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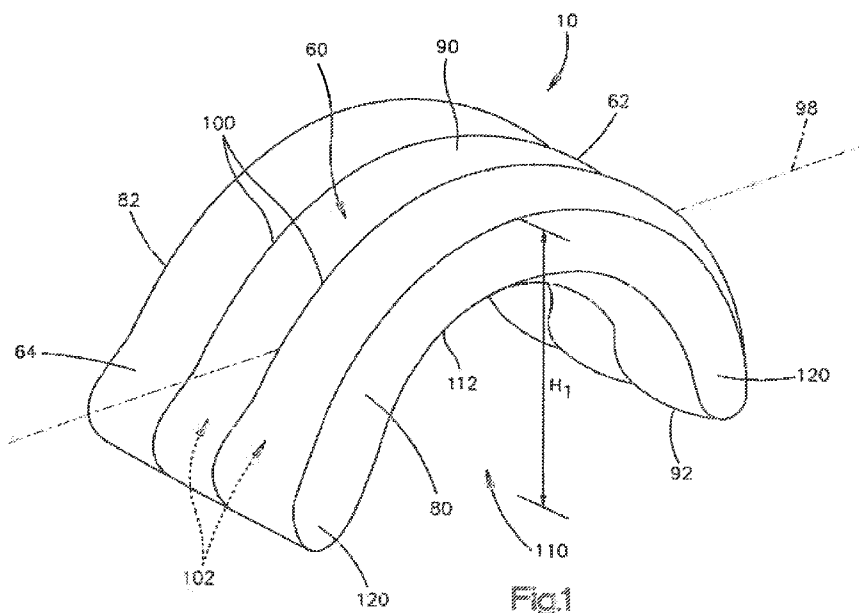
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(54) Title: SELF-CONFORMING AIRBAG



(57) Abstract: An apparatus (10) for helping to protect an occupant (20) of a vehicle (12) having a seat (16 or 22) for receiving the occupant (20) includes an inflatable protection device (14) inflatable from a stored condition in the vehicle (12) adjacent a reaction surface (19, 23, 36) to a deployed condition between the reaction surface and the vehicle occupant (20). The protection device (14) includes a front portion (62) presented toward the seat (22) and an inflatable volume for receiving a penetrating occupant (20) when the protection device (14) is in the deployed condition. A rear portion (64) connected to the front portion (62) has an inflatable volume spaced from the front portion (62) by a space (110).



SELF-CONFORMING AIR BAG

Related Applications

[0001] This application claims the benefit of U.S. Serial No. 14/583,856, filed December 29, 2014 which claims benefit from U.S. Provisional Application Serial No. 62/066,605, filed October 21, 2014 and U.S. Provisional Application Serial No. 62/067,075, filed October 22, 2014 the entirety of which are incorporated herein by reference.

Field of the Invention

[0002] The present invention relates to an apparatus for helping to protect an occupant of a vehicle. More particularly, the present invention relates to an air bag inflatable between a reaction surface of a vehicle and an occupant in a vehicle seat.

Background of the Invention

[0003] It is known to provide an inflatable vehicle occupant protection device, such as an air bag, for helping to protect an occupant of a vehicle. One particular type of air bag is a frontal air bag inflatable between an occupant of a front seat of the vehicle and an instrument panel of the vehicle. Such air bags can be driver air bags or passenger air bags. When inflated, the driver and passenger air bags help protect the occupant from impacts with parts of the vehicle such as the instrument panel and/or a steering wheel of the vehicle.

[0004] Passenger air bags are typically stored in a deflated condition in a housing that is mounted to the vehicle instrument panel. An air bag door is connectable with the housing and/or instrument panel to help enclose and conceal the air bag in a stored condition. Upon deployment of the passenger air bag, the air bag door opens to permit the air bag to move to an inflated position. The air bag door opens as a result of forces exerted on the door by the inflating air bag.

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[0005] Driver air bags are typically stored in a deflated condition in a housing that is mounted on the vehicle steering wheel. An air bag cover is connectable with the housing and/or steering wheel to help enclose and conceal the air bag in a stored condition. Upon deployment of the driver air bag, the air bag cover opens to permit the air bag to move to an inflated position. The air bag cover opens as a result of forces exerted on the cover by the inflating driver air bag.

[0006] Another type of air bag is a side impact air bag inflatable between a side structure of a vehicle and a vehicle occupant. Side impact air bags may, for example, be seat mounted, side structure mounted, or door mounted. Another type of air bag is an inflatable knee bolster inflatable between an instrument panel and/or steering column of a vehicle and a vehicle occupant. Inflatable knee bolsters may, for example, be mounted in the instrument panel or on the steering column.

[0007] Passenger side and frontal air bags are typically designed to extend to a height within the vehicle that provides a barrier between the head of a taller vehicle occupant and a windshield of the vehicle. This air bag height adds volume to the air bag and places a portion of the air bag volume above the shoulders of a shorter occupant. There is a need in the art for an air bag construction that reduces the volume of the air bag above the shoulders of taller and shorter occupants.

Summary of the Invention

[0008] The present invention relates to an apparatus for helping to protect an occupant of a vehicle having a seat for receiving the vehicle occupant. According to one aspect, the apparatus includes an inflatable vehicle occupant protection device inflatable from a stored condition to a deployed condition in which the protection device is inflated and positioned between a reaction surface of the vehicle and any occupant of the vehicle seat. The

protection device includes a rear portion positioned adjacent or near the reaction surface when the protection device is in the inflated and deployed condition, and a front portion positioned between the rear portion and any occupant of the vehicle seat when the protection device is in the inflated and deployed condition. The front and rear portions have a spaced configuration in which there is an open space outside the inflatable volume between the front and rear portion when in the inflated and deployed condition. The front portion can move relative to the rear portion into the open space in response to occupant penetration and against pressurization forces within the protection device.

[0009] According to another aspect, alone or in combination with any other aspect described herein, the front portion can be configured to be moveable relative to the rear portion in fore-aft directions and in lateral directions.

[0010] According to another aspect, alone or in combination with any other aspect described herein, the front portion of the protection can be configured to provide a first degree of restraint to occupant penetration due primarily to pressurization forces when the front portion is spaced from the rear portion. The protection device can provide a second degree of restraint to occupant penetration, greater than the first degree of restraint, in response to the penetrating occupant moving the front portion into engagement with the rear portion.

[0011] According to another aspect, alone or in combination with any other aspect described herein, the first degree of restraint can be sufficient to absorb some of the initial impact forces of the penetrating occupant while at the same time permitting the front portion to move relative to the rear portion.

[0012] According to another aspect, alone or in combination with any other aspect described herein, the apparatus can include seams that control the inflated depth of the front

and rear portions to define different chamber within the front and rear portions. The chambers can be configured to provide different degrees of resistance to occupant penetration.

[0013] According to another aspect, alone or in combination with any other aspect described herein, the protection device can include a connecting portion positioned between the front and rear portions. The connecting portion can interconnect the front portion and the rear portion at one of the upper, lower, inboard, and outboard extents of the front and rear portions, such that the protection device is has a generally curved U-shaped or hook-shaped configuration when in the inflated and deployed condition.

[0014] According to another aspect, alone or in combination with any other aspect described herein, the connecting portion can include a central portion of the generally U-shaped or hook-shaped configuration and the front and rear portions can include the portions that extend from the central portion to complete the generally U-shaped or hook shaped configuration and thereby space the front and rear portions from each other.

[0015] According to another aspect, alone or in combination with any other aspect described herein, the front and rear portions each have an inflated thickness measured in the fore-aft direction between respective pairs of opposing panels that define each of their respective inflatable volumes. A rear panel of the front portion engages a front panel of the rear portion when the front panel is deflected into engagement with the rear portion.

[0016] According to another aspect, alone or in combination with any other aspect described herein, the protection device can include a pair of connecting portions that interconnect either upper and lower portions of the front and rear portions, or inboard and outboard portions of the protection device. The protection device can thereby take the form of a closed loop wherein the space extends centrally through the protection device and is bounded by the closed loop defined by the protection device.

[0017] According to another aspect, alone or in combination with any other aspect described herein, the protection device can include at least one non-inflatable support member extending between the connecting portions for maintaining the connecting portions at a predetermined position relative to one another.

[0018] According to another aspect, alone or in combination with any other aspect described herein, the at least one non-inflatable support member can include a pair of non-inflatable support members on opposing sides of the space for maintaining the connecting portions substantially parallel to one another when the protection device is in the deployed condition.

[0019] According to another aspect, alone or in combination with any other aspect described herein, the protection device can include a pair of inflatable retaining portions that extend laterally outward from opposite lateral sides of the front portion.

[0020] According to another aspect, alone or in combination with any other aspect described herein, the protection device can have a substantially triangular shape when viewed from the top.

[0021] According to another aspect, alone or in combination with any other aspect described herein, the protection device can have a generally inverted U-shaped configuration, and the lower extent of the front portion extends vertically below the lower extent of the rear portion.

[0022] According to another aspect, alone or in combination with any other aspect described herein, a pocket can extend into the front portion towards the rear portion.

[0023] According to another aspect, alone or in combination with any other aspect described herein, the seat can be a rear seat of the vehicle and the protection device can be stored in a seat back positioned forward of the seat. The protection device can be deployable

between the occupant and a seat back such that the seat back acts as a reaction surface for the protection device.

[0024] According to another aspect, alone or in combination with any other aspect described herein, the seat can be a rear seat of the vehicle and the protection device can be stored in a roof of the vehicle. The protection device can be deployable between the occupant and a seat back positioned forward of the occupant's seat such that the seat back acts as a reaction surface for the protection device.

[0025] According to another aspect, alone or in combination with any other aspect described herein, the seat can be a front seat of the vehicle and the protection device can be stored in an instrument panel of the vehicle. The protection device can be deployable between the occupant and the instrument panel such that the instrument panel acts as a reaction surface for the protection device.

[0026] According to another aspect, alone or in combination with any other aspect described herein, the seat can be a front seat of the vehicle and the protection device can be stored in a roof of the vehicle. The protection device can be deployable between the occupant and an instrument panel of the vehicle such that the instrument panel acts as a reaction surface for the protection device.

[0027] According to another aspect, alone or in combination with any other aspect described herein, the seat can be a driver seat of the vehicle and the protection device can be stored in a roof of the vehicle. The protection device can be deployable between the occupant and a steering wheel of the vehicle such that the steering wheel acts as a reaction surface for the protection device.

Brief Description of the Drawings

[0028] The foregoing and other features of the present invention will become apparent to one skilled in the art to which the present invention relates upon consideration of the following description of the invention with reference to the accompanying drawings, in which:

[0029] Fig. 1 is a schematic illustration of an apparatus for helping to protect an occupant of a vehicle in accordance with an embodiment of the present invention.

[0030] Fig. 2 is a schematic side view of the apparatus of Fig. 1 illustrating different conditions with a belted vehicle occupant.

[0031] Figs. 3A-3C are schematic side views of the apparatus of Fig. 1 illustrating different rear seat conditions with a belted vehicle occupant.

[0032] Figs. 4A-4B are schematic illustrations of an apparatus for helping to protect an occupant of a vehicle in accordance with another embodiment of the present invention.

[0033] Figs. 5A-5C are schematic illustrations of an apparatus for helping to protect an occupant of a vehicle in accordance with another embodiment of the present invention.

[0034] Figs. 6A-6B are schematic illustrations of an apparatus for helping to protect an occupant of a vehicle in accordance with another embodiment of the present invention.

[0035] Figs. 7A-7C are schematic illustrations of an apparatus for helping to protect an occupant of a vehicle in accordance with another embodiment of the present invention.

[0036] Figs. 8A-8C are schematic illustrations of an apparatus for helping to protect an occupant of a vehicle in accordance with another embodiment of the present invention.

[0037] Figs. 9A-9B are schematic illustrations of an apparatus for helping to protect an occupant of a vehicle in accordance with another embodiment of the present invention.

