment of the adjustable restraining means also results in adjustment of the amount of energy absorbed by the EA means during a vehicle collision.

The invention provides the significant advantage of enabling the amount of energy absorbed to be adjusted. In this way, the kinetics of the CRS during a collision are
30 adjusted to the needs of the child passenger. It will be appreciated that incorrect levels of energy absorption can be as dangerous or even more dangerous than a

complete absence of such means. For example, if a child of age 5 years is placed in CRS comprising EA means calibrated for use with a young toddler, the amount of energy absorbed by the CRS during a collision will likely be inadequate for the increased mass possibly leading to whiplash or other recoil injuries. Likewise, placing a baby in a CRS with EA means calibrated for use with an older child, could result in situation where the EA means are not deployed due to insufficient passenger mass, resulting in a complete absence of energy absorption.

Further, it will also be appreciated that the mass and size of children of the same age varies considerably not only within a population, but also between children of different countries. Hence, a significant advantage of the invention is that it does not rely on the 'one-size-fits-all' approach which best serves only those children meeting a notional average standard.

The CRS of the invention is suitably fitted in passenger-carrying automobiles and motor vehicles. Typically, in use, the CRS of the invention is detachably installed in cars, multi-passenger vehicles (MPVs), sports utility vehicles (SUVs), mini-vans, and any other passenger vehicle suitable for transporting a small child.

In one embodiment of the invention the energy absorbing (EA) means can be a friction device; a hydraulic piston; a pneumatic piston; a shock absorber; a non-elastic compressible material; a deformable material; or a spring. It is preferable that the EA means is capable of a controlled non-elastic deformation, although this does not preclude the use of elastic materials as a component within the EA means as a whole. As mentioned previously, the intention of the EA means is to allow a more controlled deceleration of the child passenger by absorbing some of the energy of a sudden vehicle collision. Hence, any material and mechanism that meets the objective of facilitating greater energy absorption than that experienced by a passenger in conventional static mounted CRS, is suitable for use in the invention.

In a specific embodiment, the seat portion of the present CRS is connected to the base portion via a seat mounting means. The base portion can comprise at least one mounting rail onto which the seat mounting means is slidably located. Typically, the base portion will comprise at least two mounting rails arranged in parallel and aligned in the direction of vehicle travel – i.e. pointing towards the front of the vehicle. Optionally, the mounting rail can further comprise the EA means. Alternatively, the seat mounting means can further comprise the EA means.

The EA means can suitably comprise a material that is used to generate frictional resistance to a body (or contact member) passing through it, or across its surface. Alternatively, the EA means can comprise a material that can be bent, cut, abraded, drawn or formed in such a way as to absorb at least a part of the energy of a vehicle collision. In the present invention such a material is referred to as a sacrificial material. In an embodiment of the invention where the sacrificial material interacts with the contact member to generate frictional resistance, the sacrificial material is typically made from a material that is softer than the contact member but hard enough not to allow a cut to be initiated during normal use of the CRS. Hence, during normal day-to-day use the seat portion remains securely fixed relative to the base portion of the CRS, and the sliding movement only occurs during the conditions of a vehicle collision, typically a frontal collision. Suitable materials that can be used as a substrate in manufacture of the sacrificial material include, but are not limited to, aluminium; a suitable metal alloy; a polymer material (e.g. resin, rubber); a plastics material (e.g. polystyrene, polyethylene, kevlarTM, nylon); or a wood based material (e.g. plywood, hardwood or fibreboard such as MDF).

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In a specific embodiment of the invention the EA means comprises a sacrificial material that is located on a mounting rail. The slidably mounted seat mounting means also comprises at least one contact member that contacts the surface of the sacrificial material when the seat mounting means slides along the mounting rail. The contact member can comprise one or more cutting edges that cut into the surface of the sacrificial material as the seat mounting means slides along the mounting rail.

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In this way the sacrificial material serves to absorb at least some of the energy of a vehicle collision.

In an alternative embodiment of the invention the EA means comprises a sacrificial material and is located on the seat mounting means. In this arrangement the contact member(s) is located on the mounting rail, such that the surface of the sacrificial material is abraded by the contact member(s) when the seat mounting means slides along the at least one mounting rail.

The contact member may suitably comprise one or more of a cutting tool; an armature; a pin; a rasp; a mandrel; a bending roller; a forming tool; a rotating cutter and a blade. Indeed, the contact member serves to interact with the sacrificial material in such a way as to cut, deform, bend or abrade it, thereby absorbing at least some of the energy of a vehicle collision. The position of the contact member relative to the surface level of the sacrificial material can be adjustable, thereby, enabling the depth of a cut or the level of contact to be regulated. Additionally, where the contact member comprises a plurality of cutting edges, the number of those cutting edges or the area of the cutting edges that are placed in contact with the surface of the sacrificial material can also be adjusted.

In a specific embodiment of the invention, the position of the contact member relative to the surface level of the sacrificial material is varied according to the mass of the child passenger. This adjustment may be achieved via use of regulator means that governs the position of the contact member relative to the surface of the sacrificial material. Likewise the regulator means can be used to govern the number of cutting edges that engage the surface of the sacrificial material.

In accordance with the invention, the adjustable restraining means can comprise one or more of a safety belt; a harness; a bar; a strap; a shield and a fastener. In fact, any suitable form of adjustable restraint used in the art can be employed in the CRS of the present invention. As will be apparent to the skilled person, a certain number of restraint systems are approved for use as child safety restraints by the relevant

regulatory authorities. Hence, it is envisaged that those approved restraint systems could be suitably used in the presently described CRS. In one embodiment of the invention, the adjustable restraining means comprises at least one safety belt connected to a safety belt adjuster means, further characterised in that the safety belt
5 adjuster means is coupled to the regulator means. In this way adjustment of the adjustable restraining means results in adjustment of the regulator means, thereby governing the position of the contact member relative to the surface of the sacrificial material.

10 The CRS of the invention should be securely anchored to the body of the vehicle. Optionally, the CRS can be anchored via anchor means located on the mounting rail. Suitable anchor means may include, without being limited to, a latch; a hook; a carabiner; a screw fixing; an ISOFIX mounting; a bayonet fixing; a hasp; and a pin fixing. In Europe the vehicle manufacturing industry recognises the ISOFIX
15 mounting as an industry standard. In the US the equivalent LATCH mounting system is used.

In a particular embodiment of the invention, the seat mounting means comprises an adjustable pivot means for enabling the pitch of the seat portion of the CRS to be
20 displaced from an upright position to a reclined position and vice versa. This is of particular advantage because the reclined state can provide a more comfortable sleeping position for the child.

The CRS of the present invention includes configurations wherein the seat portion
25 faces in the direction of vehicle travel as well as in the opposite direction to that of vehicle travel (i.e. where the back of the CRS faces in the direction of vehicle travel). Where the CRS is in the latter configuration – i.e. where the CRS faces in the opposite direction to vehicle travel – a problem can arise during a collision when the seat portion is in the reclined state. Sudden uncontrolled deceleration of the vehicle
30 can result in high vertical loading to child passenger's neck, particularly in the region of the cervical vertebrae. Hence, to minimise such an effect the present invention

further provides a correction means for correcting the pitch of the seat portion from a reclined position to a substantially upright position during a vehicle collision. Optionally, the correction means can be comprised within the EA means. In one embodiment, the correction means comprises a substantially non-elastic flexible
5 member that extends from the base of the seat portion to the region of the base portion proximate to the anchor means. Typically the anchor means will be located towards the rear of the base portion.

In a second aspect the invention provides a CRS suitable for use in a vehicle,
10 comprising:

a body that comprises a base portion and a seat portion;

the seat portion comprising adjustable restraining means for securing a child
15 passenger in the seat portion, wherein the seat portion is connected to the base portion and is capable of movement relative to the base portion in a direction that is consistent with the direction of vehicle travel; and

the base portion comprising anchor means for fixing the CRS to the interior of a
20 vehicle, and energy absorbing (EA) means for absorbing at least a part of the energy during a vehicle collision;

characterised in that the amount of energy absorbed by the energy absorbing means
25 can be adjusted according to the mass of the child passenger.

A third aspect of the invention provides for an energy absorption device for use with
a CRS, comprising

a seat mounting means for the seat portion of a CRS;
30

at least one mounting rail onto which the seat mounting means is slidably located;

EA means for absorbing at least a part of the energy during a vehicle collision; and

an EA regulator means for controlling the amount of energy absorbed by the EA
5 means during a vehicle collision.

