

[54] **ENERGY ABSORBING RESTRAINT FOR PASSENGERS**

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[58] Field of Search 297/390, 384, 385, 389, 297/DIG. 1; 280/150 B, 150 SB

[56]

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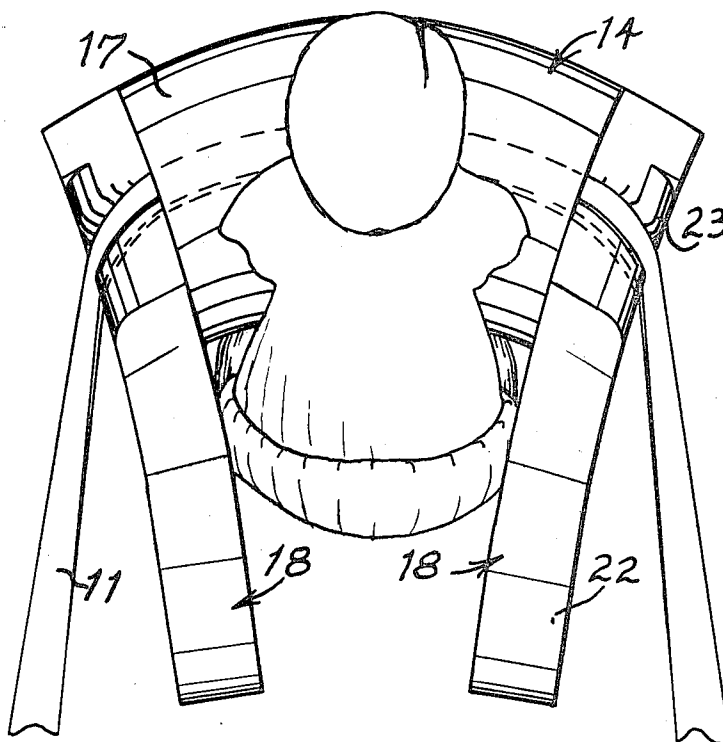