[0038] Figs. 10A-10B are schematic illustrations of an apparatus for helping to protect an occupant of a vehicle in accordance with another embodiment of the present invention.

[0039] Figs. 11A-11B are schematic illustrations of an apparatus for helping to protect an occupant of a vehicle in accordance with another embodiment of the present invention.

[0040] Figs. 12A-12B are schematic illustrations of an apparatus for helping to protect an occupant of a vehicle in accordance with another embodiment of the present invention.

[0041] Fig. 13 is a schematic illustration of an apparatus for helping to protect an occupant of a vehicle in accordance with another embodiment of the present invention.

[0042] Fig. 14 is a schematic illustration of an apparatus for helping to protect an occupant of a vehicle in accordance with another embodiment of the present invention.

[0043] Fig. 15 is a schematic illustration of an apparatus for helping to protect an occupant of a vehicle in accordance with another embodiment of the present invention.

[0044] Figs. 16A-16B are schematic illustrations of an apparatus for helping to protect an occupant of a vehicle in accordance with another embodiment of the present invention.

[0045] Figs. 17A-17B are schematic illustrations of an apparatus for helping to protect an occupant of a vehicle in accordance with another embodiment of the present invention.

[0046] Figs. 18A-18B are schematic illustrations of an apparatus for helping to protect an occupant of a vehicle in accordance with another embodiment of the present invention.

[0047] Figs. 19A-19B are schematic illustrations of an apparatus for helping to protect an occupant of a vehicle in accordance with another embodiment of the present invention.

[0048] Figs. 20A-20B are schematic illustrations of an apparatus for helping to protect an occupant of a vehicle in accordance with another embodiment of the present invention.

Detailed Description of the Invention

[0049] The present invention relates to an apparatus for helping to protect an occupant of a vehicle. More particularly, the present invention relates to an air bag inflatable between a reaction surface of a vehicle and an occupant in a vehicle seat. An apparatus 10 for helping to protect an occupant 20 of a vehicle 12 includes an inflatable vehicle occupant protection device 14 in the form of an air bag 14. In the embodiment illustrated in Figs. 1-4C, the air bag 14 is a passenger air bag for helping to protect an occupant 20 of a rear seat 22 on a side 24 of the vehicle 12 behind a front seat 16 of the vehicle. The front seat 16 is positioned behind and presented towards an instrument panel 36. The side 24 can be the driver side (as shown) or the passenger side (not shown) of the vehicle 12. The vehicle 12 also includes a roof 19 and a seatbelt 18 connected to the rear seat 22 for helping to protect the vehicle occupant 20.

[0050] Referring to Fig. 2, the air bag 14 can be part of an air bag 14 module 30 that includes an inflator 32 and a housing 34. The air bag 14 has a stored condition, indicated by dashed lines in Fig. 2, in which the air bag is folded and placed in a stored condition within the housing 34. The module 30 is mounted to or within a seat back 23 of the front seat 16 of the vehicle 12. The housing 34 helps contain and support the air bag 14 and inflator 32 in the

seat back 23. Alternatively, the module 30 can be mounted in the B-pillar, door, rear seat cushion, center console, instrument panel 36 or roof 19 of the vehicle 12 (not shown).

[0051] A module 30 door (not shown) can be releasably connected to the seat back 23 and/or the housing 34. In a closed condition (not shown), the door forms a cover for the module 30 and helps enclose the air bag 14 in the stored condition in the housing 34 within the seat back 23. The door is movable to an opened condition that uncovers an opening 44 in the housing 34 and seat back 23 through which the air bag 14 can be deployed from the stored condition in the housing 34 to an inflated or deployed condition. The door can be connected to the vehicle 12, *e.g.*, connected to the seat back 23, either directly or through the housing 34, by means (not shown), such as a plastic hinge portion, a strap or a tether.

[0052] The inflator 32 is actuatable to provide inflation fluid to an inflatable volume 60 of the air bag 14 to deploy the air bag 14 to the inflated condition. The inflator 32 can be of any known type, such as stored gas, solid propellant, augmented or hybrid. The apparatus 10 includes a sensor, illustrated schematically at 50, for sensing an event for which inflation of the air bag 14 is desired, such as a collision. The inflator 32 is operatively connected to the sensor 50 *via* lead wires 52.

[0053] The air bag 14 can be constructed of any suitable material, such as nylon (*e.g.*, woven nylon 6-6 yarns), and can be constructed in any suitable manner. For example, the air bag 14 can include one or more pieces or panels of material. If more than one piece or panel is used, the pieces or panels can be interconnected by known means, such as stitching, ultrasonic welding, heat bonding or adhesives, to form the air bag 14. The air bag 14 can be uncoated, coated with a material, such as a gas impermeable urethane or laminated with a material, such as a gas impermeable film. The air bag 14 thus can have a gas-tight or substantially gas-tight construction. Those skilled in the art will appreciate that alternative

materials, such as polyester yarn, and alternatives coatings, such as silicone, can also be used to construct the air bag 14.

[0054] In the illustrated embodiment, the air bag 14 is constructed of one or more panels of material interconnected to define the inflatable volume 60 of the air bag having the configuration illustrated in Figs. 1-4C. Referring to Figs. 1-2, the inflated air bag 14 deploys from the housing 34 away from the seat back 23 in an aft direction toward the occupant 20 in the rear seat 22. The seat back 23 therefore acts as a reaction surface of the vehicle 12 for the deploying air bag 14. The air bag 14 has an inverted U-shape configuration when viewed from the side and a generally rectangular shape when viewed from the top (not shown). The inflated air bag 14 includes a front portion 62 adjacent the occupant 20 and a rear portion 64 adjacent the seat back 23.

[0055] In the deployed condition, the front portion 62 is spaced from the front seat 16 and includes a front panel or surface 70 presented towards the occupant 20 in the rear seat 22. The rear portion 64 is positioned adjacent and connected to the seat back 23 via its connection to the module 34. The surface 70 is spaced from the seat back 23 by a distance or depth D1 extending in a fore-aft direction of the vehicle 12. Lateral portions 80, 82 extend between the front portion 62 and the rear portion 64. The lateral portions 80, 82 extend substantially parallel to one another on opposite sides of the air bag 14. The lateral portion 80 is positioned outboard in the vehicle 12 and the lateral portion 82 is positioned inboard in the vehicle.

[0056] A top portion 90 is presented toward the vehicle roof 19 and connects the front portion 62 to the rear portion 64. A bottom portion 92 is positioned nearer the rear seat 22. The front portion 62, rear portion 64, lateral portions 80, 82, top portion 90, and bottom portion 92 cooperate with one another to help define the inflatable volume 60 of the air bag

14. Each of the front portion 62, the rear portion 64, the lateral portions 80, 82, the top portion 90, and the bottom portion 92 can include non-inflatable portions (not shown) in addition to their respective inflatable portions.

[0057] One or more seams 100 can extend generally in the fore-aft direction along the length of the air bag 14 from the front portion 62 to the rear portion 64 for separating the inflatable volume 60 into a plurality of chambers 102. The depth of each seam 100 into the inflatable volume 60 can be tailored to form a chamber 102 having a desired cross-section and/or pressurization, *i.e.*, the seams can be the same or can be different from one another such that the chambers inflate and pressurize at different rates. The seams 100 can also be configured to control the volume(s) of the chambers 102 to thereby control the size of the inflator 32 needed to fully inflate and deploy the air bag 14. Controlling the volume(s) of the chambers 102 also controls the stiffness of the air bag 14 to meet desired performance criterion. In one example, the middle chamber(s) 102 in the inboard-outboard direction can be made smaller to thereby provide a reduced stiffness relative to the stiffness of the more inboard and more outboard chambers.

[0058] The air bag 14 includes a space 110 defining an uninflated or unpressurized volume outside the inflatable volume 60. In the construction shown in Fig. 1, the space 110 extends from the bottom portion 92 towards the top portion 90. The space 110 extends entirely between the lateral portions 80, 82 and terminates at an inner surface 112 of the top portion 90. Consequently, the air bag 14 is bifurcated into two inflatable lobes 120 spaced apart from one another at the bottom portion 92 and connected to one another by the top portion 90 to help define the shape of the space 110. Each of the lobes 120 has substantially the same height in the vertical direction such that the air bag 14 is substantially symmetric

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about the top portion 90. The air bag 14 shown in Fig. 1 therefore has the shape of an arch or upside-down U.

[0059] A midline 98 extends through the air bag 14 in the fore-aft direction of the vehicle 12. The midline 98 is spaced equidistantly from the uppermost edge and the lowermost edge of the air bag 14, *i.e.*, the midline is positioned half way along the air bag height, indicated generally at H_1 . In the embodiment of Fig. 1, the size of the front portion 62, top portion 90, and rear portion 64 are chosen such that the space 110 extends above the midline 98, *i.e.*, the space has a depth from the lowermost edge of the air bag 14 that is greater than half of the height H_1 of the inflated air bag 14. Alternatively, the space 110 can have a depth that is half or less than half of the height H_1 of the air bag 14 (not shown). The presence of the space 110 in the air bag 14 reduces the size of the inflatable volume 60 in order to provide desirable inflation performance criterion.

[0060] Upon sensing the occurrence of an event for which inflation of the air bag 14 is desired, such as a vehicle collision, the sensor 50 provides a signal to the inflator 32 *via* the lead wires 52. Upon receiving the signal from the sensor 50, the inflator 32 is actuated and provides inflation fluid to the inflatable volume 60 of the air bag 14 in a known manner. The inflating air bag 14 exerts a force on the seat back 23 of the front seat 16 to rupture the seat back and allow the air bag to inflate from the stored condition to the deployed condition, such as the fully inflated, deployed, and pressurized condition illustrated in solid lines in Fig. 2. The air bag 14, when deployed, helps protect the vehicle occupant 20 from impacts with parts of the vehicle 12, such as impacts with the front seat 16.

[0061] The air bag 14, when deployed, helps protect the occupant 20 by helping to absorb the force of impact placed on the air bag by the occupant. Referring to Fig. 2, when the occupant 20 impacts the air bag 14, the occupant penetrates the air bag, which absorbs

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and distributes the impact forces throughout the area and volume of the air bag. By “penetrates” into the air bag 14, it is meant to refer to the instance where, in the case of a frontal impact to the vehicle 12, the occupant 20 is moved forward, as indicated by the arrow labeled 42 and the dashed lines labeled 20’ in Fig. 2, into engagement with the air bag. The “penetration” of the occupant 20 into the air bag 14 is the distance or degree to which the occupant moves into the inflated depth of the air bag relative to the point at which the occupant first engages the inflated air bag, *i.e.*, engages the surface 70 of the front portion 62.

[0062] In other words, the degree of penetration could be measured as the distance a given point on the surface 70 is moved toward the front seat 16 by the penetrating occupant 20’. For example, the degree of penetration in Fig. 2 can be calculated as the difference between the fully inflated depth D1 of the entire air bag 14 and the penetrated depth of the entire air bag (not shown) relative to the seat back 23. Alternatively, penetration could be measured as the change in distance between a point on the surface 70 and a fixed point on the front seat 16 facing the occupant or between a point on the occupant 20, *e.g.*, the occupant’s chest, and a fixed point on the seat back 23 starting when the occupant first contacts the air bag 14 (not shown).

[0063] Several factors determine the degree to which an occupant 20 penetrates the air bag 14. For example, the size or mass of the occupant 20, the speed at which the occupant strikes the air bag 14, and the pressurization of the air bag all help determine the degree to which the occupant penetrates the air bag in a given deployment scenario.

[0064] As shown in Fig. 2, in the case of a belted occupant 20, the seatbelt 18 serves to help restrain the occupant. As a result, the belted occupant 20, especially the occupant’s lower torso 122 and hips 130, is restrained from moving toward the front seat 16. This allows the air bag 14 to inflate and deploy with comparatively little resistance or inhibition

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from the occupant 20. As shown in dashed lines at 20', the belted occupant's head 124 penetrates the front portion 62 of the air bag 14 and, more specifically, penetrates the surface 70 of the air bag near the top portion 90. The belted occupant's head 124 can also penetrate the top portion 90 of the air bag 14, depending on the size of the occupant and/or the height H_1 of the air bag. The belted occupant's upper torso 126 penetrates the bottom portion 92 of the air bag 14 at the front lobe 120.