In a specific embodiment, the invention provides for EA device wherein the seat
mounting means further comprises a pin that is capable of engagement with pin
guiding means located on the at least one mounting rail. Typically the pin guiding
10 means is located towards the end of the guiding rail furthest from the resting or
normal position occupied by the seat mounting means. Optionally, the pin guiding
means may comprise a slot that is marginally narrower in width than the diameter of
the pin. In this way a steady and more controlled deceleration is effected when the
seat mounting means approaches the end of the mounting rail. Alternatively, the pin
15 guiding means can comprise a slot that tapers from a first region that is marginally
greater in width than the diameter of the pin, to a second region that is marginally
narrower in width than the diameter of the pin. Thus, in this latter arrangement an
even more steady deceleration of the seat portion relative to the base can be effected.

20 The invention is now described in detail with reference to the accompanying
drawings in which:

Fig. 1 shows a child seat portion of the prior art with integral safety belts;

25 Fig. 2 shows a CRS in forward facing mode with integral ISOFIX mounts which
protrude out of the back of the child seat mount, and which can secure the CRS into
the vehicle by latching around metal bars fitted within, behind or below the vehicle
seats (not shown);

Fig. 3 shows the same CRS as shown in Figure 2, but set up in a rearward facing configuration, with the ISOFIX mounts exiting from the rear of the base portion, and connected to the vehicle's integral ISOFIX mounts;

- 5 Fig. 4 shows the movement of the seat portion of the CRS of the invention relative to the base portion during a frontal collision of the vehicle, (a) where the seat is facing rearwards, T_0 shows the seat at a point in time before the collision, T_{end} shows the position of the seat portion after the collision, (b) where the seat is in the forward facing configuration T_0 and T_{end} have the same meaning as in part (a).

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Fig. 5 shows the mechanism of action of one of the energy absorption systems of the invention;

- 15 Fig. 6 shows the CRS of the present invention mounted in the rear passenger seat of a vehicle, the top left figure shows the CRS in normal use, the top right figure shows one embodiment of the invention where the CRS, (seat portion and base portion), slides on mounting rails fitted to the vehicle's ISOFIX mounts, the bottom left figure shows another embodiment where the seat portion slides on mounting rails fitted to base portion, and the bottom right hand figure shows another embodiment of the invention with the additional feature of pitch attitude correction;
- 20

Fig. 7 shows one embodiment of the adjustable EA mechanism of the invention;

- 25 Fig. 8 shows the configuration of the pin guiding means in one embodiment of the invention;

Fig. 9 shows a rear view of a CRS according to one embodiment of the present invention;

- 30 Fig. 10 shows a magnified view of the region encircled and labelled X in Fig. 9;

Fig. 11 shows a close up view of the seat belt adjuster gate mechanism of one embodiment of the invention;

Fig. 12 shows a more detailed view of the interaction of the contact member with the
5 sacrificial material; and

Fig. 13 shows a seat mounting means of one embodiment of the invention.

A child seat of the type known in the art is shown in Fig. 1. In a CRS (10) of the
10 present invention the child is seated in a CRS (10) that can be mounted within the
vehicle via an energy absorbing base portion (20). Figures 2 and 3 show CRS's that
may be used in a forward facing or rearward facing configuration. The energy
absorbing child seat mount (or base portion (20)) provides the CRS (10) with an
energy absorbing (EA) means (40) and is suitable for use in either configuration. By
15 incorporating the EA means (40) into the base portion (20), the invention allows for
production of both a complete CRS (10) as well as a separate EA device base portion
(20) as an additional "upgrade" part.

Under normal operation, the CRS (10) of the invention is located as close as possible
20 to the seat back on which the CRS (10) is mounted. In a vehicle collision there is a
sudden deceleration of the vehicle relative to the passenger. The forward momentum
of the passenger is such that there is a perceived acceleration of the passenger's body
relative to the vehicle. In the case of the present invention in use, when this
'acceleration' force rises beyond a pre-determined threshold the initiation load
25 required to start the EA system is overcome. Hence, at the end of the collision, when
the vehicle is stationary, the seat portion (30) will have slid forward at a controlled
rate (see Figs. 4(a) and (b)), thereby enabling deceleration of the child passenger in a
more controlled manner and lessening the risk of injury.

30 Figs. 5 and 12 show one embodiment of a suitable EA means (40). In this
embodiment of the invention a contact member (cutting tool) (41), in normal use,

rests against a 'step' (42) located in an energy absorbing component located on a mounting rail (22). The mounting rail comprises a sacrificial material (43) as the energy absorbing component. Depending on the shape of the contact member (41), the height of the step (42) and the hardness of the sacrificial material (43), the initiation force may be readily selected by a person of skill in the art. The initiation force should be set at a level that is sufficient to ensure that a cut cannot be initiated during normal use of the CRS (10). Once the forces transmitted from the CRS (10) (as a result of rapid deceleration of the vehicle) are sufficient to overcome the initiation force, then the contact member (41) will be forced across the surface of the sacrificial material (43) until either the force drops below a cutting threshold or the pre-determined end-stop (44) is reached.

The CRS (10) of the present invention is not limited to rear seat use as long as the frontal passenger airbag has been de-activated when a CRS (10) is occupying the frontal passenger seat.

In Fig. 6 the additional feature of pitch attitude correction is shown. This feature allows the CRS (10) to move a reclined seat portion (30) into a more upright position during a collision so as to reduce the vertical loading on an infant passenger's neck. In this case the seat portion (30) is typically attached to the base portion (20) via a gimbal or pivot joint (not shown), which allows the parent to recline the seat (30) from an upright position to reclined position in order to allow a child to sleep more comfortably. During a crash, a mechanism can - as a result of the crash forces exceeding a predetermined threshold - rotate the child seat (30) to a more upright position. The pitch attitude correction mechanism can be a part of the EA means system (40) or can be fitted as a completely independent component of the CRS (10) of the invention.

Figs. 7 and 9 set out one embodiment of the adjustable EA means (40) of the invention. In this embodiment an EA regulator (50) (see Fig. 11 also) adjusts the level of available energy absorption depending on the child's size. This is achieved

by coupling the adjustment of the CRS's integral safety belt shoulder harness (60) with the adjustment of the EA means (40). An adjustable EA means (40) is suitably arranged as follows:

- 5 The EA regulator (50) is connected to a sliding seat belt adjuster gate (51). As the child grows, the parent adjusts the height of the shoulder belts (60) on the seat portion (30), the larger the child the higher the positioning of the shoulder belts (60). As the shoulder belts (60) are adjusted to a higher position the EA regulator (50) adjusts the contact member (41) to engage more of the sacrificial material (43) either
10 by means of increased cutting depth or by engaging additional cutting edges (41a, 41b, 41c) for each shoulder belt height increment.

An EA regulator-adjustment yolk (52) moves in response to the seat belt height adjuster gate (51) movement, moving parallel with the shoulder belt apertures (61a,
15 61b). This component ensures that in embodiments of the invention comprising two mounting rails (22), the left hand and right hand contact members (41) are equally positioned.

A contact member armature (411) connects to the adjuster yolk (52) at one end and
20 has cutting edges (41a, 41b, 41c) at the opposite end.

A seat mounting means (21) (cutter guide) serves three main functions, to guide the contact member (41) vertically along its adjustment, to guide the seat (30) on the mounting rails (22), preventing pitching or yawing of the child seat section (30)
25 relative to the vehicle, and to connect the seat portion (30) to the mounting rail (22), and thus the base portion (20), via the contact member (41). In use, during a collision the seat portion (30) "pulls" the mounting means (21), and thereby the contact member (41) across the sacrificial material (43), and as material is cut the forward motion of the seat portion (30) is impeded and in the process energy is absorbed
30 from the crash allowing a more controlled deceleration.

Mounting rails (22) – comprising the sacrificial material (43) - are connected to the ISOFIX mounts (23) at one end. They may be additionally supported at the other end where desired.

5 Tension means (25), such as springs, elastomers or other suitable biasing means, serve three functions, they keep a constant force on the seat belt adjuster gate (51) to improve set up feel and lightly tension the belts (60), they keep a permanent load on the mechanism to reduce the possibility of vibration. The tension means (25) can also act as a fail-safe, in the event that the device is not correctly installed and the
10 belt adjustment gate (51) has been bypassed by incorrect belt routing, the system will revert to engaging the maximum number of cutting edges (41a, 41b, 41c) or greatest cutting depth so tending in performance to a standard, non-energy absorbing CRS.

15 When the CRS (10) is correctly installed for, the integral seat portion restraining means (e.g. shoulder belts) (60) are adjusted to their lowest to best fit. In the adjustable system shown in Fig 7., for a small baby this means that the EA regulator (50) sets the contact member (41) to engage the sacrificial material (43) with a minimum depth of cut and/or a minimum number of cutting edges (41a, 41b, 41c).
20 This is typically sufficient for managing the energy from the mass of a small infant. In the event of a frontal impact only one small section of sacrificial material (43) would be cut away.