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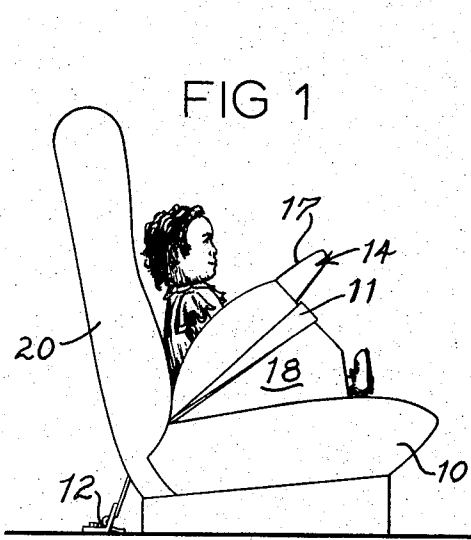
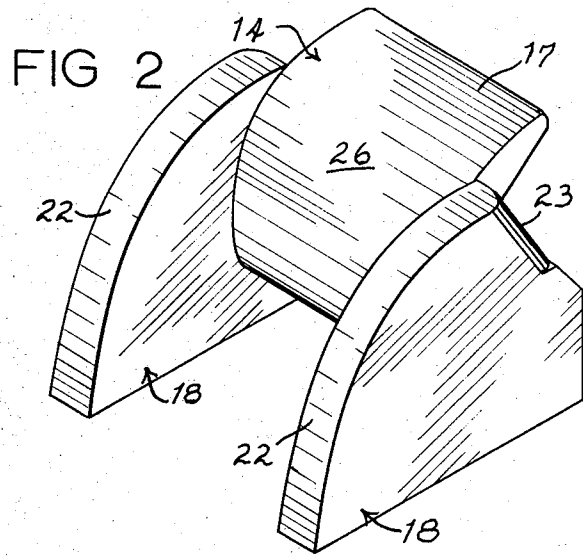
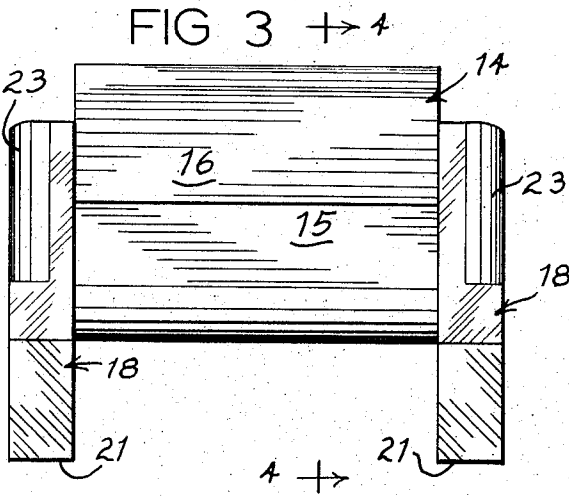
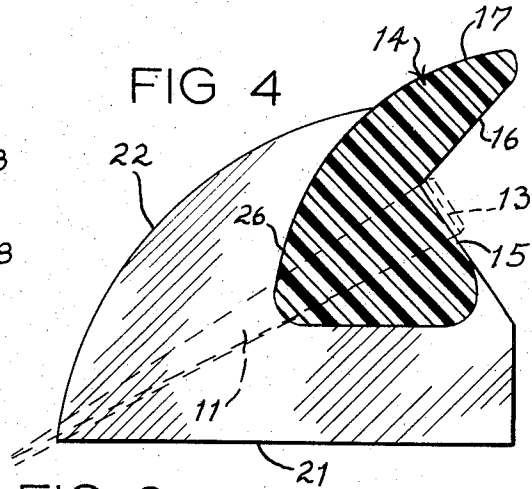
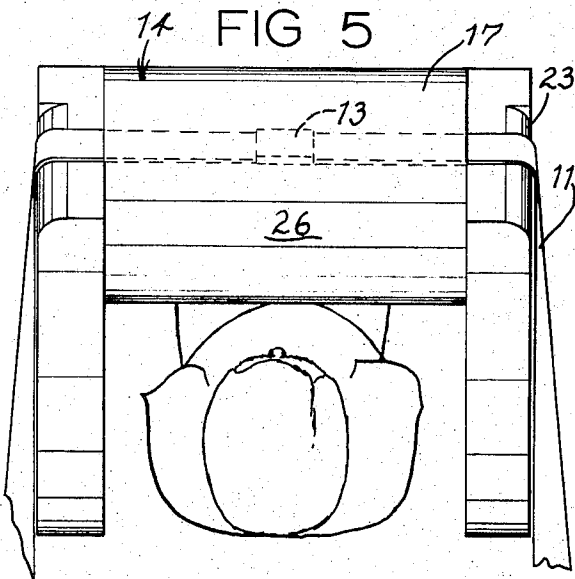
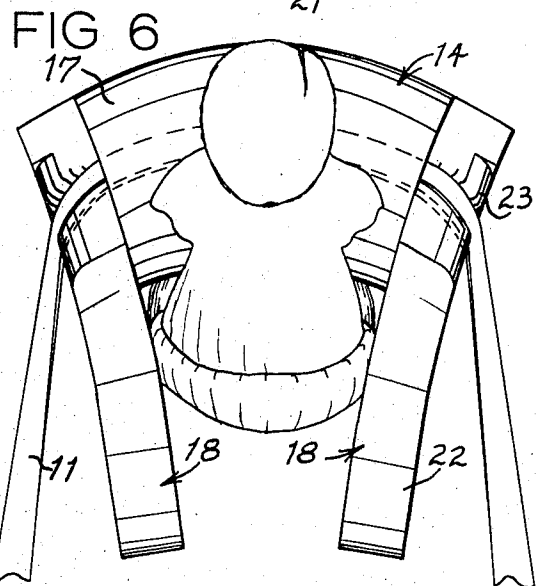