[0065] Due to the configuration of the air bag 14, the front portion 62 is deflected by the penetrating occupant 20 in a direction towards the front seat 16 and, thus, the front portion is deflected towards the rear portion 64 of the air bag. Since the space 110 is unpressurized and positioned between the front portion 62 and the rear portion 64, the front portion is deflected into the space and closer to the rear portion. The degree or distance to which the occupant 20' penetrates the air bag 14 can be comparatively or relatively small. The air bag 14 can be configured such that the front portion 62 remains spaced from the rear portion 64 throughout full penetration of the belted occupant 20 into the front portion. To this end, the stiffness of the air bag 14 can be tailored to ensure the volume of the space 110 does not completely disappear when the occupant 20 penetrates the air bag.

[0066] Due to the space 110 between the front and rear portions 62, 64, the restraint forces provided by the lower portions of the air bag 14 are less (softer) than the restraint forces provided by the upper portions because the front portion can deflect into the space in a pivotal or sliding fashion *via* the joining region to the top portion 90. In other words, since the space 110 is not pressurized as it would be in an air bag 14 volume that is continuous throughout the entire depth D_1 the size of the inflatable volume 60 the occupant 20 interacts with is reduced and, thus, restraint by the lower portions of the air bag 14 is initially softer relative to a continuous bag design. If the occupant 20 penetrates the air bag 14 sufficient to

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cause the front portion 62 to contact the rear portion 64, then the restraint by the contacted portions will become stiffer such that engagement of the penetrating occupant 20' with the front seat can be avoided.

[0067] In contrast, the top portion 90 of the air bag 14 extends substantially continuously from the back of the front seat 16 to the occupant 20 with little or no open space. The top portion 90 therefore provides a stiffer restraint to the penetrating occupant's head 124 and upper torso 126 relative to the restraint provided by the lobe 120 to the occupant's lower torso 122. The air bag 14 of the present invention is therefore advantageous in providing variable restraint to the penetrating occupant 20' in order to meet desirable performance criterion.

[0068] Furthermore, due to the vertical configuration of the seams 100, each chamber 102 provides substantially similar restraint along the front portion 62 between its lowermost edge and uppermost edge. Consequently, occupants 20 having different head positions or heights experience similar restraint, regardless of where the head 124 strikes along the height of the front portion 62. The height of each chamber 102 on the front portion 62 can therefore be configured to correspond with the range of possible occupant head 124 locations based upon the expected size(s) of occupants 20 in the rear seat 22.

[0069] If the belted occupant 20 penetrate into the air bag 14 sufficient to cause the front portion 62 to engage the rear portion 64, *i.e.*, the space 110 between the front portion and the rear portion substantially or entirely disappears, the air bag of the present invention produces substantially the same occupant restraint as two smaller volume air bags positioned adjacent and abutting one another in the fore-aft direction. In other words, such a dual air bag configuration would result in substantially the same homogenous occupant 20 restraint as

the single volume air bag 14 of the present invention provided with the unpressurized space 110.

[0070] Engagement of the front portion 62 with the rear portion 64 occurs with larger occupants 20 and/or in higher speed crash events. Consequently, this resulting stiffening of restraint during the later stages of a crash event is advantageous for reducing the possibility of occupant-to-front seat 16 contact. The space 110 of the present invention advantageously allows the air bag 14 to provide variable occupant 20 restraint by region, *i.e.*, head 124 vs. torso 122, 126, as well as restraint that varies, *i.e.*, stiffens, if and when the head 124 and upper torso get close enough to the front seat 16 that the space collapses to at or near zero volume.

[0071] The spaced, moveable chamber configuration of the air bag 14 also overcomes another problem with conventional air bags related to angular occupant movement. Conventional air bags without spaced, moveable chambers typically are deployed directly adjacent to or in engagement with its intended reaction surface. As soon as an occupant engages the conventional air bag (or shortly thereafter), the air bag becomes pinned between the occupant and the reaction surface. At this point, any resistance to lateral shifting of the air bag is significantly reduced or eliminated altogether. As a result, resistance to angular or lateral shifting of the air bag can result in rotational movement of the occupant, especially the occupant's head, and can result in neck injuries.

[0072] According to the spaced, moveable chamber configuration of the air bag 14, the front portion 62 not only can move in the fore-aft direction relative to the rear portion 64, but can also move in angular directions relative to the rear portion. Thus, in events causing the occupant 20 to engage the air bag 14 in a direction other than a purely forward direction, such as an angular or skewed direction, the initially engaged front portion 62, being spaced

from the rear portion 64, can move along with the occupant in his or her angular or skewed direction. This may, for example, be the case in the event of angular or offset vehicle impacts or collisions. This also may be the case where the occupant is positioned away from the normally seated position at the time of the event for which deployment of the air bag 14 occurs.

[0073] Because the front portion is spaced from the rear portion and does not itself contact the reaction surface, it possesses a certain degree of lateral freedom, in addition to fore-aft freedom, to move with respect to the rear portion. Moving with the occupant while initially absorbing impact forces, can help reduce the degree and severity with which impacting the air bag 14 causes rotation of the occupant's head and twisting of the neck.

[0074] The low volume configuration of the air bag 14 also facilitates earlier initiation of restraint since the reduced volume air bag 14 can be positioned and filled more rapidly compared to a continuous volume air bag. There is also the potential to reduce the required size and cost of the inflator 32.

[0075] The inflator 32, top portion 90, front portion 62, and the space 110 of the air bag 14 are sized to provide a volume of inflation fluid sufficient to inflate, deploy, and pressurize the air bag to the inflated condition of Fig. 2 within desired performance parameters. Since the belted occupant 20 is the expected condition, the top portion 90, front portion 62, and space 110 configurations of Fig. 2 help bolster the reliability of the apparatus.

[0076] Furthermore, it will be appreciated that the low volume construction of the air bag 14 of the present invention can allow the air bag to be free of active or adaptive venting while still providing variable restraint for the penetrating occupant 20'. The low volume construction of the air bag 14 of the present invention also allows the height of the front portion 62 of the air bag to be increased sufficient to engage the roof 19 to accommodate

taller occupants without compromising the ability of the air bag to provide variable occupant restraint.

[0077] Referring to Figs. 3A-3C, the construction of the air bag 14 of the present invention is adapted to advantageously conform to various positions of the front seat 16 and/or rear seat 22 to enable the air bag to help protect the occupant 20 of the rear seat based on various front seat conditions. In other words, the air bag 14 of the present invention is operable to help provide similar restraint to the occupant 20 as the distance in the fore-aft direction between the front seat 16 and rear seat 22 varies. The space 110 between the front portion 62 and rear portion 64 of the air bag 14 allows the inflated air bag to exhibit the same general arch shape regardless of the fore-aft distance between the front seat 16 and the rear seat 22.

[0078] As the fore-aft distance between the front seat 16 and the rear seat 22 increases (thereby moving the occupant 20 further from the front seat), the front portion 62 inflates and deploys further away from the rear portion 64 fixed to the front seat. As a result, the size of the space 110 in the fore-aft direction increases, thereby decreasing the height H_1 of the air bag 14. Similarly, as the fore-aft distance between the front seat 16 and the rear seat 22 decreases (thereby moving the occupant 20 closer to the front seat), the front portion 62 deploys closer to the rear portion 64 fixed to the front seat. As a result, the size of the space 110 in the fore-aft direction decreases, thereby increasing the height H_1 of the air bag 14. In other words, the arch shaped configuration of the air bag 14 of the present invention expands or collapses to conform to different spatial relationships between the front and rear seats 16, 22.

[0079] The air bag 14 operates in substantially the same manner regardless of the fore-aft spacing between the front and rear seats 16, 22. The seat back 23 acts as the primary

reaction surface against forward movement of the air bag 14 due to deployment and the penetrating occupant 20'. Consequently, in each case the front portion 62 is fully inflated before it engages the occupant 20 and remains fully inflated during movement towards the occupant and upon engagement with the occupant. The penetrating occupant 20' then causes the front portion 62 to move toward the rear portion 64 while providing restraint to the occupant, which increases once the front and rear portions abut one another to stiffen the air bag 14 as described.

[0080] Fig. 3A illustrates the occupant 20 in the rear seat 22 spaced a first distance d_1 from the front seat 16. This can occur, for example, when the front seat 16 is moved away from the rear seat 22 and towards the instrument panel 36 to accommodate a smaller or shorter front seat occupant 20. In this condition, the fore-aft depth of the air bag 14 is equal to the distance d_1 , with the air bag in an expanded arch shape. The air bag 14 in Fig. 3A has the height H_1 .

[0081] Fig. 3B illustrates an occupant 20 in the rear seat 22 spaced a second distance d_2 from the front seat 16 less than the first distance d_1 . This can occur, for example, when the front seat 16 is moved a distance from the instrument panel 36 to accommodate a normally sized, front seat occupant 20. In this condition, the fore-aft depth of the air bag 14 is equal to the distance d_2 and, thus, the arched air bag 14 in Fig. 3B is condensed in the fore-aft direction relative to the air bag 14 in Fig. 3A. Consequently, the air bag 14 in Fig. 3B has a height H_2 greater than the height H_1 .

[0082] Fig. 3C illustrates an occupant 20 in the rear seat 22 spaced a third distance d_3 from the front seat 16 less than the second distance d_2 . This can occur, for example, when the front seat 16 is moved toward the rear seat 22 and away from the instrument panel 36 to accommodate a larger or taller front seat occupant 20. In this condition, the fore-aft depth of

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the air bag 14 is equal to the distance d_1 and, thus, the arched air bag in Fig. 3C is condensed in the fore-aft direction relative to the air bags in Figs. 3A and 3B. Consequently, the air bag 14 in Fig. 3C has a height H_3 greater than the height H_2 .

[0083] During deployment of the air bag 14 in any of the seat conditions of Fig. 3A-3C, the inflated front portion 62 moves away from the rear portion 64 and toward the rear seat 22 until the surface 70 abuts the occupant 20. At this point, the front portion 62 is fully inflated and the occupant is not penetrating the air bag 14. The occupant 20 can thereafter interact with the deployed air bag 14 in the manner previously described.

[0084] Conventional air bags have only one inflation depth in the fore-aft direction when the air bag is allowed to fully deploy, *i.e.*, when the occupant does not penetrate the air bag. In other words, once the occupant is spaced beyond a predetermined distance from the front seat the conventional air bag fully inflates to the same inflation depth, leaving a gap between the deployed air bag and the occupant. This gap is problematic in that it allows the occupant to gain speed while moving towards the air bag before engaging the same, thereby unnecessarily increasing the degree of restraint needed from the air bag. In other words, these conventional air bags provide delayed restraint of the occupant during the time the occupant moves through the gap into engagement with the air bag. As a result, not only can the occupant gain speed during this time, but the occupant can also move inboard or outboard, causing the occupant to strike the air bag in a less than optimal manner.

[0085] On the other hand, the air bag 14 of the present invention conforms or adapts to the distance between the front seat 16 and the occupant 20 in the rear seat 22 by lengthening or expanding in the fore-aft direction during deployment. This fore-aft movement by the air bag 14 helps to ensure the air bag engages the occupant regardless of the distance between front and rear seats 16, 22. Consequently, no gap exists between the fully

deployed, conforming air bag 14 of the present invention and the occupant 20 of the rear seat 22. As a result, the air bag 14 provides immediate restraint to the penetrating occupant 20', which helps prevent the occupant from speeding up while traveling towards the front seat 16 and helps reduce the chances the occupant moves inboard or outboard during interaction with the air bag.