As the infant grows (both in size and mass), a correctly installed CRS (10) requires
25 that the integral restraining means (60) are adjusted for shoulder height. It is apparent that as the child grows the seated height of the shoulders increases, and as the mass increases the energy absorption required from the system also increases. The CRS (10) of the present invention thus allows for coupling between the shoulder belt height increases and the number of cutting edges (41a, 41b, 41c) or the depth or area
30 of said cutting edges in contact with the sacrificial material (43).

The dimensions of the cutting edges (41a, 41b, 41c) may be designed such that they are all alike or varied. In either case, the person of skill in the art will appreciate that care must be taken to account for the mass of the seat portion (30) which is likely to be greater than that of a baby infant but less than that of a toddler.

5

If required, an additional "static" cutter (not shown) may also be employed, which is calibrated for the energy management requirements of the moving mass of the child seat section alone (30). This static cutter would not be re-positioned during the re-adjustment of the child seat belts (60) like the other cutters. This approach offers the
10 designer the flexibility to fine-tune the adjustable cutter force to optimise child restraint performance. In addition, a static cutter arrangement allows for a combinatorial approach to energy management, in which more than one type of EA mechanism is used. For example, the static cutter could be combined with a shock absorber mechanism.

15

When the restraining means is adjusted to accommodate the largest size of child that the CRS (10) is designed to accommodate, the cutting edges (41a, 41b, 41c) are set for maximum cut to offer the maximum level of energy absorption. Typically, the connection point between the seat mounting means (21) and the contact member is
20 mounted in the same plain as the mounting rails (22) in order to minimise any twisting or displacement of the contact member (41) relative to the mounting rails (22).

Figure 8 shows one embodiment of the end-stop (44) design for an EA device of the
25 invention. This figure shows one embodiment, in which at the end of the permitted travel of the seat mounting means (21) along the mounting rail (22) the child seat (30) is not brought to an abrupt halt. Instead, the seat connection pin (24) on the seat mounting means (21) acts as an additional energy absorber, as it is guided to pass through a pin guiding means (45) that comprises a slot (46) which is too narrow for
30 the pin (24). Typically the slot (46) will be only slightly narrower in width than the pin (24) diameter, for example between 5% and 35% smaller than the pin (24)

diameter, more preferably between 10% and 20% smaller than the pin (24) diameter. This arrangement greatly increases the resistance to the movement of the seat portion (30), slowing it down more quickly before it reaches the end of the rail (22), rather than simply hitting a stop (44).

5

Typically, the pin guiding means (45) is only engaged by the seat mounting means (21) in the most severe of frontal vehicle impacts. By tuning the dimensions of the connection pin (24) and the slot (46) the kinetic profile of the stop (44) can be optimised to reduce trauma to the child passenger. The pin guiding means (45) is typically combined with other EA means to provide maximum control of deceleration of the CRS (10) during a collision. However, the pin guiding means (45) could also be used in isolation.

In all cases mentioned above, there are many other possible means of energy absorption that could suitably be employed in the CRS and EA devices of the invention. By means of controlling the movement of the seat portion (30) relative to the vehicle, contact members (41) may be replaced by other friction devices, hydraulics, pneumatics, bending material, drawing material, deformable material or other methods of absorbing energy. The cutting edges (41a, 41b, 41c) need not be linear, they may work by means of a rotating cutter or energy absorbing medium or both. A key advantage of the present invention is the ability to mitigate the forces of deceleration on a child passenger by allowing some controlled relative movement of the seat portion of the CRS relative to the vehicle.

Although particular embodiments of the invention have been disclosed herein in detail, this has been done by way of example and for the purposes of illustration only. The aforementioned embodiments are not intended to be limiting with respect to the scope of the appended claims, which follow. It is contemplated by the inventors that various substitutions, alterations, and modifications may be made to the invention without departing from the spirit and scope of the invention as defined by the claims.

CLAIMS:

1. A child restraint system (CRS) suitable for use in a vehicle, comprising

5

a body (10) that comprises a base portion (20) and a seat portion (30);

the seat portion (30) comprising adjustable restraining means (60) for securing a child passenger in the seat portion (30), wherein the seat portion (30) is connected to the base portion (20) via seat mounting means (21), and is capable of movement relative to the base portion (20) in a direction that is consistent with the direction of vehicle travel; and

10

the base portion (20) comprising anchor means (23) for fixing the body (10) to the interior of a vehicle, energy absorbing (EA) means (40) for absorbing at least a part of the energy during a vehicle collision, and EA regulator means (50) for controlling the amount of energy absorbed by the EA means (40) during a vehicle collision;

15

wherein the adjustable restraining means (60) is coupled to the EA regulator means (50), such that adjustment of the adjustable restraining means (60) also results in adjustment of the amount of energy absorbed by the EA means (40) during a vehicle collision.

20

2. A CRS according to claim 1, wherein the EA means (40) is selected from a friction device; a hydraulic piston; a pneumatic piston; a shock absorber; a non-elastic compressible material; a deformable material; and a spring.

25

3. A CRS according to claims 1 and 2, wherein the base portion (20) comprises at least one mounting rail (22) onto which the seat mounting means (21) is slidably located.

30

4. A CRS according to claim 3, wherein the at least one mounting rail (22) further comprises the EA means (40).

5. A CRS according to claims 1 to 3, wherein the seat mounting means (21) further
5 comprises the EA means (40).

6. A CRS according to claims 1 to 4, wherein the EA means (40) comprises a
sacrificial material (43) and the seat mounting means (21) comprises at least one
contact member (41) that contacts the surface of the sacrificial material (43) when
10 the seat mounting means (21) slides along the at least one mounting rail (22).

7. A CRS according to claim 5, wherein the EA means (40) comprises a sacrificial
material (43) and the at least one mounting rail (22) comprises at least one contact
member (41) that contacts the surface of the sacrificial material (43) when the seat
15 mounting means (21) slides along the at least one mounting rail (22).

8. A CRS according to claims 6 and 7, wherein the contact member (41) comprises
one or more cutting edges (41a, 41b, 41c) that cut into the surface of the sacrificial
material (43) as the seat mounting means (21) slides along the at least one mounting
20 rail (22).

9. A CRS according to claim 8, wherein the EA regulator means (50) governs
adjustably the number of cutting edges (41a, 41b, 41c) that are able to contact the
surface of the sacrificial material (43).

25

10. A CRS according to claims 8 and 9, wherein the EA regulator means (50)
governs adjustably the depth of cut of the cutting edges (41a, 41b, 41c) and/or the
area of the cut of the cutting edges (41a, 41b, 41c) relative to the surface of the
sacrificial material (43).

30

11. A CRS suitable for use in a vehicle, comprising

a body (10) that comprises a base portion (20) and a seat portion (30);

5 the seat portion (30) comprising adjustable restraining means (60) for securing a child passenger in the seat portion (30), wherein the seat portion (30) is connected to the base portion (20) and is capable of movement relative to the base portion (20) in a direction that is consistent with the direction of vehicle travel; and

10 the base portion (20) comprising anchor means (23) for fixing the CRS (10) to the interior of a vehicle, and EA means (40) for absorbing at least a part of the energy during a vehicle collision;

characterised in that the amount of energy absorbed by the EA means (40) can be adjusted according to the mass of the child passenger.

15

12. A CRS according to claim 11, wherein the EA means (40) is selected from a friction device; a hydraulic piston; a pneumatic piston; a shock absorber; a non-elastic compressible material; a deformable material; and a spring.

20 13. A CRS according to claims 11 and 12, wherein the seat portion (30) is connected to the base portion (20) via a seat mounting means (21).

14. A CRS according to claim 13, wherein the base portion (20) comprises at least one mounting rail (22) onto which the seat mounting means (21) is slidably located.

25

15. A CRS according to claim 14, wherein the at least one mounting rail (22) further comprises the EA means (40).

16. A CRS according to claim 13, wherein the seat mounting means (21) further
30 comprises the EA means (40).

17. A CRS according to claim 15, wherein the EA means (40) comprises a sacrificial material (43) and the seat mounting means (21) comprises at least one contact member (41) that contacts the surface of the sacrificial material (43) when the seat mounting means (21) slides along the at least one mounting rail (22).

5

18. A CRS according to claim 16, wherein the EA means (40) comprises a sacrificial material (43) and the at least one mounting rail (22) comprises at least one contact member (41) that contacts the surface of the sacrificial material (43) when the seat mounting means (21) slides along the at least one mounting rail (22).