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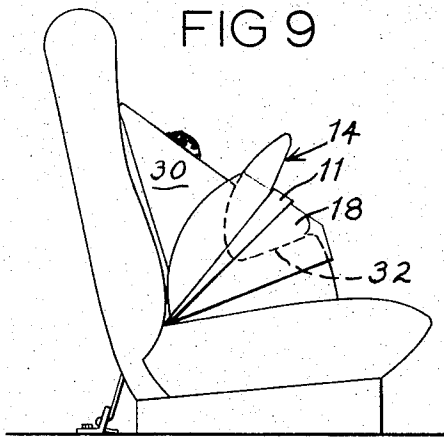
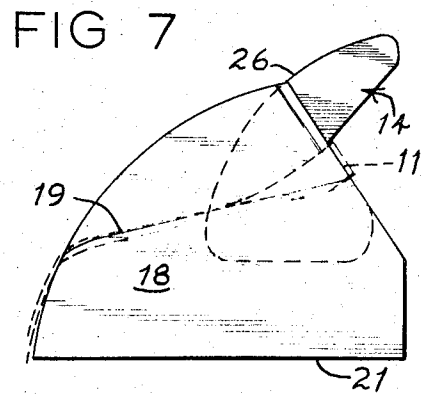
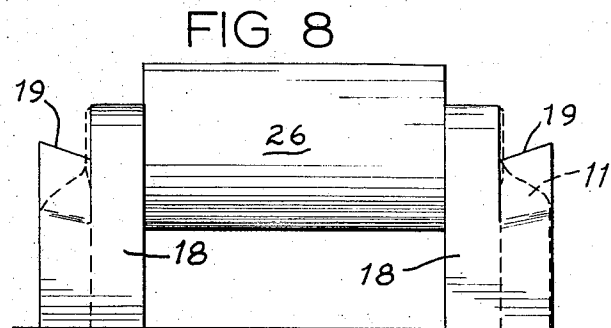
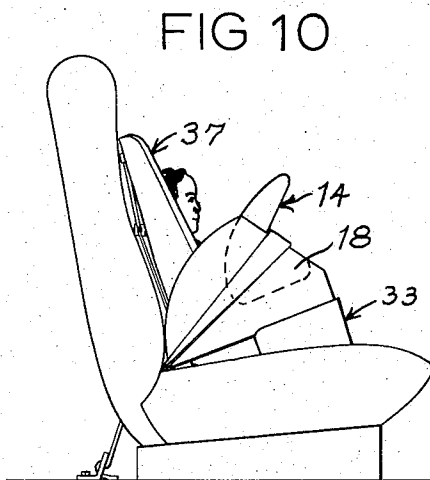
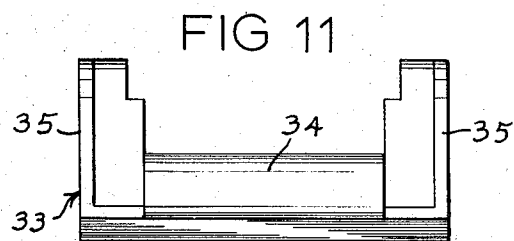
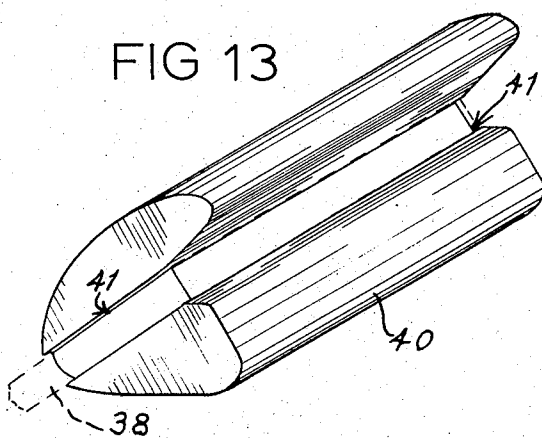
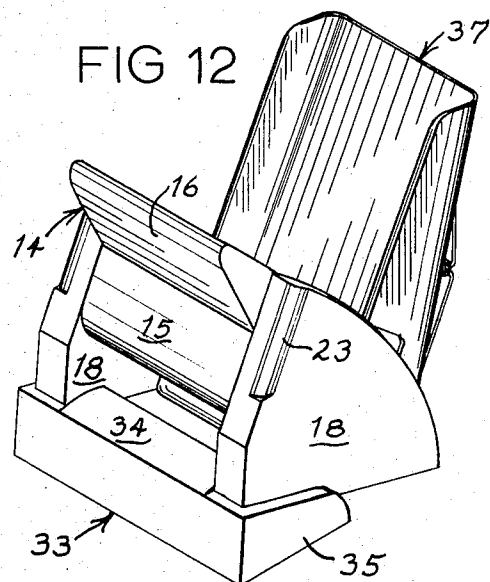
ABSTRACT