[0086] Figs. 4A and 4B illustrate an air bag 14a in accordance with another embodiment of the present invention. Certain components in Figs. 4A and 4B are similar or identical to components of Figs. 1-3C. These similar or identical components are given the same reference as Figs. 1-3C. On the other hand, the suffix "a" is added to the reference numbers of components in Figs. 4A and 4B that are dissimilar to the components of Figs. 1-3C to avoid confusion.

[0087] In Figs. 4A and 4B, the lowermost edge of the bottom portion 92 of the air bag 14a is misaligned from the lowermost edge of the top portion 90 relative to the midline 98. As shown, the bottom of the front portion 62 extends below the bottom of the rear portion 64. The inflated air bag 14a is therefore generally curved, having a hook-shaped or U-shaped configuration. As shown in Fig. 4B, the bottom of the front and rear portions 62, 64 extends outward (inboard and outboard) relative to the remainder of the air bag 14a. More specifically, the bottoms of the front and rear portions 62, 64 have a substantially frustoconical shape while the remainder of the air bag 14a is substantially rectangular when viewed from the top. The seams 100 defining the chambers 102 extend in the fore-aft direction along the length of the air bag 14.

[0088] Similar to the air bag 14 of Figs. 1-3C, the restraint forces of the air bag 14a acting on the penetrating occupant 20' are reduced until the front portion 62 and rear portion 64 contact one another. Further occupant 20 penetration into the air bag 14a results in greater

restraint by the air bag. Additionally, the air bag 14a of Figs. 4A-4B automatically expands in the fore-aft direction to the degree necessary to conform to the distance between the occupant 20 and the front seat 16.

[0089] Figs. 5A-5C illustrate an air bag 14b in accordance with another embodiment of the present invention. In Figs. 5A-5C, the bottom portion 92 includes a recess or pocket 125 that helps reduce the size of the inflatable volume 60, thereby allowing a smaller inflator 32 to be used. The bottom of the front portion 62 is enlarged on the inboard and outboard sides of the recess 125. The air bag 14b has a generally rectangular shape when viewed from the top. The bottom of the rear portion 64 attached to the front seat 16 has an enlarged, rounded shape compared to the remainder of the rear portion. The seams 100 defining the chambers 102 extend in the fore-aft direction along the length of the air bag 14b.

[0090] Similar to the air bag 14a of Figs. 4A and 4B, the air bag 14b is generally curved, having a hook-shaped or U-shaped configuration, and the restraint forces of the air bag acting on the penetrating occupant 20' are reduced until the front portion 62 and rear portion 64 contact one another. Further occupant 20 penetration into the air bag 14b results in greater restraint by the air bag. Additionally, the air bag 14a of Figs. 5A-5C automatically expands in the fore-aft direction to the degree necessary to conform to the distance between the occupant 20 and the front seat 16.

[0091] Figs. 6A and 6B illustrate an air bag 14c in accordance with another embodiment of the present invention. In Figs. 6A and 6B, the air bag 14c is generally curved, having a hook-shaped or U-shaped configuration similar to the air bag 14a of Figs. 4A and 4B. The air bag 14c, however, is upside-down compared to the air bag 14a (Fig. 4A) such that the space 110 extends through the top portion 90 towards the bottom portion 92 and terminates at an inner surface 128 of the bottom portion 92. The air bag 14c has a generally

rectangular shape when viewed from the top. The top of the front portion 62 extends above the top of the rear portion 64. Although the front and rear portions 62, 64 are illustrated as being offset from one another in the vertical direction it will be appreciated that the front and rear portions can alternatively be aligned to form a more symmetric arch- or U-shaped air bag 14c (not shown). The seams 100 defining the chambers 102 extend generally in the fore-aft direction along the length of the air bag 14c.

[0092] Similar to the air bag 14 of Figs. 1-3C, the restraint forces of the air bag 14c acting on the penetrating occupant 20' are reduced until the front portion 62 and rear portion 64 contact one another. Further occupant 20 penetration into the air bag 14c results in greater restraint by the air bag. Additionally, the air bag 14c of Figs. 6A and 6B automatically expands in the fore-aft direction to the degree necessary to conform to the distance between the occupant 20 and the front seat 16.

[0093] Figs. 7A-7C illustrate an air bag 14d in accordance with another embodiment of the present invention. In Figs. 7A-7C, the front portion 62 and rear portion 64 are connected together by both the top portion 90 and the bottom portion 92. In other words, the inflated air bag 14d forms a rounded or polygonal loop, with the space 110 extending entirely through the air bag 14d in the inboard-outboard direction. The space 110 therefore does not extend through either the top portion 90 or the bottom portion 92. The seams 100 defining the chambers 102 extend along the portions 62, 64, 90, 92 of the air bag 14d such that the seams encircle the space 110. The seams 100 can extend vertically and/or horizontally to define the chambers 102.

[0094] The air bag 14d can additionally include one or more retaining portions 140 connected to the front portion 62. As shown, the retaining portions 140 constitute inflatable portions that extend from the front surface 70 adjacent each lateral portion 80, 82 of the air

bag 14. Each retaining portion 140 extends lengthwise in the vertical direction along the front portion 62. The retaining portions 140 can extend outward (inboard and outboard) relative to one another or can be parallel to one another (not shown). The retaining portions 140 increase the surface area of the front portion 62 to help protect occupants 20 that move inboard or outboard during penetration into the air bag 14d. The retaining portions 140 help minimize occupant head 124 rotation by accounting for laterally oblique impacts with the air bag 14d.

[0095] Similar to the air bag 14 of Figs. 1-3C, the restraint forces of the air bag 14d acting on the penetrating occupant 20' are reduced until the front portion 62 and rear portion 64 contact one another. Further occupant 20 penetration into the air bag 14d results in greater restraint by the air bag. Additionally, the air bag 14d of Figs. 7A-7C automatically expands in the fore-aft direction to the degree necessary to conform to the distance between the occupant 20 and the front seat 16.

[0096] Figs. 8A-8C illustrate an air bag 14e in accordance with another embodiment of the present invention. In Figs. 8A-8C, the inflated air bag 14e forms a rounded or polygonal loop, with the space 110 extending vertically through the entire air bag 14e. The space 110 therefore does not extend through or to the lateral portions 80, 82 but rather is bounded by the lateral portions. In this embodiment, the retaining portions are omitted but can alternatively be provided on the front portion 62 (not shown). The lateral portions 80, 82 extend outward (inboard and outboard) from the rear portion 64 and outward from one another such that the air bag 14e has a generally triangular shape with rounded corners when viewed from the top. The angle between the lateral portions 80, 82 can be adjusted to meet performance criterion. The front portion 62 is thicker in the fore-aft direction than the rear portion 64. The seams 100 for defining the chambers 102 extend horizontally along each

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portion in the inboard-outboard direction such that the seams encircle the space 110.

Additional seams 100 can extend vertically to further help define and tailor the chambers 102.

[0097] Similar to the air bag 14 of Figs. 1-3C, the restraint forces of the air bag 14e acting on the penetrating occupant 20' are reduced until the front portion 62 and rear portion 64 contact one another. Further occupant 20 penetration into the air bag 14e results in greater restraint by the air bag. Additionally, the air bag 14e of Figs. 8A-8C automatically expands in the fore-aft direction to the degree necessary to conform to the distance between the occupant 20 and the front seat 16.

[0098] Figs. 9A and 9B illustrate an air bag 14f in accordance with another embodiment of the present invention. The air bag 14f is similar to the air bag 14e of Figs. 8A-8C. The air bag 14f, however, includes one or more support members 150 extending between and connecting the lateral portions 80, 82 for maintaining the lateral portions at a predetermined orientation or angle from one another. The support members 150 can constitute or include non-inflatable portions, such as elastic or inelastic tethers or pieces of fabric. The support members 150 can be positioned at the uppermost edge of the air bag 14f and/or at the lowermost edge of the air bag (not shown).

[0099] The support members 150 bring the lateral portions 80, 82 closer to parallel with one another, which increases the stiffness of the air bag 14f. By pulling the lateral portions 80, 82 closer together the inboard-outboard depth of the space 110 is reduced, and the lateral portions extend closer to a direction along the fore-aft direction of the vehicle 12. In this construction the lateral portions 80, 82 are compressed during occupant 20 penetration more along their length, as opposed to being compressed at an angle. The support members 150 also help prevent outward bowing of the lateral portions 80, 82 during occupant 20

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restraint. Alternatively or additionally, the support members 150 can extend between the seams 100 to serve the same purpose (not shown).

[00100] The seams 100 defining the chambers 102 extend horizontally along each portion 62, 64, 80, 82, 90, 92 in the inboard-outboard direction such that the seams encircle the space 110. Additional seams 100 can extend vertically to further help define and tailor the chambers 102. The seams 100 are also configured such that the chambers 102 of the air bag 14f are concave. In other words, the chambers 102 of the air bag 14f curve inwards towards the space 110, thereby reducing the inflated volume of the air bag.

[00101] Similar to the air bag 14 of Figs. 1-3C, the restraint forces of the air bag 14f acting on the penetrating occupant 20' are reduced until the front portion 62 and rear portion 64 contact one another. Further occupant 20 penetration into the air bag 14f results in greater restraint by the air bag. Additionally, the air bag 14f of Figs. 9A-9C automatically expands in the fore-aft direction to the degree necessary to conform to the distance between the occupant 20 and the front seat 16.

[00102] Figs. 10A-and 10B and Figs. 11A-and 11B illustrate air bags 14g, 14h having substantially similar configurations to the air bag 14f of Figs. 9A-9C. The air bags 14g, 14h both include one or more support members 150, with the space 110 in the air bags 14g, 14h being slightly modified from the space 110 in the air bag 14f.

[00103] Figs. 12A-12B illustrate an air bag 14i in accordance with another embodiment of the present invention. In Figs. 12A-12B, the top portion 90 has a greater thickness t_1 , e.g., chamber 102 thickness, than the thickness of either the front portion 62 or the rear portion 64. The increased thickness in the top portion 90 provides greater restraint to the penetrating occupant 20'. The air bag 14i has a generally rectangular shape when viewed from the top. The seams 100 defining the chambers 102 extend in the fore-aft direction along

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the length of the air bag 14b. The seams 100 are configured to provide the top portion 90 with an enlarged volume relative to the volume of the lobes 120. The lobe 120 nearest the occupant 20 has a substantially constant thickness t_2 in the fore-aft direction along its length from the top portion 90 to its lowermost edge adjacent the occupant's lower torso 122.

[00104] Similar to the air bag 14a of Figs. 4A and 4B, the air bag 14i is generally curved, having a hook-shaped or U-shaped configuration and the restraint forces of the air bag acting on the penetrating occupant 20' are reduced until the front portion 62 and rear portion 64 contact one another. Further occupant 20 penetration into the air bag 14i results in greater restraint by the air bag. Additionally, the air bag 14i of Figs. 12A-12B automatically expands in the fore-aft direction to the degree necessary to conform to the distance between the occupant 20 and the front seat 16.

[00105] Referring to Fig. 13, in accordance with another aspect of the present invention, an air bag 14' is configured to be secured to and deployable from the roof 19 of the vehicle 12. Consequently, in this configuration the roof 19 of the vehicle 12 acts as a reaction surface for the deploying air bag 14' and the distance D1 has a component in both the fore-aft direction and a vertical direction. The air bag 14' can constitute any one of the previously described air bags 14-14c. The air bag module 30 is positioned within the roof 19 such that the air bag 14' deploys downward towards the occupant 20 between the front seat 16 and the rear seat 22. The air bag 14' can be similar to the air bags 14-14c in Figs. 1, 4A, 5A or 6A and, thus, the air bag can be hooked, arcuate or U-shaped.