10

19. A CRS according to claims 17 and 18, wherein the contact member (41) comprises one or more cutting edges (41a, 41b, 41c) that cut into the surface of the sacrificial material (43) as the seat mounting means (21) slides along the at least one mounting rail (22).

15

20. A CRS according to claims 17 to 19, wherein the contact member (41) is selected from one or more of a cutting tool; an armature; a pin; a rasp; a rotating cutter; a forming tool; a mandrel; a bending roller; and a blade.

21. A CRS according to claims 17 to 20, wherein the sacrificial material (43) is made from a material that is softer than the contact member (41) but hard enough not to allow a cut to be initiated during normal use of the CRS (10).

22. A CRS according to claims 17 to 20, wherein the sacrificial material (43) is made from a material that is deformable when contacted by the contact member (41).

25

23. A CRS according to claims 21 or 22, wherein the sacrificial material (43) is selected from aluminium; a polymer material; a plastics material; a wood based material; and any other suitable metal alloy.

30

24. A CRS according to claims 17 to 23, wherein the position of the contact member (41) relative to the surface level of the sacrificial material (43) is adjustable.

25. A CRS according to claim 24, wherein the position of the contact member (41)
5 relative to the surface level of the sacrificial material (43) is varied according to the mass of the child passenger.

26. A CRS according to claims 17 to 25, wherein the CRS (10) further comprises a
10 regulator means (50) that governs the position of the contact member (41) relative to the surface of the sacrificial material (43).

27. A CRS according to claims 17 to 26, wherein the CRS further comprises a
15 regulator means (50) that governs the number of cutting edges (41a, 41b, 41c) of the contact member (41) that are placed in contact with the surface of the sacrificial material (43) and/or the area of the contact member (41) that is placed in contact with the sacrificial material (43).

28. A CRS according to any of claims 1 to 27, wherein the adjustable restraining
20 means (60) comprises one or more of the group selected from a safety belt; a harness; a bar; a strap; a shield; and a fastener.

29. A CRS according to claim 28, wherein the adjustable restraining means (60)
25 comprises at least one safety belt connected to a safety belt adjuster means (51), further characterised in that the safety belt adjuster means (51) is coupled to the EA regulator means (50), such that adjustment of the adjustable restraining means (60) results in adjustment of the EA regulator means (50) thereby governing the position of the contact member (41) relative to the surface of the sacrificial material (43).

30. A CRS according to claims 14 to 29, wherein the at least one mounting rail (22)
30 further comprises the anchor means (23).

31. A CRS according to any of claims 1 to 30, wherein the anchor means (23) is selected from a latch; a hook; a carabiner; a screw fixing; an ISOFIX mounting; a bayonet fixing; a hasp; and a pin fixing.

5 32. A CRS according to any of claims 1 to 31, wherein the seat mounting means (21) comprises an adjustable pivot means for enabling the pitch of the seat portion (30) to be displaced from an upright position to a reclined position and vice versa.

10 33. A CRS according to claim 32, further comprising correction means for correcting the pitch of a rearward facing seat portion (30) from a reclined position to a substantially upright position during a vehicle collision.

34. A CRS according to claim 33, wherein the correction means is comprised within the EA means.

15

35. A CRS according to claim 34, wherein the correction means comprises a non-elastic flexible member that extends from the base of the seat portion (30) to the region of the base portion (20) proximate to the anchor means (23).

20 36. An energy absorption (EA) device for use with a CRS, comprising

a seat mounting means (21) for engaging the seat portion (30) of a CRS (10);

25 at least one mounting rail (22) onto which the seat mounting means (21) is slidably located;

EA means (40) for absorbing at least a part of the energy during a vehicle collision; and

30 an EA regulator means (50) for controlling the amount of energy absorbed by the EA means (40) during a vehicle collision

37. An energy absorption device according to claim 36, wherein the at least one mounting rail (22) comprises the EA means (40).

5 38. An energy absorption device according to claim 36, wherein the seat mounting means (21) comprises the EA means (40).

39. An energy absorption device according to claim 36, wherein the EA means (40) comprises a sacrificial material (43) and the seat mounting means (21) comprises at
10 least one contact member (41) that contacts the surface of the sacrificial material (43) when the seat mounting means (21) slides along the at least one mounting rail (22).

40. An energy absorption device according to claim 38, wherein the EA means (40)
15 comprises a sacrificial material (43) and the at least one mounting rail (22) comprises at least one contact member (41) that contacts the surface of the sacrificial material (43) when the seat mounting means (21) slides along the at least one mounting rail (22).

20 41. An energy absorption device according to claims 39 to 40, wherein the contact member (41) comprises one or more cutting edges (41a, 41b, 41c) that cut into the surface of the sacrificial material (43) as the seat mounting means (21) slides along the at least one mounting rail (22).

25 42. An energy absorption device according to claims 39 to 41, wherein the contact member (41) is selected from one or more of a cutting tool; an armature; a pin; a rasp; a rotating cutter; a forming tool; a mandrel; a bending roller; and a blade.

43. An energy absorption device according to claims 39 to 42, wherein the sacrificial
30 material (43) is made from a material that is softer than the contact member (41) but

hard enough not to allow a cut to be initiated at a time other than during a vehicle collision.

44. A CRS according to claims 39 to 42, wherein the sacrificial material (43) is made
5 from a material that is deformable when contacted by the contact member (41).

45. An energy absorption device according to claims 43 or 44, wherein the sacrificial material (43) is selected from aluminium; a polymer material; a plastics material; a suitable metal alloy; and a wood based material.

10 46. An energy absorption device according to claims 39 to 45, wherein the EA regulator means (50) governs the position of the contact member (41) relative to the surface level of the sacrificial material (43).

15 47. An energy absorption device according to claims 39 to 46, wherein the seat mounting means (21) further comprises a pin (24) that is capable of engagement with pin guiding means (45) located on the at least one mounting rail (22).

20 48. An energy absorption device according to claim 47, wherein the pin guiding means (45) comprises a slot (46) that is marginally narrower in width than the diameter of the pin (24).

25 49. An energy absorption device according to claim 47, wherein the pin guiding means (45) comprises a slot (46) that tapers from a first region that is marginally greater in width than the diameter of the pin (24), to a second region that is marginally narrower in width than the diameter of the pin (24).

50. An energy absorption device according to claims 36 to 49, further comprising anchor means (23) for fixing the device to the interior of a vehicle.