A deformable safety device upon which a seated passenger in a violently decelerating conveyance can lose kinetic energy by doing mechanical work. The device includes a horizontal portion across the passenger's lap, extending upwardly in front of his upper torso and head, which can bend transversely under load like a straight beam. The device, secured by a conventional vehicle lap belt, is permanently self supporting but contains no rigid structure. Alternate embodiments of the device further include vertical portions to each side of the passenger's torso which can bend under load like flat plates.

10 Claims, 13 Drawing Figures







ENERGY ABSORBING RESTRAINT FOR PASSENGERS

RELATED APPLICATIONS

This is a continuation-in-part of pending application Ser. No. 122,946, now abandoned, filed Mar. 10, 1971.

BACKGROUND OF THE INVENTION

This disclosure relates to an energy absorbing restraint for a person seated in a moving vehicle and particularly to a restraint for infants and children. In this document all considerations for children in autos at today's legal speeds are meant to apply equally to adults in higher speed conveyances. Also it is to be understood that all consideration of decelerating forces apply equally to accelerating force, as arise when a vehicle with little momentum is impacted by a vehicle with large momentum.

It is well understood that a device is required between a child and a motor vehicle seat belt, not only to restrain him but to spread decelerating forces over a large body area so as to lessen localized pressure on his undeveloped body, and to prevent injurious whiplash between restrained and unrestrained portions of his body. The prior device which most nearly meets these requirements is disclosed in U.S. Pat. No. 3,424,497 as a generally curved rigid plastic molding, having an "energy absorbing pad" covering only the upper forward portion designed to be impacted by the passenger's upper torso and face in forward collision.

Additional U.S. Pats. relating to child protective devices are exemplified by Pat. Nos. 3,220,769 and 3,232,665.

Crash testing has now established that a passenger in a vehicle subject to violent deceleration should not impact padded rigid structures, but rather surfaces designed to yield at force levels not seriously injurious to the passenger but sufficient to accomplish his deceleration to a state of rest relative to the vehicle in the allowable displacement. Examples of proven life saving efficacy are flat but bendable door, roof, and dash board panels, as well as collapsible steering columns and blanket windshields. A human body cannot do sufficient work upon "energy absorbing padding" of practical thickness to accomplish deceleration to a state of rest, unless it is so strong as to cause injury, and so retains most of its kinetic energy into the rigid substructure where injury results from work done on the passenger. The padding is too weak and the rigid structure is too strong. "Rigid" is of course a relative term when applied to real substances; it is here understood to mean stronger or less yielding than the human body and therefore injury-causing upon impact. Further, the child-padded rigid restraint combination disclosed in U.S. Pat. No. 3,424,497 cannot effectively communicate its kinetic energy to its surroundings for dissipation since the lap belt which secures it must be strong enough to restrain an adult with much more inertia without undo stretching, and the vehicle seat upon which the combination is stationed and into which it tends to pitch under load is again a softly padded rigid structure of poor design for high energy absorption.

The basic structure of the present restraint is a front horizontal member, formed entirely of deformable material and interposed between the person and a safety lap belt. It normally maintains the belt in a straight

transverse configuration across the lap of the person, but the flexible belt permits the member to deform in a forwardly bent arcuate configuration within the limits of the belt geometry.

In contrast to prior art, the present device is designed specifically to yield at appropriate force levels, with improved capability of distributing force correctly over maximum body area. Since it deforms under load in all directions so as to fit its occupant more snugly, the possibility of ejection is significantly reduced, and a wider range of occupant size can be accommodated by a single model. Being altogether deformable and very lightweight it will not injure other passengers, whether as barrier or projectile; and by the same token it protects its occupant from shock by impact from other bodies which might strike it.

It must be admitted that at present far too high a percentage of infants and children travel unprotected in autos. Since the present device is inherently cheaper to produce and much less cumbersome to employ than devices described in prior art and currently offered on the market, it should enjoy wider use, especially since a single durable model will serve the entire critical period from infancy through five years.

SUMMARY OF THE INVENTION

An energy absorbing restraint constructed in accordance with this invention is adapted to be interposed between a vehicle passenger and a restraining safety belt. The device comprises straight members which normally maintain the restraining belt in rectangular configuration around the passenger. Under force load from a rapidly decelerating passenger these members, together with the normally straight belt sections restraining them, are bent into an outwardly bent arcuate configuration. Material moduli and dimensions are chosen so that the work required for full bending of these members is commensurate with the occupant kinetic energy to be dissipated; or equivalently, force levels required for full deformation are designed to correspond to the product of occupant mass and anticipated crash deceleration magnitude. The bendable members of the device have sufficient strength and geometric extension to effectively spread necessary restraining force over large body area, and prevent injurious whiplash between restrained and unrestrained portions of the body; yet are soft enough to cushion minor bumps, i.e., progressively greater force is required for deformation. Further, material for construction is chosen so that the device will recover from deformation quickly enough to serve during successive multiple impacts but not with enough force to rebound the occupant; and recover sufficiently to continue in service even after crash loading.