[00106] In any case, the air bag 14' includes the space 110 that allows the deploying air bag to conform to a variety of seat 16, 22 conditions. The airbag 14' can deploy in a direction towards the occupant 20 such that the front portion 62 moves aft in the vehicle relative to the rear portion 64 until the front portion abuts the rear seat occupant. In other

words, the roof-mounted air bag 14' behaves similar to the front seat mounted air bag 14-14c. One or more tethers (not shown) can connect the front portion 62 to the vehicle roof 19 to control deployment of the air bag 14' and movement of the front portion 62 relative to the rear portion 64.

[00107] Figs. 14 and 15 illustrate air bags 14j, 14k configured to be secured to and deployable from the instrument panel 36, with the side 24 constituting the passenger side of the vehicle 12. Consequently, in this configuration the instrument panel 36 acts as a reaction surface for the deploying air bags 14j, 14k. Alternatively, the air bags 14j, 14k can be secured to and deployable from a steering wheel (not shown) on the driver side of the vehicle 12, with the steering wheel thereby acting as the reaction surface. Moreover, it will be appreciated that either air bag 14j or 14k can constitute any one of the previously described air bags 14-14i (not shown).

[00108] Referring to Fig. 14, the air bag module 30 is positioned within the instrument panel 36 such that the air bag 14j deploys in the fore-aft direction towards the occupant 20 between the instrument panel and the front seat 16. The lobe 120 on the rear portion 64 is spaced from the opening 44 in the housing 34 and positioned aft of the instrument panel 36.

[00109] The air bag 14j includes the space 110 that allows the deploying air bag to conform to a variety of front seat 16 conditions relative to the instrument panel 36. The airbag 14j can therefore deploy in a direction towards the front seat occupant 20 such that the front portion 62 moves aft in the vehicle relative to the rear portion 64 until the front portion abuts the occupant. In other words, the instrument panel-mounted air bag 14j of Fig. 14 automatically expands in the fore-aft direction to the degree necessary to conform to the distance between the front seat occupant 20 and the instrument panel 36 reaction surface. Furthermore, similar to the air bags 14-14i of Figs. 1-12B, the restraint forces of the air bag

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14j acting on the penetrating occupant 20' are reduced until the front portion 62 and rear portion 64 contact one another. Further occupant 20 penetration into the air bag 14j therefore results in greater restraint by the air bag.

[00110] Referring to Fig. 15, the air bag module 30 is positioned within the instrument panel 36 such that the air bag 14k deploys in the fore-aft direction towards the occupant 20 between the instrument panel and the front seat 16. The lobe 120 on the rear portion 64 extends through the opening 44 in the housing 34 and towards the roof 19 of the vehicle 12.

[00111] The air bag 14k includes the space 110 that allows the deploying air bag to conform to a variety of front seat 16 conditions relative to the instrument panel 36. The airbag 14k can deploy in a direction towards the front seat occupant 20 such that the front portion 62 moves aft in the vehicle relative to the rear portion 64 until the front portion abuts the front seat occupant. In other words, the instrument panel-mounted air bag 14k of Fig. 15 automatically expands in the fore-aft direction to the degree necessary to conform to the distance between the front seat occupant 20 and the instrument panel 36 reaction surface.

[00112] Furthermore, similar to the air bags 14-14j of Figs. 1-12B and 14, the restraint forces of the air bag 14k acting on the penetrating occupant 20' are reduced until the front portion 62 and rear portion 64 contact one another. Further occupant 20 penetration into the air bag 14k therefore results in greater restraint by the air bag.

[00113] Figs. 16A-20B illustrate different implementations of the air bag configurations described herein. The implementations illustrated in these figures illustrate various locations in the vehicle where the air bag module/housing can be mounted and the general configurations and orientations of the air bags that can be implemented at those locations. The air bag configurations illustrated in Figs. 16A-20B are illustrative of these general module/housing mounting locations and general air bag configurations and

orientations only. The illustrations of these components in Figs. 16A-20B are not meant to be limiting as to the specific locations, configurations, shapes, sizes, and extents shown in these figures. The air bag illustrated in Figs. 16A-20B can have any of the configurations described in conjunction with any of the embodiments described herein above, as long as those configurations are consistent with the general implementation shown in each respective general implementation.

[00114] Figs. 16A-16B illustrate seat and instrument panel mounting locations for the air bag module and potential general air bag configurations that can be implemented at those mounting locations. In Figs. 16A-16B, to help protect the occupant 20 of the front seat 16 on the passenger side 28 of the vehicle 12, the air bag module 30m is mounted in the instrument panel 36. To help protect the passenger 20 of the rear seat 22, driver or passenger side, the air bag module 30m is mounted in the seatback 23 of the seat positioned in front of the rear seat passenger (passenger side in Figs. 16A-16B). In Fig. 16A, the air bags 14m have inverted curved hook or U-shaped configurations similar or identical to those described herein above. In Fig. 16B, the air bags 14m have generally upward facing curved hook or U-shaped configurations similar or identical to those described herein above.

[00115] Figs. 17A-17B illustrate seat and instrument panel mounting locations for the air bag module and potential general air bag configurations that can be implemented at those mounting locations. In Figs. 17A-17B, the illustrated occupant can be a passenger seated anywhere except in the driver seat. The illustrations in these figures of certain vehicle structure is therefore illustrated schematically so as to be generic to these different vehicle seating locations.

[00116] Fig. 17A illustrates a laterally extending generally curved hook or U-shaped air bag 14n that can be similar or identical to those described herein above. Where the

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occupant 20 is seated in the front seat 16 on the passenger side of the vehicle 12, the module 30n is mounted in the instrument panel 36 and the hook or U-shape of the air bag 30n extends concavely inboard. Where the occupant 20 is seated in a rear seat 16 on the passenger side of the vehicle, the module 30n is mounted in the seatback 23 positioned in front of the occupant 20 and the hook or U-shape of the air bag 30n extends concavely inboard. Where the occupant 20 is seated in a rear seat 16 on the driver side of the vehicle, the module 30n is mounted in the seatback 23 positioned in front of the occupant 20 and the hook or U-shape of the air bag 30n extends concavely outboard.

[00117] Fig. 17B illustrates a laterally extending generally curved hook or U-shaped air bag 14n that can be similar or identical to those described herein above. Where the occupant 20 is seated in the front seat 16 on the passenger side of the vehicle 12, the module 30n is mounted in the instrument panel 36 and the hook or U-shape of the air bag 30n extends concavely outboard. Where the occupant 20 is seated in a rear seat 16 on the passenger side of the vehicle, the module 30n is mounted in the seatback 23 positioned in front of the occupant 20 and the hook or U-shape of the air bag 30n extends concavely outboard. Where the occupant 20 is seated in a rear seat 16 on the driver side of the vehicle, the module 30n is mounted in the seatback 23 positioned in front of the occupant 20 and the hook or U-shape of the air bag 30n extends concavely inboard.

[00118] Figs. 18A-18B illustrate roof mounting locations for the air bag module and potential general air bag configurations that can be implemented at those mounting locations. In Figs. 18A-18B, to help protect the occupant 20 of the front seat 16 on the passenger side 28 of the vehicle, the air bag module 30p is mounted in the vehicle roof 19, above the instrument panel 36 adjacent or near the windshield 38. To help protect the passenger 20 of the rear seat 22, driver or passenger side, the air bag module 30p is mounted in the vehicle

roof 19 generally above the space between the rear seat passenger and the seat positioned in front of that passenger. In Fig. 18A, the air bags 14p have upward facing curved hook or U-shape configurations, similar or identical to those described herein above. In Fig. 16B, the air bags 14p have generally inverted curved hook or U-shape configurations, similar or identical to those described herein above.

[00119] Figs. 19A-19B illustrate additional roof mounting locations for the air bag module and potential general air bag configurations that can be implemented at those mounting locations. In Figs. 19A-19B, the air bag module 30r and air bag 14r help protect the occupant 20 of the front seat 16 on the driver side 24 of the vehicle 12. In these figures, the air bag module 30r is mounted in the vehicle roof 19, adjacent or near the windshield 38 and above the instrument panel 36 and steering wheel 48. In Fig. 19A, the air bag 14r has an upward facing curved hook or U-shape configuration, similar or identical to those described herein above. In Fig. 19B, the air bag 14r has a generally inverted curved hook or U-shape configuration, similar or identical to those described herein above.

[00120] Figs. 20A-20B illustrate roof mounting locations for the air bag module and potential general air bag configurations that can be implemented at those mounting locations. In Figs. 20A-20B, the illustrated occupant can be a passenger seated anywhere in the vehicle 12, driver side 24 or passenger side 28, including driver seat. The illustrations in these figures of certain vehicle structure is therefore illustrated schematically so as to be generic to these different vehicle seating locations.

[00121] Fig. 20A illustrates a laterally extending generally curved hook or U-shaped air bag 14s that can be similar or identical to those described herein above. The module 30s is mounted in the vehicle roof 19. Where the occupant 20 is seated on the passenger side of the vehicle 12, the hook or U-shape of the air bag 30s extends concavely outboard. Where the

occupant 20 is seated on the driver side of the vehicle, the hook or U-shape of the air bag 30s extends concavely inboard.

[00122] Fig. 20B illustrates a laterally extending generally curved hook or U-shaped air bag 14s that can be similar or identical to those described herein above. The module 30s is mounted in the vehicle roof 19. Where the occupant 20 is seated on the passenger side of the vehicle 12, the hook or U-shape of the air bag 30s extends concavely inboard. Where the occupant 20 is seated on the driver side of the vehicle, the hook or U-shape of the air bag 30s extends concavely outboard.

[00123] From the above description of the invention, those skilled in the art will perceive improvements, changes and modifications. For example, the operational and functional advantages of the air bag constructions described herein with regard to any specific example embodiment of the invention can be realized with any of the variations described with regard to the other example embodiments described herein. These and other such improvements, changes and modifications within the skill of the art are intended to be covered by the appended claims.

Having described the invention, the following is claimed:

1. An apparatus for helping to protect an occupant of a vehicle having a seat for receiving the vehicle occupant, the apparatus comprising:

an inflatable vehicle occupant protection device inflatable from a stored condition to a deployed condition in which the protection device is inflated and positioned between a reaction surface of the vehicle and any occupant of the vehicle seat, the protection device comprising:

a rear portion positioned adjacent or near the reaction surface when the protection device is in the inflated and deployed condition; and

a front portion positioned between the rear portion and any occupant of the vehicle seat when the protection device is in the inflated and deployed condition, the front and rear portions having a spaced configuration in which there is an open space outside the inflatable volume between the front and rear portion when in the inflated and deployed condition, wherein the front portion can move relative to the rear portion into the open space in response to occupant penetration and against pressurization forces within the protection device.

2. The apparatus recited in claim 1, wherein the front portion is configured to be moveable relative to the rear portion in fore-aft directions and in lateral directions.

3. The apparatus recited in claim 1, wherein the front portion of the protection is configured to provide a first degree of restraint to occupant penetration due primarily to pressurization forces when the front portion is spaced from the rear portion, the protection device providing a second degree of restraint to occupant penetration, greater than the first

degree of restraint, in response to the penetrating occupant moving the front portion into engagement with the rear portion.

4. The apparatus recited in claim 3, wherein the first degree of restraint is sufficient to absorb some of the initial impact forces of the penetrating occupant while at the same time permitting the front portion to move relative to the rear portion.

5. The apparatus recited in claim 3 further comprising seams that control the inflated depth of the front and rear portions to define different chamber within the front and rear portions, the chambers being configured to provide different degrees of resistance to occupant penetration.

6. The apparatus recited in claim 1, wherein the protection device further comprises a connecting portion positioned between the front and rear portions, the connecting portion interconnecting the front portion and the rear portion at one of the upper, lower, inboard, and outboard extents of the front and rear portions, such that the protection device is has a generally curved U-shaped or hook-shaped configuration when in the inflated and deployed condition.

7. The apparatus recited in claim 6, wherein the connecting portion comprises a central portion of the generally U-shaped or hook-shaped configuration and the front and rear portions comprise the portions that extend from the central portion to complete the generally U-shaped or hook shaped configuration and thereby space the front and rear portions from each other.