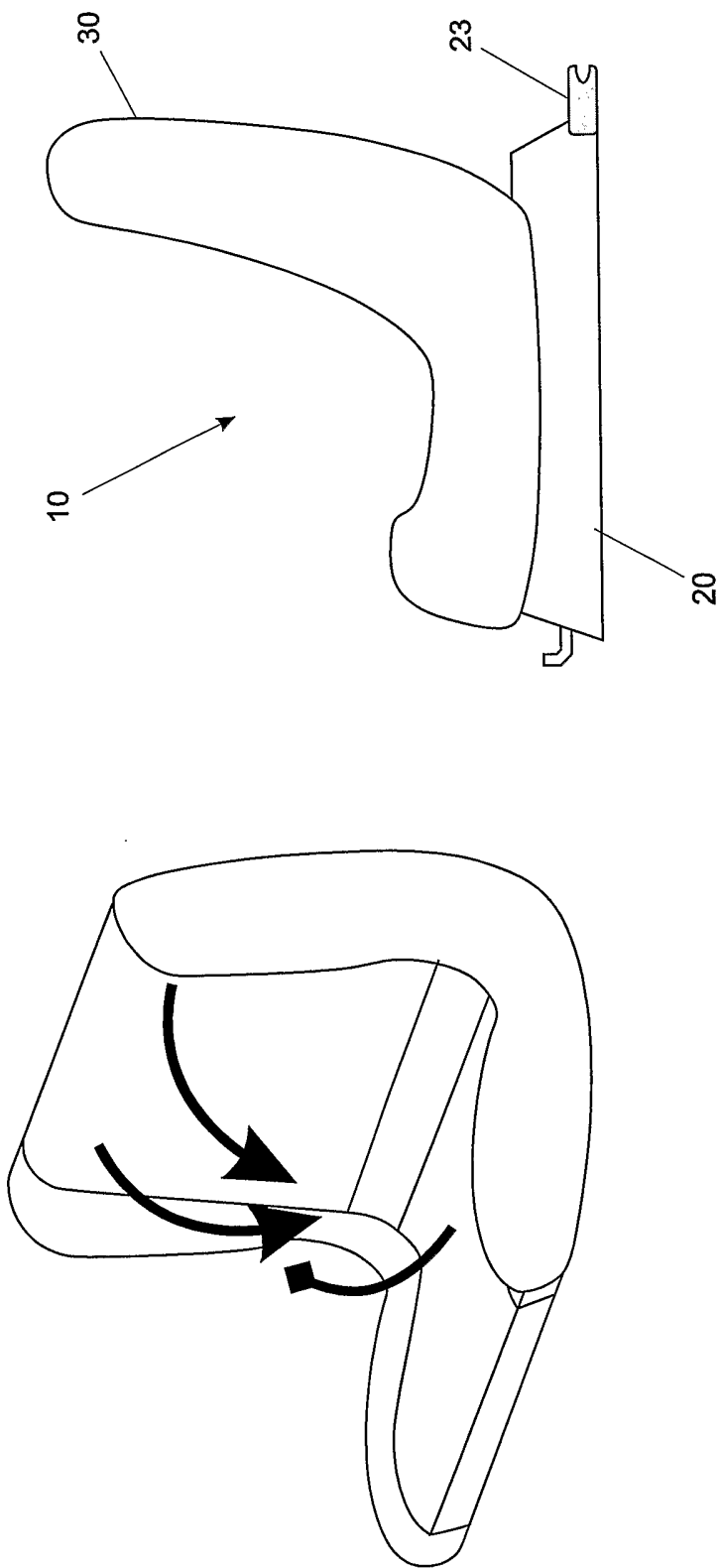


Fig.2

Fig.1

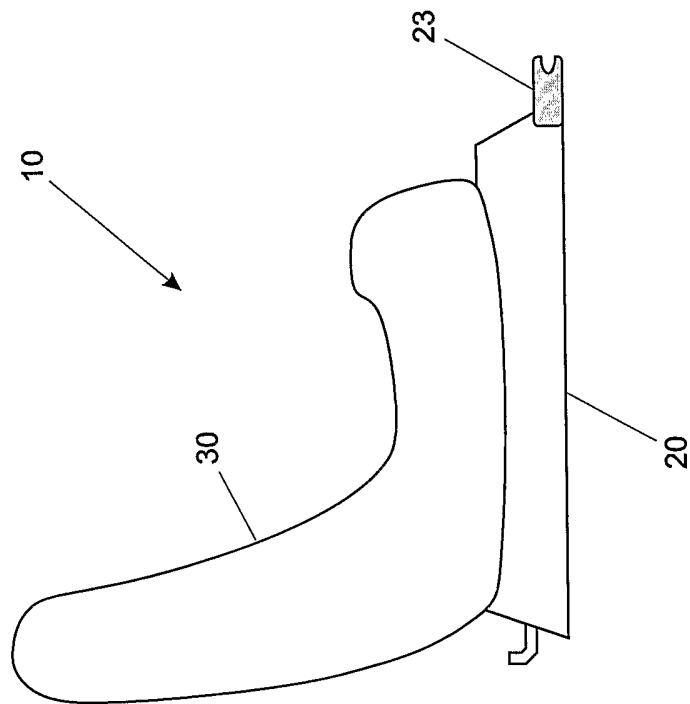


Fig.3

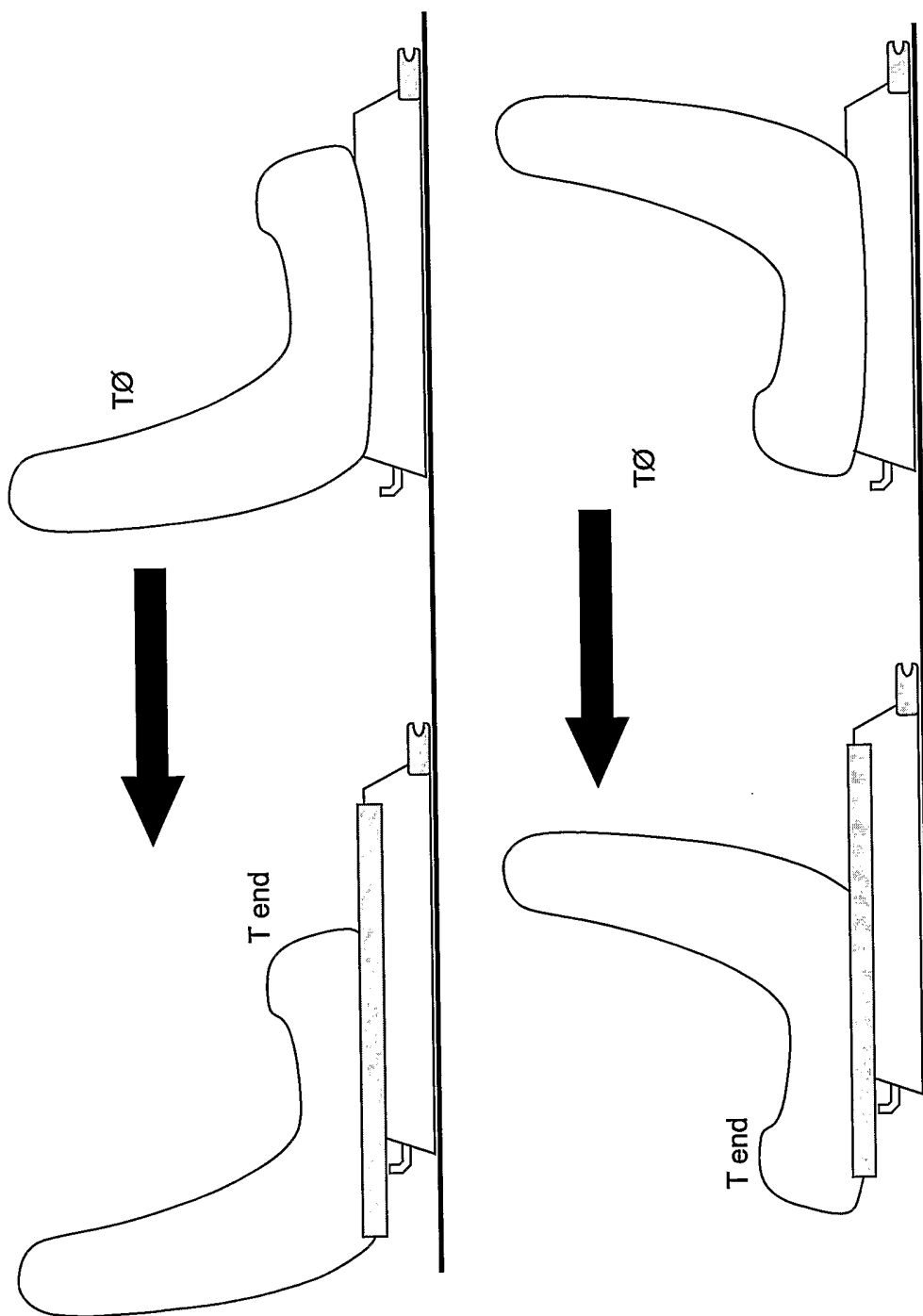


Fig.4

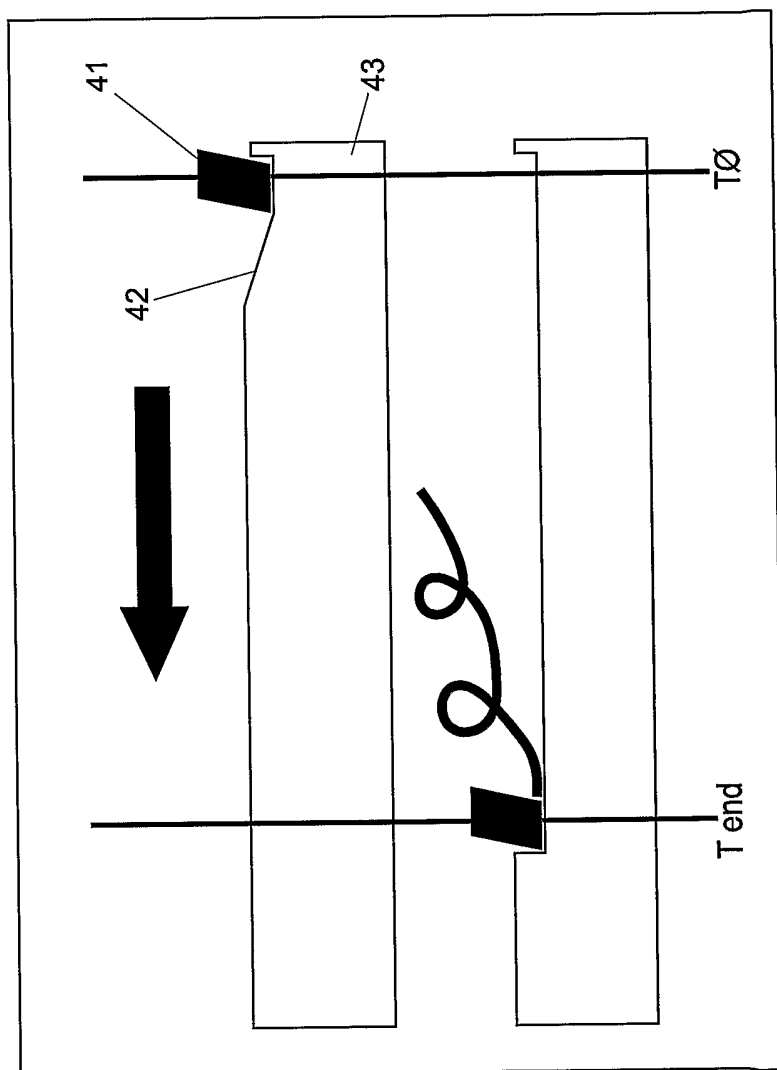