It is a first object of this invention to provide an inexpensive easily employable restraint with energy absorbing capability sufficient to assure minimum danger of bodily injury in cases of collision or violent deceleration or acceleration.

Another object of this invention is to provide such a restraint having no rigid or structural reinforcing elements which might cause further injury to the persons restrained by the device.

Another object of the invention is to provide a restraint which assures the user of maximum utilization of the restraint capabilities of a conventional safety lap belt as used in automobiles, airplanes etc.

These and further objects will be evident from the following disclosure and the accompanying drawings, which show several forms of the basic concept.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side view of a seated child protected by a first embodiment of the restraint;

FIG. 2 is a rear perspective view of the restraint shown in FIG. 1;

FIG. 3 is a front view of the restraint;

FIG. 4 is a sectional view taken along line 4—4 in FIG. 3;

FIG. 5 is a top view of the restraint as used in vehicle, a passenger being shown by a schematic model;

FIG. 6 is a view similar to FIG. 5, illustrating the manner by which the restraint yields during violent forward deceleration;

FIG. 7 is a side elevation view of a modified restraint;

FIG. 8 is a rear view of the restraint in FIG. 7;

FIG. 9 is a transverse sectional view through the infant seat shown in FIG. 8, taken along line 9—9;

FIG. 10 is another view similar to FIG. 1, showing the restraint used with a conventional infant carrier;

FIG. 11 is a top view of an adapter utilized in FIG. 10;

FIG. 12 is a front perspective view of the assembly shown in FIG. 10; and

FIG. 13 is a front perspective view of a further embodiment of the device.

PREFERRED EMBODIMENTS OF THE DEVICE

The drawings illustrate several forms of the device and related accessories which are used to accommodate persons of differing physical development, particularly children and young infants. In all instances, the restraint is made entirely from deformable material without internal or external rigid reinforcement or a supporting rigid framework. It is light in weight and readily placed over the lap of the person to act as an interposed energy absorber between the body of the person and a conventional safety lap belt. It spreads the resulting forces of violent deceleration over a large body area, wraps about the person to prevent uncontrolled movement, and absorbs his kinetic energy by being so deformed.

FIGS. 1—6 illustrate the restraint designed for children who can be safely seated on the conventional seat cushion of an automobile seat assembly. FIGS. 7 and 8 illustrate a modification of the restraint. FIG. 9 illustrates use of the device for young infants. FIGS. 10, 11 and 12 show another infant adaptation, utilizing a conventional infant carrier. FIG. 13 shows a basic embodiment of the device designed more particularly for adults, such as passengers in high speed conveyances wherein restraining forces from belts alone would be injurious.

PREFERRED EMBODIMENT FOR CHILDREN

FIG. 1 illustrates the normal proportional relationship between the device, a conventional automobile passenger seat assembly, and a child seated on the seat assembly. The seat assembly includes a substantially horizontal seat cushion 10 and a seat back 20. The seat back 20 may be either fixed or hinged, but under existing standards all seat backs that are hinged must include locking devices to prevent accidental forward movement during use of the vehicle. A safety lap belt or seat belt 11 is typically anchored at 12 to the floor

of the vehicle behind the seat cushion 10 and extends upwardly from its anchors along upward and forward paths alongside or through the intersection between the seat cushion 10 and seat back 20. It forms an adjustable enclosure that is releasably secured about the person by means of a buckle or other locking device shown typically in FIG. 5 at reference numeral 13.

The restraint includes a transverse front section 14 having a constant cross-sectional area and configuration. It has a forwardly facing surface area 15 formed across its entire width adapted to receive the safety lap belt 11 when the restraint is positioned across the lap of a person on the seat cushion 10. The surface area 15 is defined by an upwardly and forwardly projecting ledge 16 at the front of a forward projection 17 provided to engage and protect the upper torso and head of the person. The forwardly facing surface area 15 presents a transverse surface area across the device engageable by the safety lap belt 11. It has an angle of inclination when in use leading forward and downward from ledge 16 such that area 15 supports the lap belt 11 without belt distortion. It is formed in a straight configuration across the front section 14 so as to normally maintain the lap belt 11 in a substantially straight transverse configuration across the width of the restraint.