8. The apparatus recited in claim 6, wherein the front and rear portions each have an inflated thickness measured in the fore-aft direction between respective pairs of opposing

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panels that define each of their respective inflatable volumes, a rear panel of the front portion engaging a front panel of the rear portion when the front panel is deflected into engagement with the rear portion.

9. The apparatus recited in claim 1 further comprising a pair of connecting portions that interconnect either upper and lower portions of the front and rear portions, or inboard and outboard portions of the protection device, the protection device thereby taking the form of a closed loop wherein the space extends centrally through the protection device and is bounded by the closed loop defined by the protection device.

10. The apparatus recited in claim 9 further comprising at least one non-inflatable support member extending between the connecting portions for maintaining the connecting portions at a predetermined position relative to one another.

11. The apparatus recited in claim 10, wherein the at least one non-inflatable support member comprises a pair of non-inflatable support members on opposing sides of the space for maintaining the connecting portions substantially parallel to one another when the protection device is in the deployed condition.

12. The apparatus recited in claim 1 further comprising a pair of inflatable retaining portions that extend laterally outward from opposite lateral sides of the front portion.

13. The apparatus recited in claim 1, wherein the protection device has a substantially triangular shape when viewed from the top.

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14. The apparatus recited in claim 6, wherein the protection device has a generally inverted U-shaped configuration, and wherein the lower extent of the front portion extends vertically below the lower extent of the rear portion.

15. The apparatus recited in claim 1, further comprising a pocket that extends into the front portion towards the rear portion.

16. The apparatus recited in claim 1, wherein the seat is a rear seat of the vehicle, the protection device being stored in a seat back positioned forward of the seat and being deployable between the occupant and a seat back such that the seat back acts as a reaction surface for the protection device.

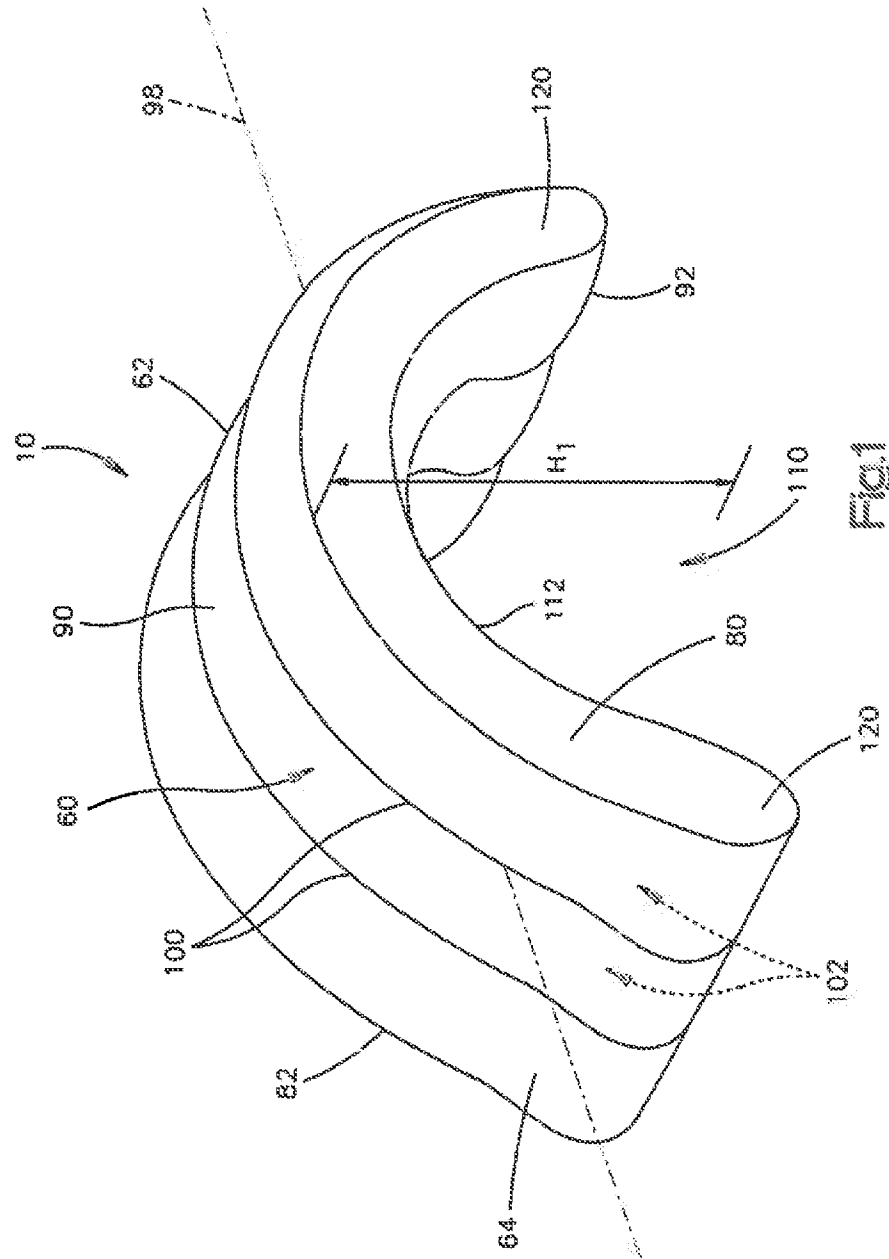
17. The apparatus recited in claim 1, wherein the seat is a rear seat of the vehicle, the protection device being stored in a roof of the vehicle and being deployable between the occupant and a seat back positioned forward of the occupant's seat such that the seat back acts as a reaction surface for the protection device.

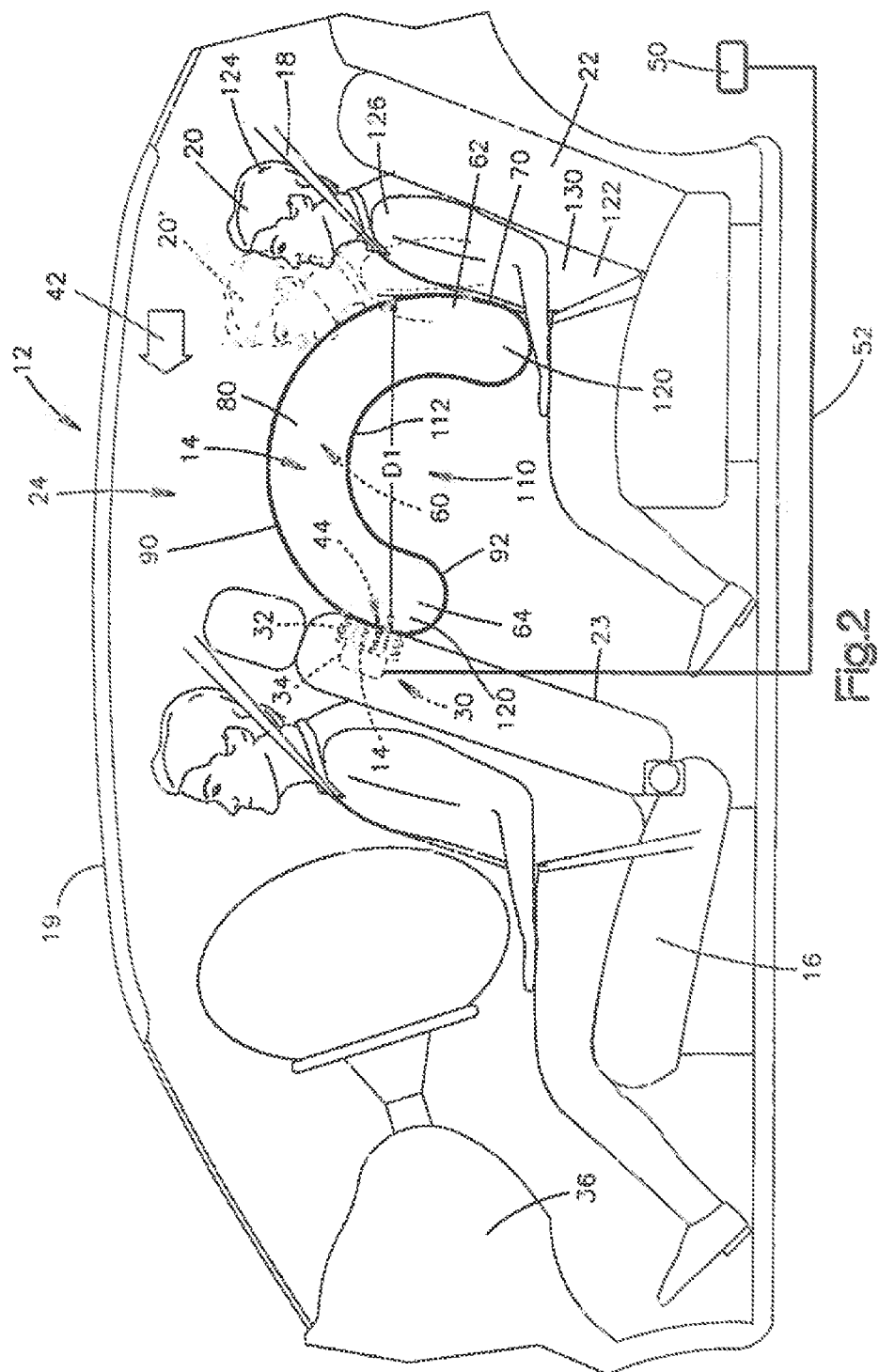
18. The apparatus recited in claim 1, wherein the seat is a front seat of the vehicle, the protection device being stored in an instrument panel of the vehicle and being deployable between the occupant and the instrument panel such that the instrument panel acts as a reaction surface for the protection device.

19. The apparatus recited in claim 1, wherein the seat is a front seat of the vehicle, the protection device being stored in a roof of the vehicle and being deployable between the occupant and an instrument panel of the vehicle such that the instrument panel acts as a reaction surface for the protection device.