Fig.5

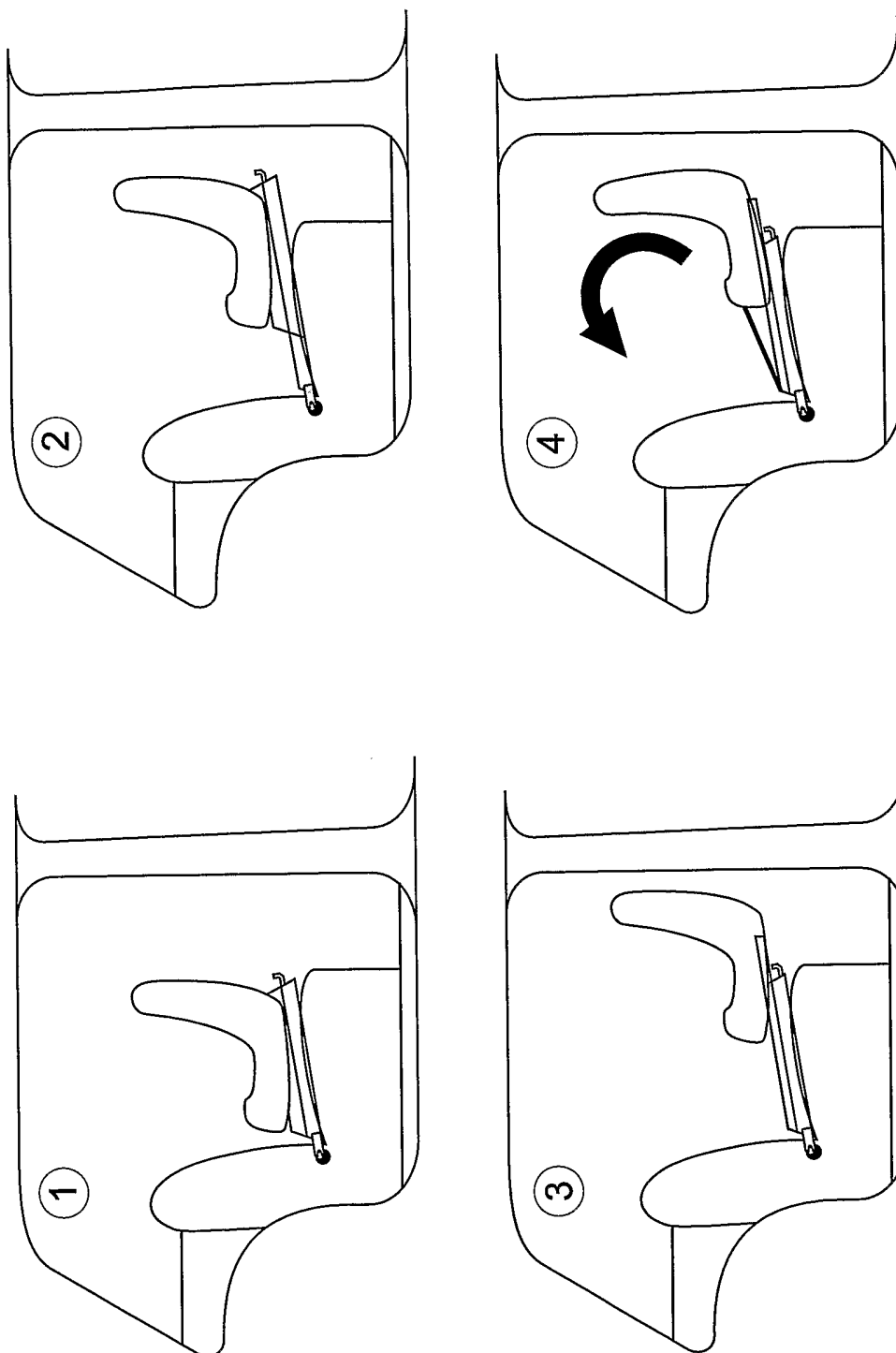


Fig.6

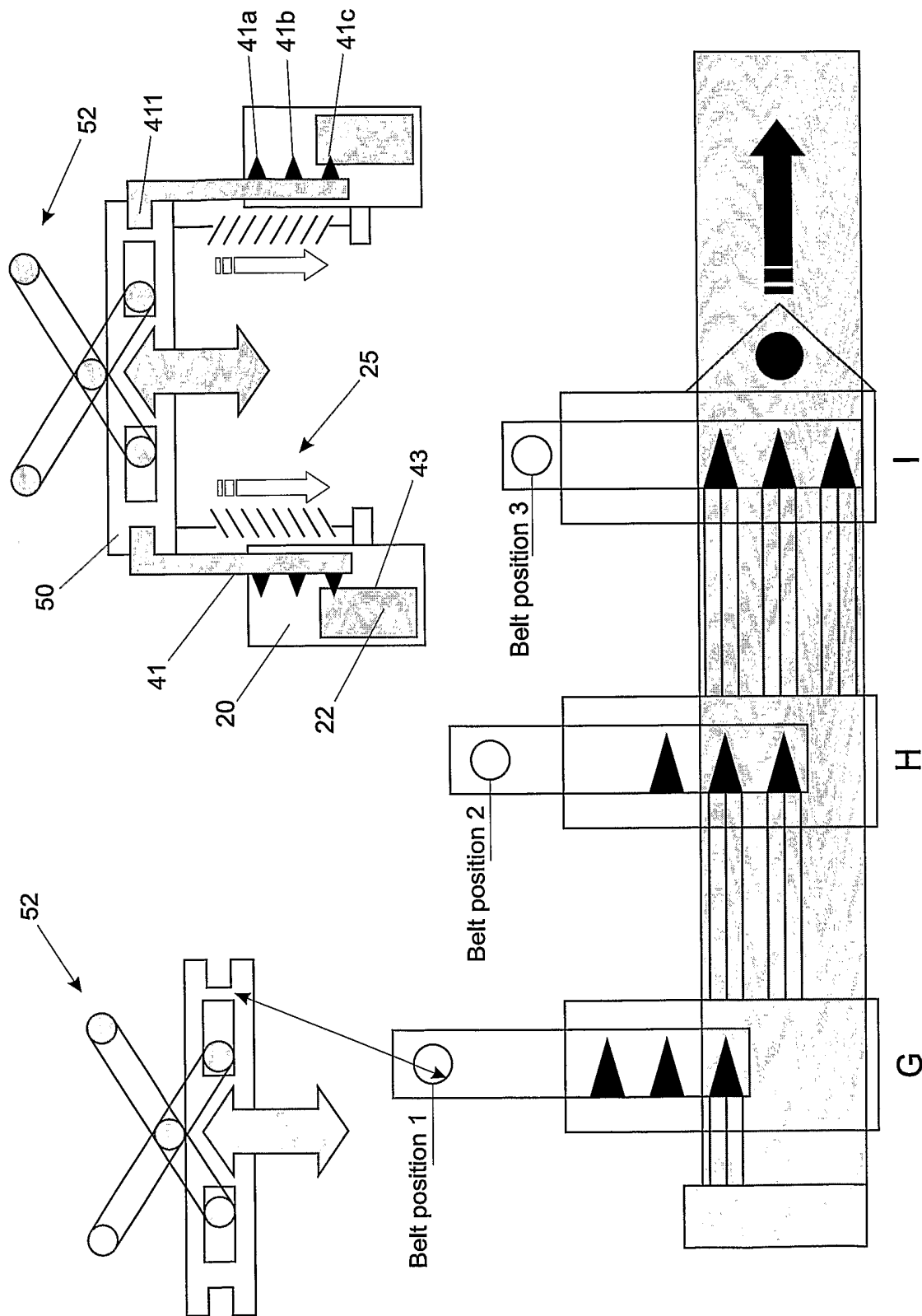


Fig.7

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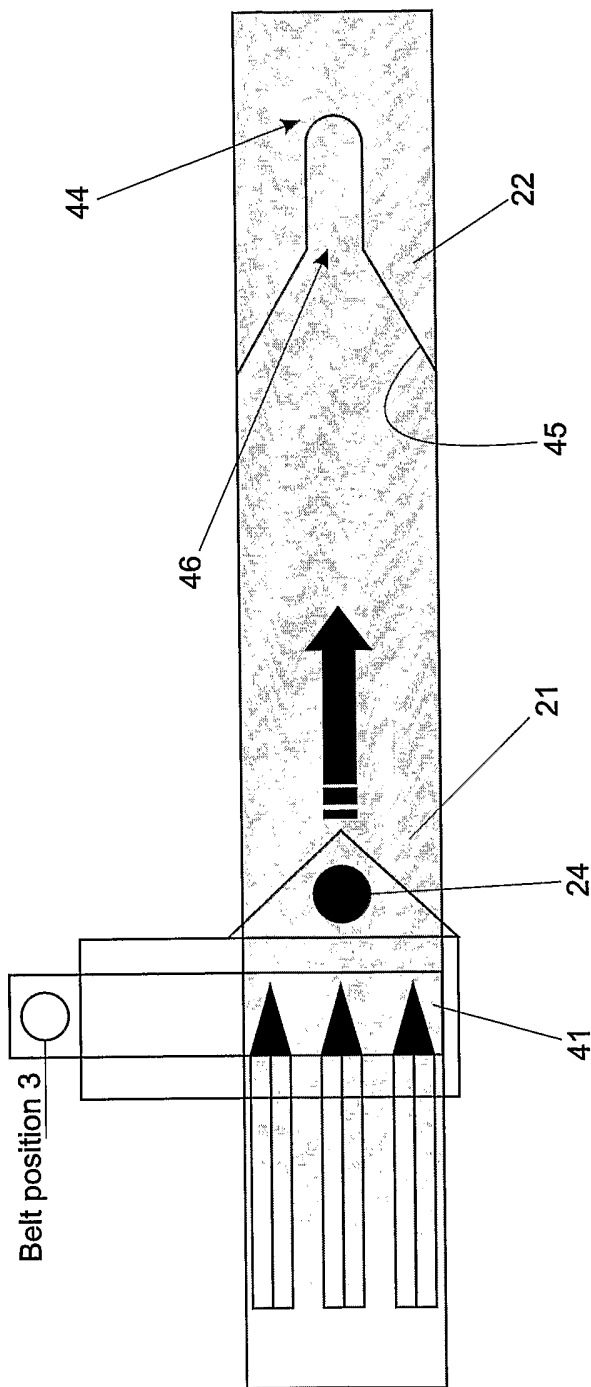