In the first form of the restraint, the front section 14 is located above the lap of the user by side sections 18 each having a lower edge 21 for vertical support and arcuate rear edges 22 extending along the sides of the person. The side sections 18 are transversely spaced to straddle the lap of the user. The upper front corners of the side sections 18 are rounded at 23 to accommodate the flexible lap belt 11 without requiring a sharp bend in the belt.

The use of the device is schematically illustrated in FIGS. 5 and 6. These figures illustrate the relation of a passenger torso 24 and head 25 to the restraint. FIG. 6 specifically illustrates the manner by which the front section 14 bends forwardly in a transverse arcuate configuration and wraps about the engaged surfaces of the passenger, bringing the side sections 18 inwardly to engage the torso 24. This serves to maximize the available area of the passenger contacted by surfaces of the restraint and grips the occupant to assure that he will remain behind the device and not be thrown over it.

In this embodiment the side sections 18 locate the front section 14 of the restraint in correct position and the child is surrounded and restrained; in a correct seated attitude.

Now it will be appreciated that the energy absorbing function of this invention depends on the mechanical properties of the material used to fabricate the front and side sections 14, 18. They must bend at appropriate and progressively increasing force levels, yet be selfsupporting, durable, and generally acceptable as baby furnishings under normal circumstances. Specifically, the device has been successfully made entirely of closed cell polyethylene foam of approximately 2 pounds per cubic foot density. It has the correct properties for children up to 50 pounds in weight. The side members are approximately 2 inches thick and the front member, about 11 inches long, has a uniform beam configuration of about 27 square inches cross-sectional area. Note immediately that since this material is over 95 percent entrapped air it shares the energy absorbing capability of a permanently emplaced non-deflatable air bag. Entrapped air compresses much

more easily than the fluids comprising the largest percentage of rupture prone body tissue and so foamed materials yield more readily, preventing injury.

As the device is bent under load, the inside or concave side of the bent portion of the restraint goes into compression and the outside or convex side goes into tension. A material is required which is soft under minor compression, as in accommodating small bumps; also it is desired that it conform readily to the contours of the impinging occupant; nevertheless it should not crush unrecoverably. Of greatest importance, however, is that the convex side, away from the occupant, have sufficient tensile strength so as not to fracture. Urethane and Styrene foams have so far proven unsatisfactory in these regards. A bending beam offers progressively larger resistance to deflection chiefly because progressively larger components of tension force on the convex side arise to counteract the distorting force. It is just this feature which is lacking when a foamed material is simply compressed against a rigid backing.

I specify closed cell polyethylene as an acceptable material because ultimate energy transfer and storage, as well as ultimate tensile strength and ability to recover geometry depend on compressed air in cells whose walls do not rupture. The material cited above has been tested in compression to 1600 psi without discernible damage. Of course other materials or combinations of materials may prove advantageous for this invention. The material cited has ideal characteristics in both tension and compression. To fabricate the restraint, the front and side members can simply be cut from ready made extrusions and bonded together.

At 20 g a 20 pound dummy deforms the device as shown in FIG. 6. Note that as the front section 14 bends, the side sections 18 are drawn in to grasp the person more firmly. Moreover, when a side section 18 is bowed by side impact, the front section 14 and other side support 18 enclose the person more tightly to accomplish the same result. This maximizes force distribution and prevents escape of the passenger.

The lap belt 11 itself cannot exert its full tension force on the child-restraint combination until the restraint has deformed to its maximum curvature, thus the initial shock of crash deceleration cannot reach the child as would be the case when the belt geometry is fixed about a curved rigid molding. Instead, the restraint allows the child to continue forward a life saving 5 or 6 inches while total restraining force builds monotonically. By the time maximum force is reached, child and restraint have intimately conformed, force distribution over his body is maximized, and he is contained within the device by the snuggest possible fit.

As an even safer embodiment, the side sections 18 could extend high enough to receive the child's head on side impact. They would be thicker, and could curve outward near the top, but would still be substantially straight from front to back, especially along the portion designed to engage the lap belt 11 in a straight line.

It is important that the most rearward extension of the curved back surface 26 of the front member 14, where the occupant's inertia first comes to bear during forward deceleration, lie below the belt notch on the front surface of this member. This is because the line of action of the seat belt is necessarily downward to the rear, and all torques tending to pitch the device downward are to be avoided. The portion designed to intercept the occupant's forwardly moving face is much less

effective if it has become horizontal. Further, unwanted centrifugal force acts on upper body elements, whipping through unnecessary arc length, and the child can be ejected over the top of the device if it is allowed to pitch downward.