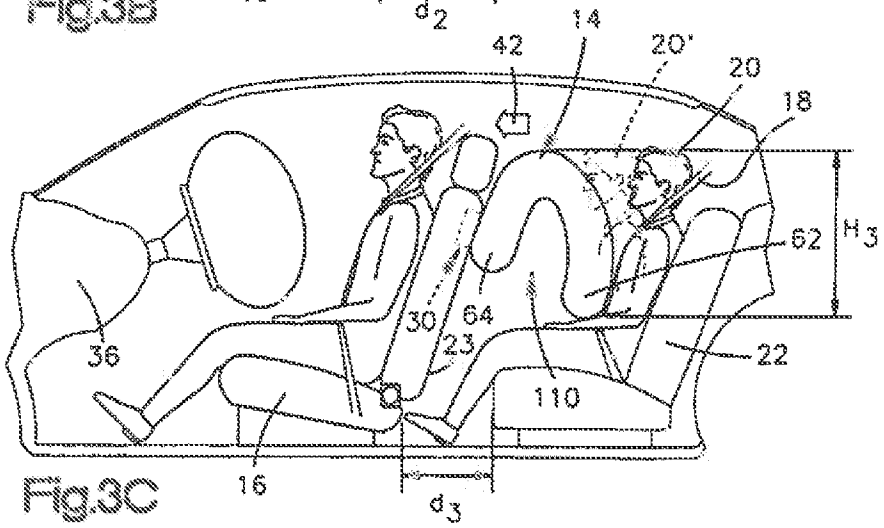
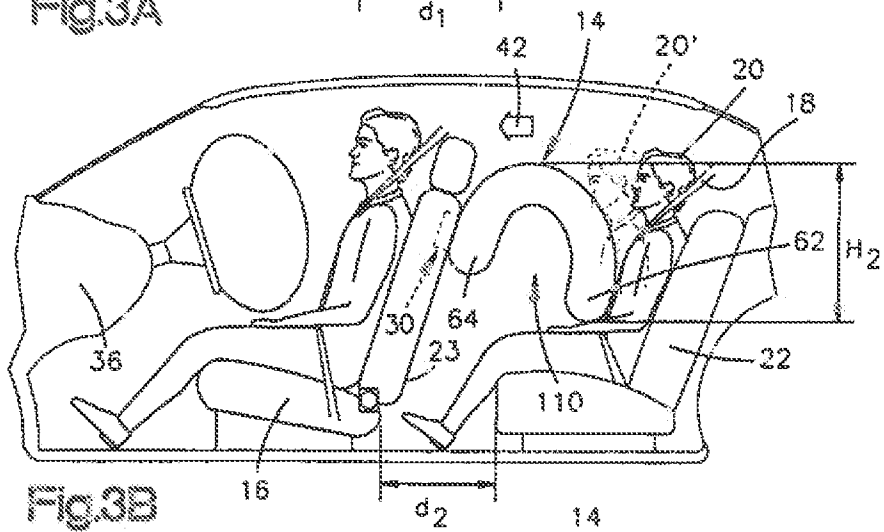
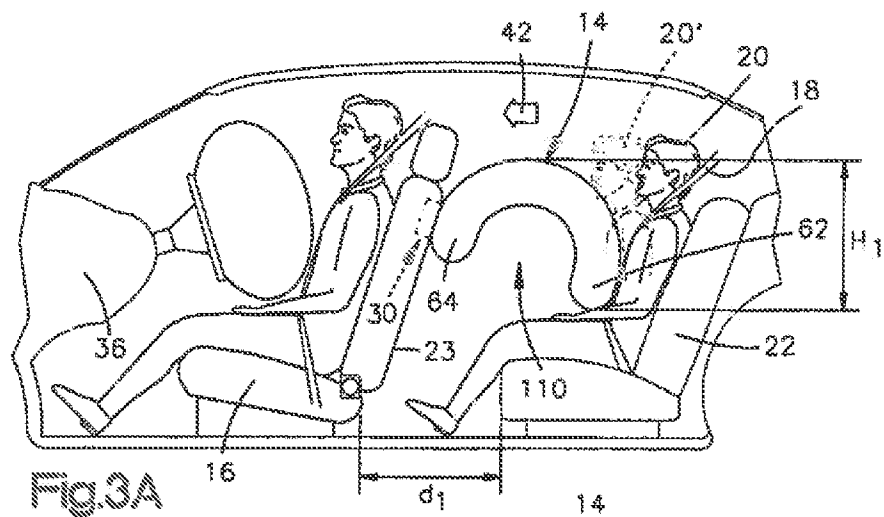
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20. The apparatus recited in claim 1, wherein the seat is a driver seat of the vehicle, the protection device being stored in a roof of the vehicle and being deployable between the occupant and a steering wheel of the vehicle such that the steering wheel acts as a reaction surface for the protection device.

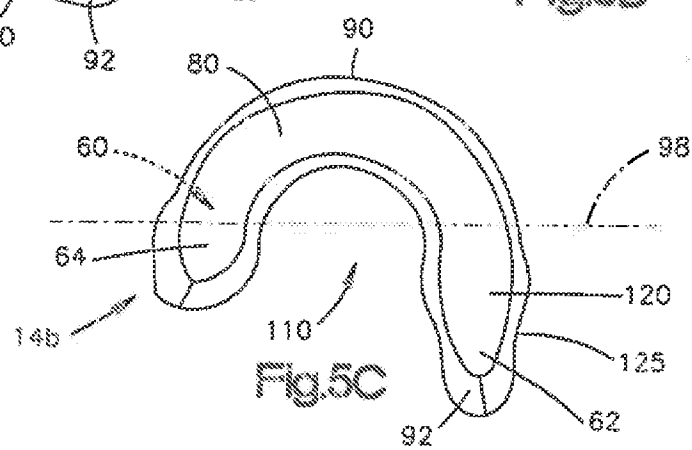
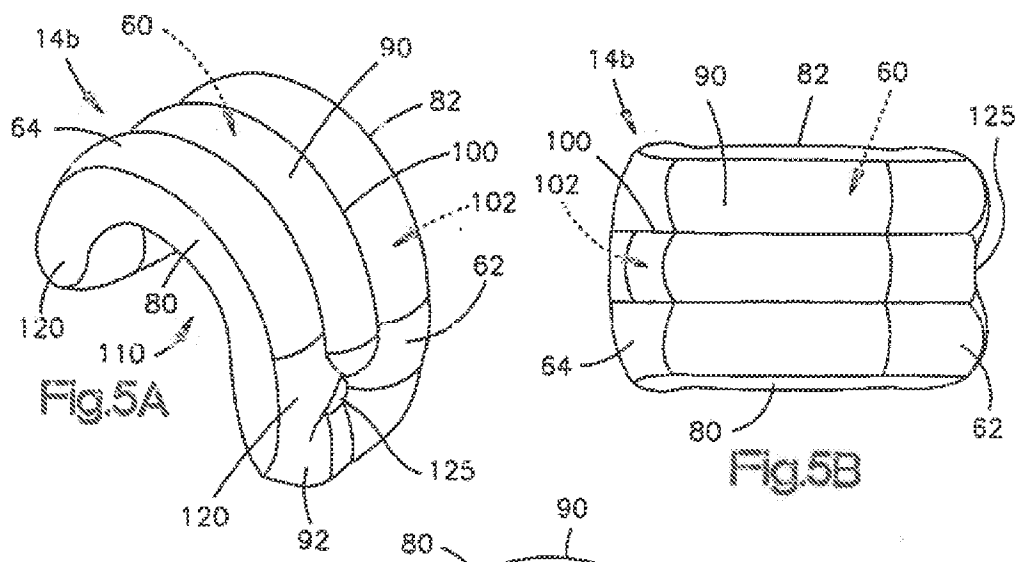
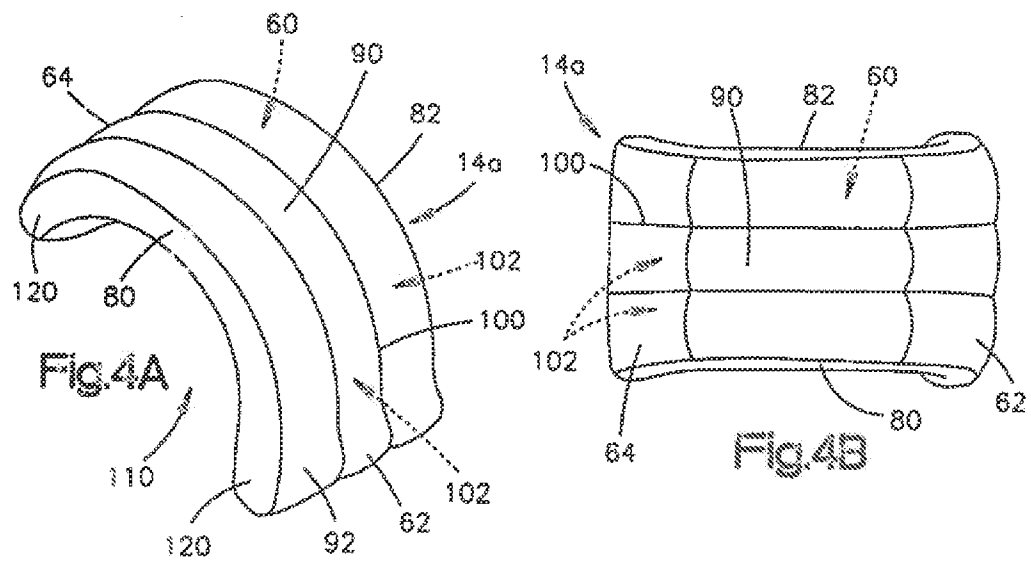




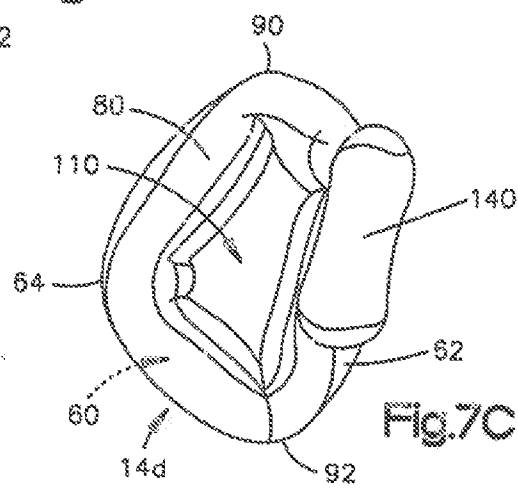
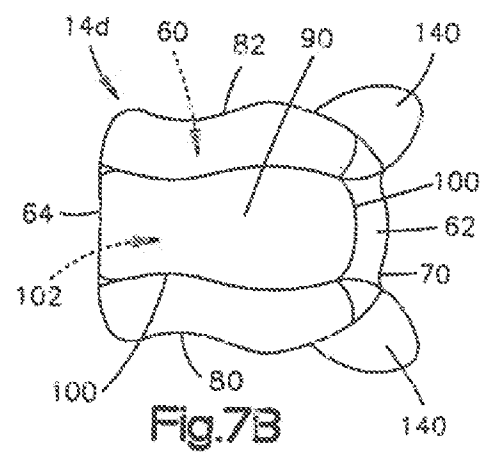
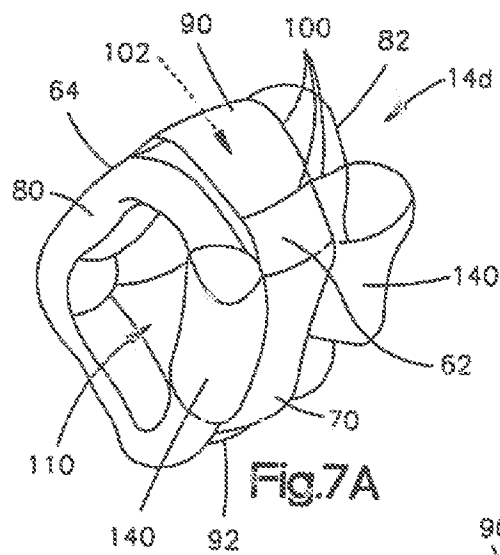
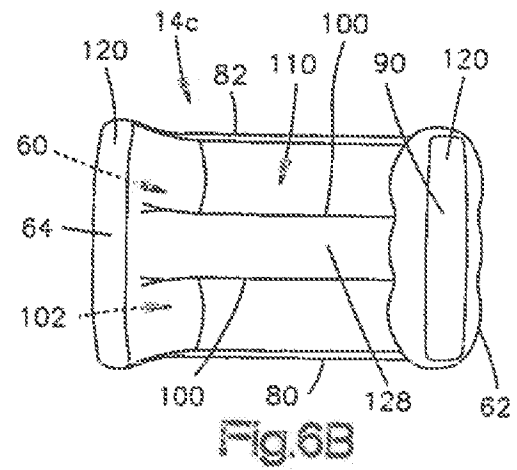
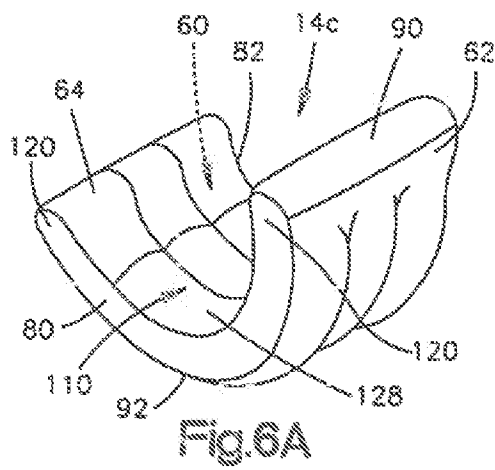
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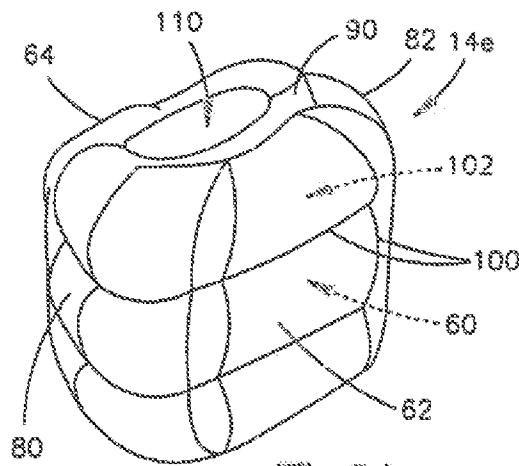