Fig.8

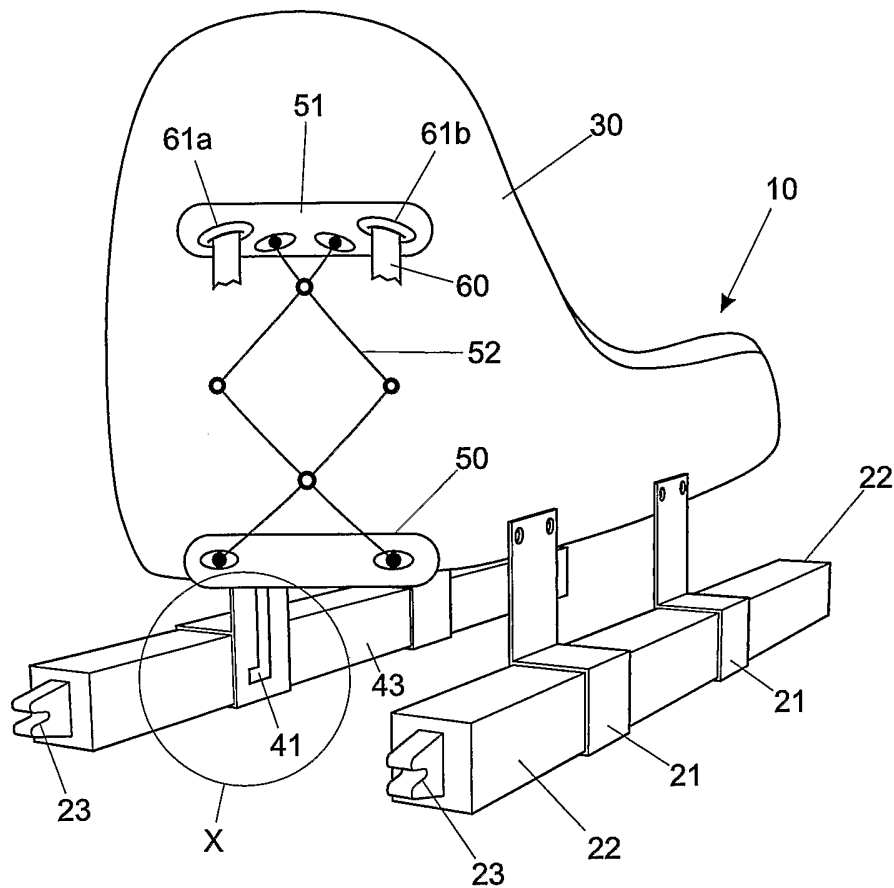


Fig.9

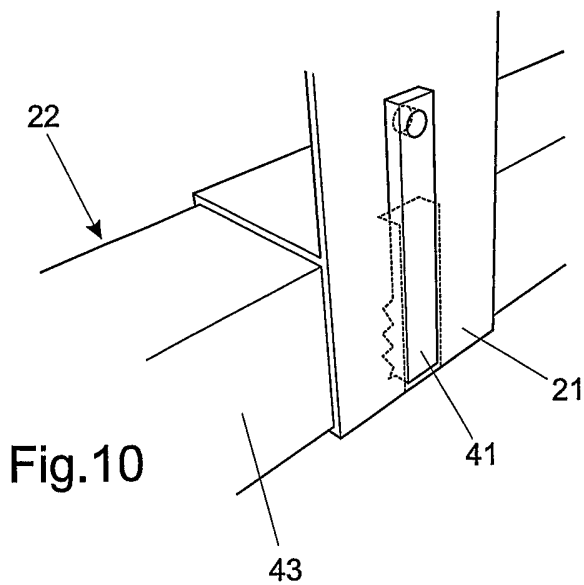


Fig.10

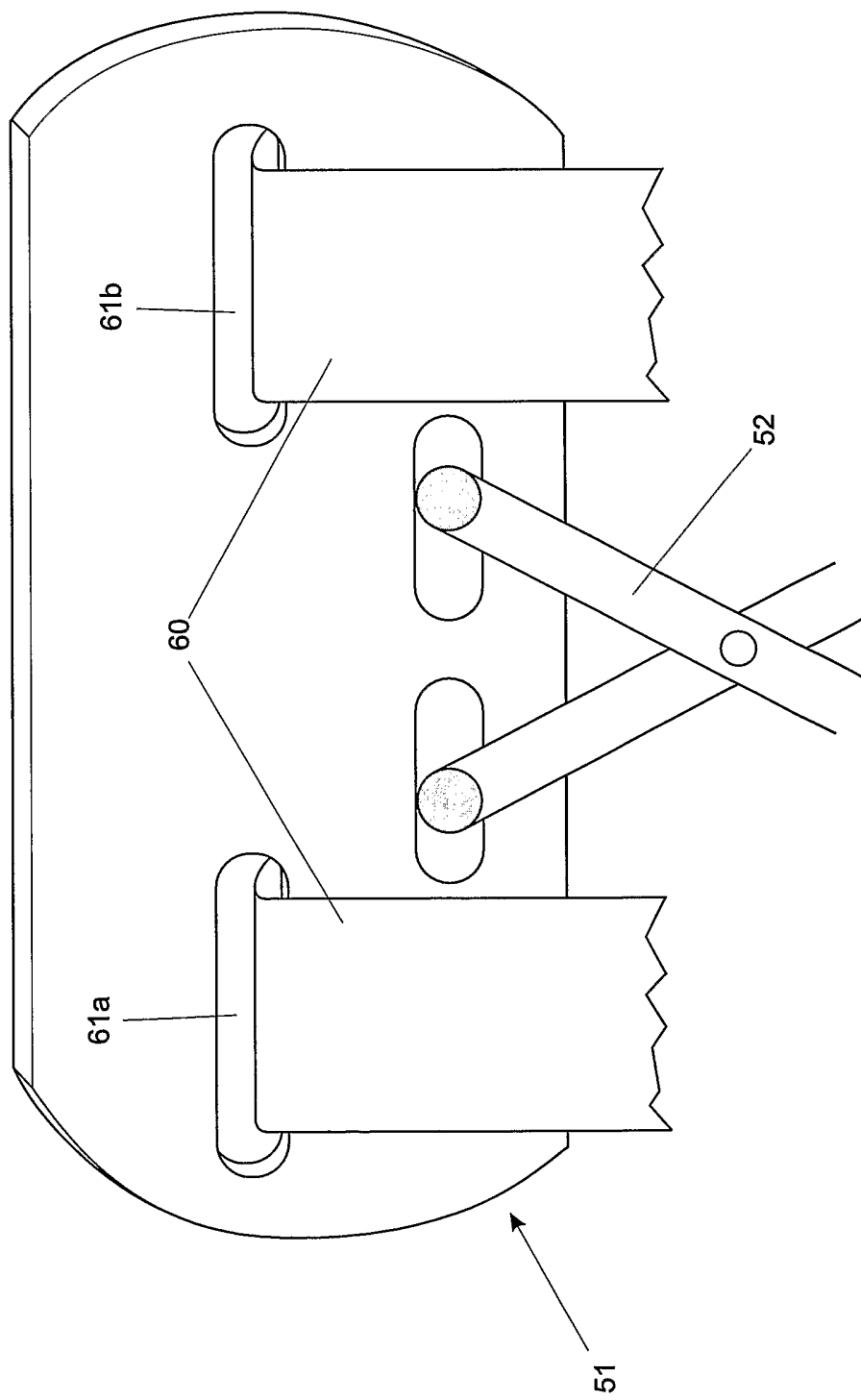


Fig.11

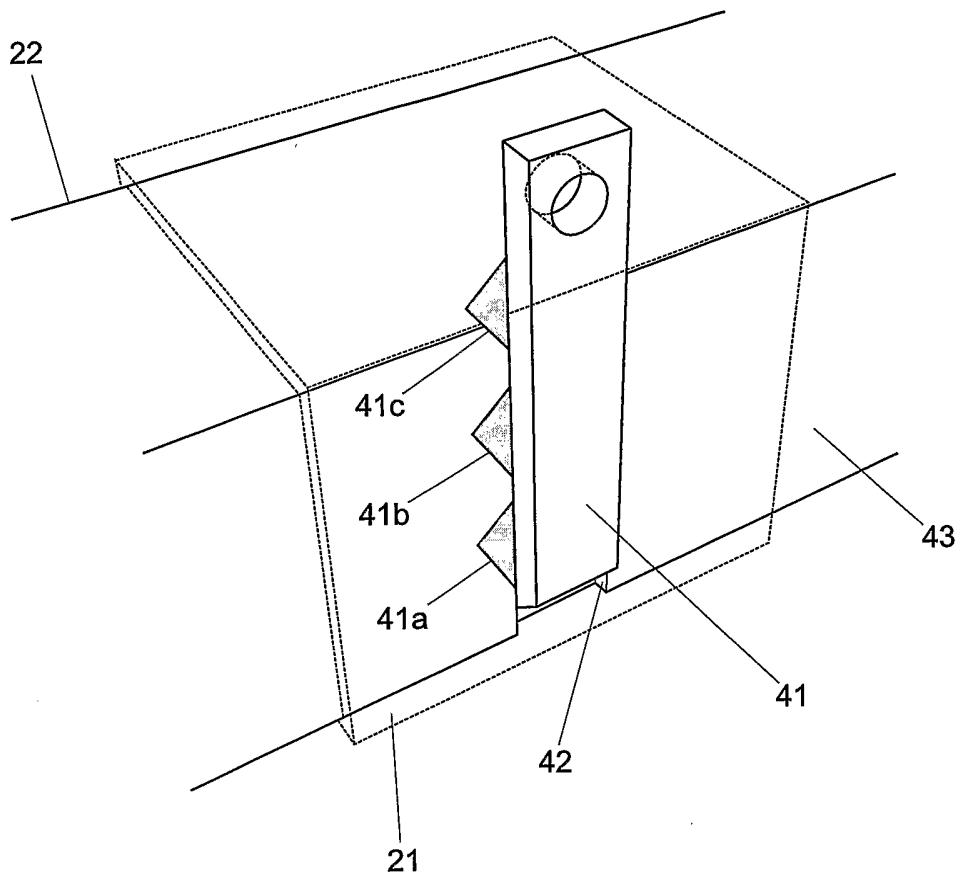


Fig.12

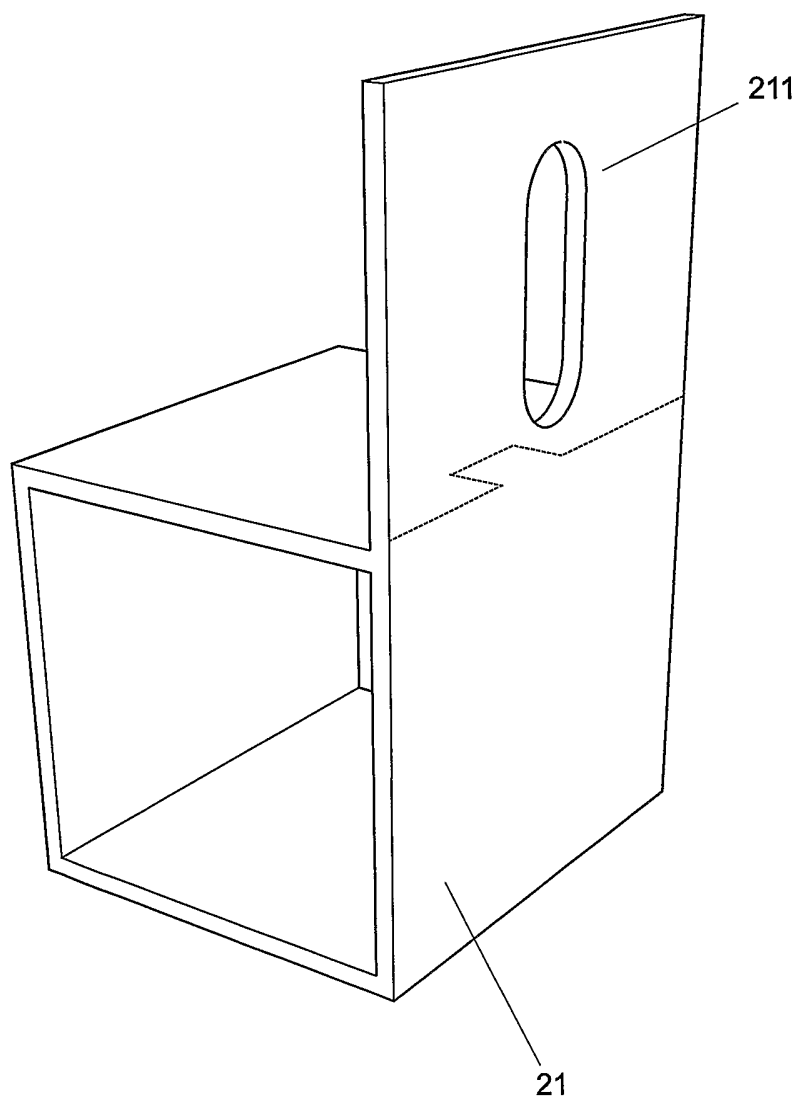


Fig.13

INTERNATIONAL SEARCH REPORT

PCT/GB2005/003166

A. CLASSIFICATION OF SUBJECT MATTER
 IPC 7 B60N2/28

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)
 IPC 7 B60N

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, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 199 52 771 A1 (ORTH, MICHAEL) 10 May 2001 (2001-05-10) the whole document	11-16, 28, 30-32, 36-38
A	US 5 664 830 A (GARCIA ET AL) 9 September 1997 (1997-09-09) cited in the application claim 1; figures 3,4,6	1, 11, 36
A	US 5 685 603 A (LANE, JR. ET AL) 11 November 1997 (1997-11-11) cited in the application claim 1; figures 1,2	1, 11, 36

Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

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Date of the actual completion of the international search

28 September 2005

Date of mailing of the international search report

06/10/2005

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 Lotz, K-D

INTERNATIONAL SEARCH REPORT

Information on patent family members

PCT/GB2005/003166

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 19952771	A1	10-05-2001	NONE
US 5664830	A	09-09-1997	CA 2214681 A1 19-05-1998 DE 69719915 D1 24-04-2003 DE 69719915 T2 11-12-2003 EP 0842811 A2 20-05-1998 JP 3301721 B2 15-07-2002 JP 10151978 A 09-06-1998
US 5685603	A	11-11-1997	NONE