Current dynamic testing shows that forward downward pitching is a common and very serious problem with children's car seats when used on many modern automobile seat cushions of relatively soft design. Even the present device may require modification to prevent it. The difficulty is that these devices are designed for use by children when they can first sit unassisted, usually at 6 months or 15 lbs. weight. A 35-70 lb. child has a higher center of gravity when seated and consequently the effective line of action of his forward inertia may lie above the downward rearward line of action of the restraining belt anchored to the floor of the vehicle. A torque on the device results. The rearward extensions of side members 18 tend to rise off the vehicle seat; their forward extensions tend to sink down into the typically over-soft vehicle seat; and surface 17 of member 14 becomes horizontal and less effective.

FIGS. 7 and 8 show an example of a structural modification of the device to prevent upward movement of the rear of the restraint. Thickened members 18 have upwardly facing ledges 19 formed thereon leading across each member to the area 15 across the front of the device. Ledges 19 raise the line of action of the belt and force the rearward extensions of members 18 downward-preventing unwanted forward pitching of the device.

In place of ledges 19, recessed slots such as discussed below with respect to FIG. 13 may be provided along each side section 18.

EMBODIMENT FOR INFANTS

Infants (less than 6 months old and incapable of sitting unassisted) can be accommodated by the same device used by children. Since an infant must recline it is necessary to tilt the device upwards in front, which is easily accomplished by a simple wedge-shaped prop for adaptation to widely used conventional infant seats, or by notches on the sides of a specially designed infant carrier which receive the underside of the front section 14 of the restraint in appropriate attitude. In either case the upper side portions of the infant seat should extend sufficiently forward so that the infant's head cannot flop to the side. The infant, together with the seat in which he is normally carried about, can simply be inserted behind the same restraint he will use during childhood, in the same forwardly facing attitude.

FIG. 9 illustrates a specially designed infant carrier having side members 30 and an integral back and seat element 31. The side members 30 each have identical notched areas 32 complementary to the exterior configuration at the rear and underside of the front section 14 of the restraint previously described. The exterior width across the infant carrier, between the outside surfaces of side members 30, is just slightly less than the interior width across the inside surfaces of the side sections 18. The restraint is capable of straddling the infant carrier in a reasonably snug condition, with the restraint pitched upward while supported in notched areas 32 and elevated slightly from the seat cushion 10.

FIGS. 10, 11 and 12 depict the use of a wedge-shaped prop at the front of the restraint. The prop is separate,

or easily detachable from the restraint when the child outgrows his infant carrier.

The exemplary prop 33 has a transverse forward section 34 and laterally spaced rearward projections 35 which decrease in height rearwardly from the front section. The upper surface of each projection 35 is recessed at 36 to snugly receive the front portions of the lower edges 21 of the respective side sections 18 in the restraint described above. As can be seen in FIGS. 10 and 12, the raising of the front end of the restraint properly locates the restraint surfaces relative to an infant reclining in a conventional seat or carrier generally indicated by numeral 37.

EMBODIMENT FOR ADULTS

The present device is adaptable to scaling up for adults. This can be accomplished by providing larger models of the restraint described above or by special structures to meet adult restraint needs. Closed cell polyethylene foam is available with up to 4 times the density and consequent strength of the material cited above for children. An example of a modified restraint is shown in FIG. 13. The most likely application of this invention for adult use is when they are seated in high speed conveyances where crash decelerations above 20 g might be expected principally in the forward direction. A very strong lap belt 38 is presumed which by itself or in conjunction with a shoulder harness could cause injury by rupture or whiplash. The front section 40 of the present device alone would considerably enhance the safety offered by a restraining belt with little added encumbrance. It might weigh only 2 or 3 pounds and so could rest upon the passengers lap without positioning side members or other support. To assure proper orientation of the device, diagonal recesses or slots 41 are formed across each side of the restraint. They maintain the desired position of the restraint and act in conjunction with the tensioned seat belt 38 to prevent forward pitching of the restraint during deceleration.

The modified restraint need not extend high enough to intercept passenger upper torso and face in order to greatly reduce the possibility of whiplash injury to the neck because, as seen above, initial shock is reduced while restraining force builds in the bending beam. As the stomach area moves forward into the arching front member, total body kinetic energy is being absorbed by the device, and time is elapsing during which other safety equipment such as air bags can deploy - all before the occupant's head is arrested in its forward motion. Also of course, force is being spread over a much larger body area.

Having disclosed my invention, I claim:

1. A vehicle occupant restraint for restraining movement of a vehicle occupant seated on a vehicle seat assembly having a substantially horizontal seat and an upright seat back in conjunction with a flexible seat belt extending forward along both sides of the seated occupant and transversely across in front of the occupant, comprising:

side panels adapted to straddle the occupant, said side panels adapted to rest on the horizontal vehicle seat with exterior side surfaces adapted to engage the seat belt as the seat belt extends forward; a substantially straight bending beam section extending between the side panels and adapted to extend across the lap of the seated vehicle occupant with

the ends of the beam connected with the side panels;

said bending beam section having a forward substantially straight longitudinal surface, said longitudinal surface adapted to support the seat belt in normally rectangular configuration in conjunction with the surfaces of the side panels;

said bending beam member having a rear surface adapted to oppose the occupant and adapted to be forcibly contacted by the occupant during sudden forward deceleration of the vehicle associated with a vehicle crash;

said bending beam section being formed entirely of self-supporting material free of internal or external rigid reinforcement elements and being of sufficient tensile strength to enable the bending beam section to progressively significantly bend outwardly into an arcuate displacement configuration between the side panels and against the seat belt, placing the forward surface of said beam in longitudinal tension and the rear surface of said beam in longitudinal compression and thereby progressively absorbing the kinetic energy of the occupant as the bending beam is being deflectively bent into the arcuate configuration without forcibly rebounding the occupant against the upright back seat.

2. A vehicle occupant restraint for restraining movement of a vehicle occupant seated on a vehicle seat assembly having a substantially horizontal seat and an upright seat back in conjunction with a flexible seat belt extending forward along both sides of the seated occupant and transversely across in front of the occupant, comprising:

a substantially straight bending beam section adapted to extend across the lap of the seated vehicle occupant;

said bending beam section having a forward substantially straight longitudinal surface, said longitudinal surface extending between ends of the beam section and adapted to support the seat belt in a normally straight configuration transversely across in front of the occupant;

side panels supporting the bending beam section by its ends and adapted to straddle the occupant and support the bending beam section across the lap of the occupant;

said bending beam member having a rear surface adapted to oppose the occupant and adapted to be forcibly contacted by the occupant during sudden forward deceleration of the vehicle associated with a vehicle crash; and

said bending beam section being formed entirely of self-supporting material free of internal or external rigid reinforcement elements and being of sufficient tensile strength to enable the bending beam section to progressively significantly bend outwardly into an arcuate displacement configuration between the side panels and against the seat belt, placing the forward surface of said beam in longitudinal tension and the rear surface of said beam in longitudinal compression and thereby progressively absorbing the kinetic energy of the occupant as the bending beam is being deflectively bent into the arcuate configuration without forcibly rebounding the occupant against the upright back seat.

3. The vehicle occupant restraint as defined in claim 2 wherein the bending beam section is formed of closed cell polyethylene foam material.

4. The vehicle occupant restraint as defined in claim 2 wherein the bending beam section has a constant cross section between the side panels.

5. The vehicle occupant restraint as defined in claim 2 wherein the side panels extend rearwardly from the bending beam section to enclose the occupant and wherein the bending beam section is affixed to the side panels at said beam section end so that as the bent beam section is bent into the arcuate displacement configuration, the side panels automatically deflect inward toward each other to engage the occupant.

6. The vehicle occupant restraint as defined in claim 2 wherein the side panels are constructed entirely of a self-supporting material free of internal or external

rigid reinforcement elements.

7. The vehicle occupant restraint as defined in claim 6 wherein the side panels are formed of the same material as the bending beam section.

8. The vehicle occupant restraint as defined in claim 6 wherein the side panels are composed of closed cell polyethylene foam.

9. The vehicle occupant restraint as defined in claim 2 wherein the side panels have recessed slots formed therein adapted to receive the forward extension of the seat belt to limit the vertical movement of the seat belt.

10. The vehicle occupant restraint as defined in claim 2 wherein the forward substantially straight longitudinal surface of the beam section is inclined with respect to the horizontal seat to receive the transverse extension of the seat belt.

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