Fig. 8A

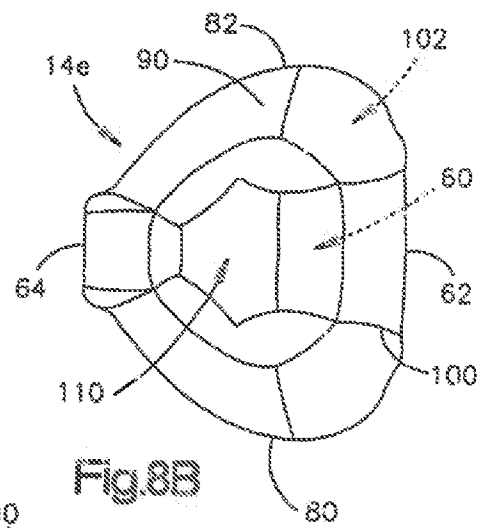


Fig. 8B

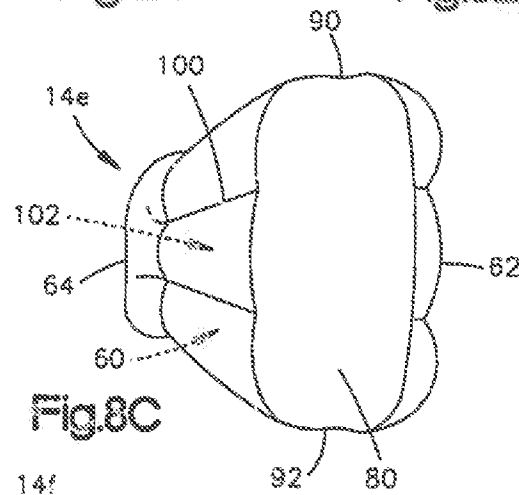


Fig. 8C

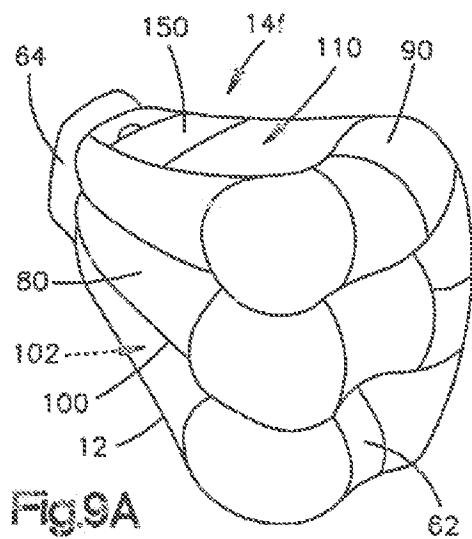


Fig. 9A

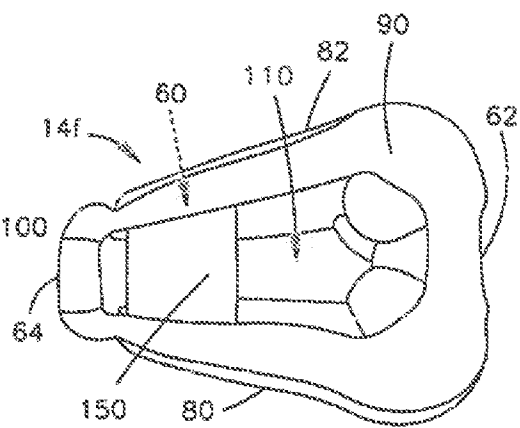
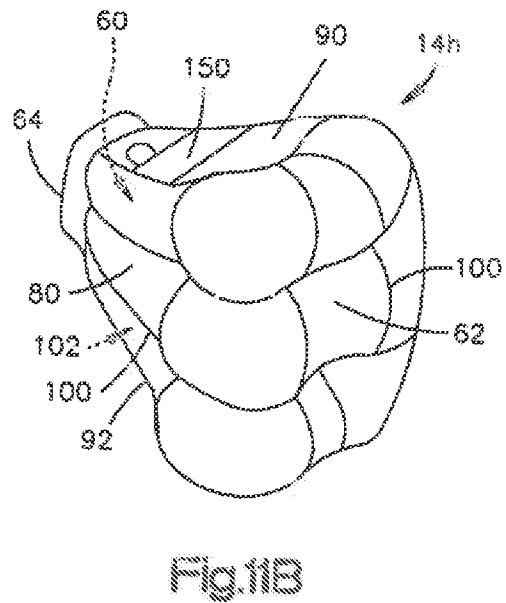
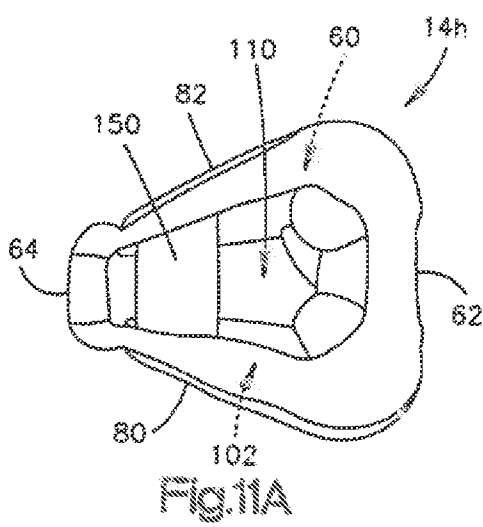
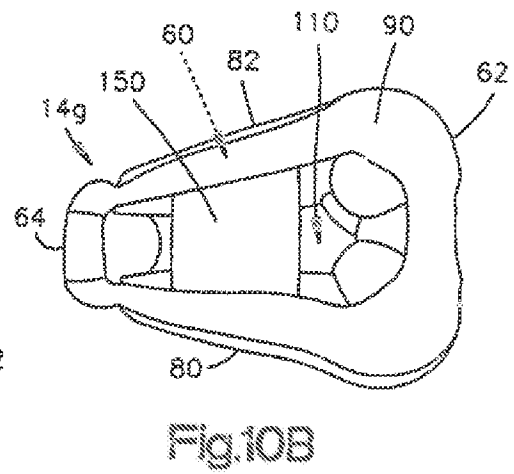
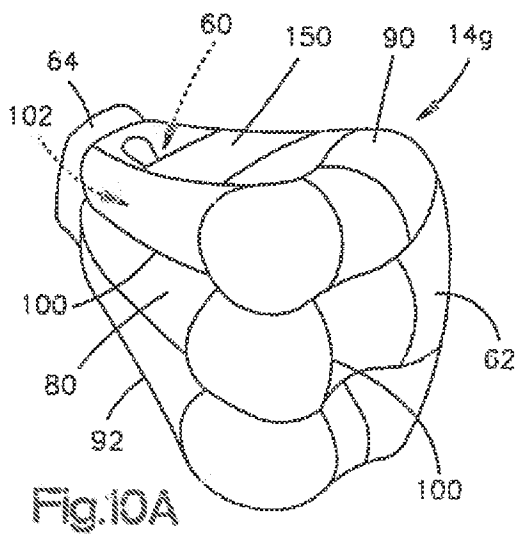
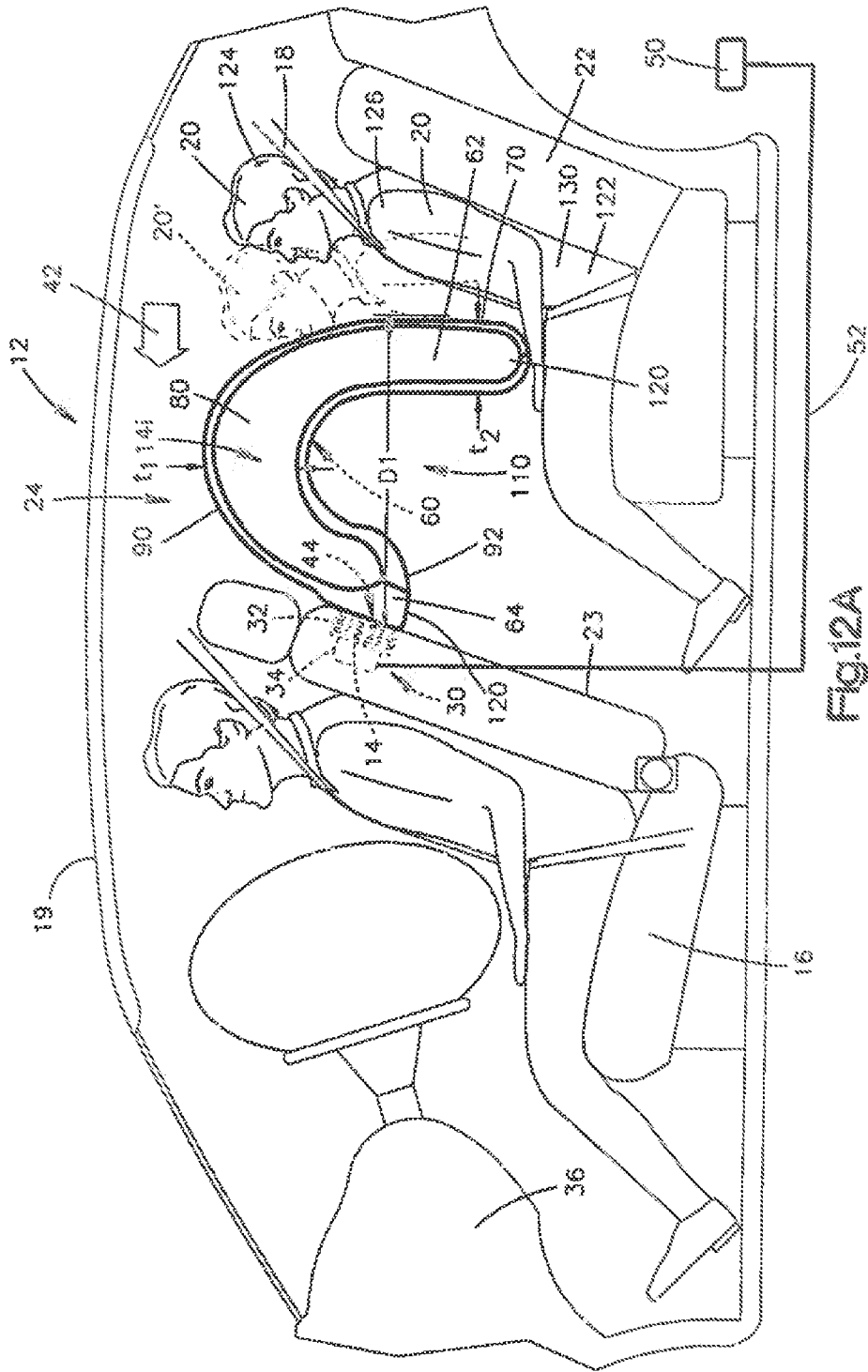


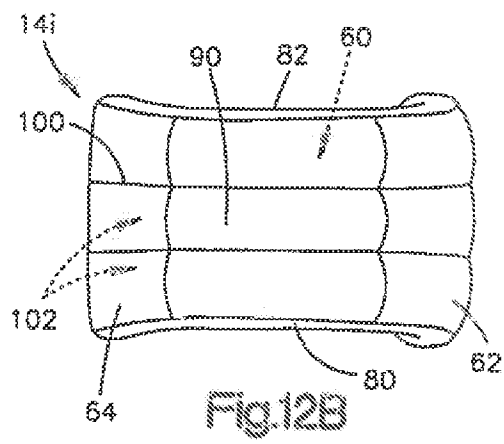
Fig. 9B

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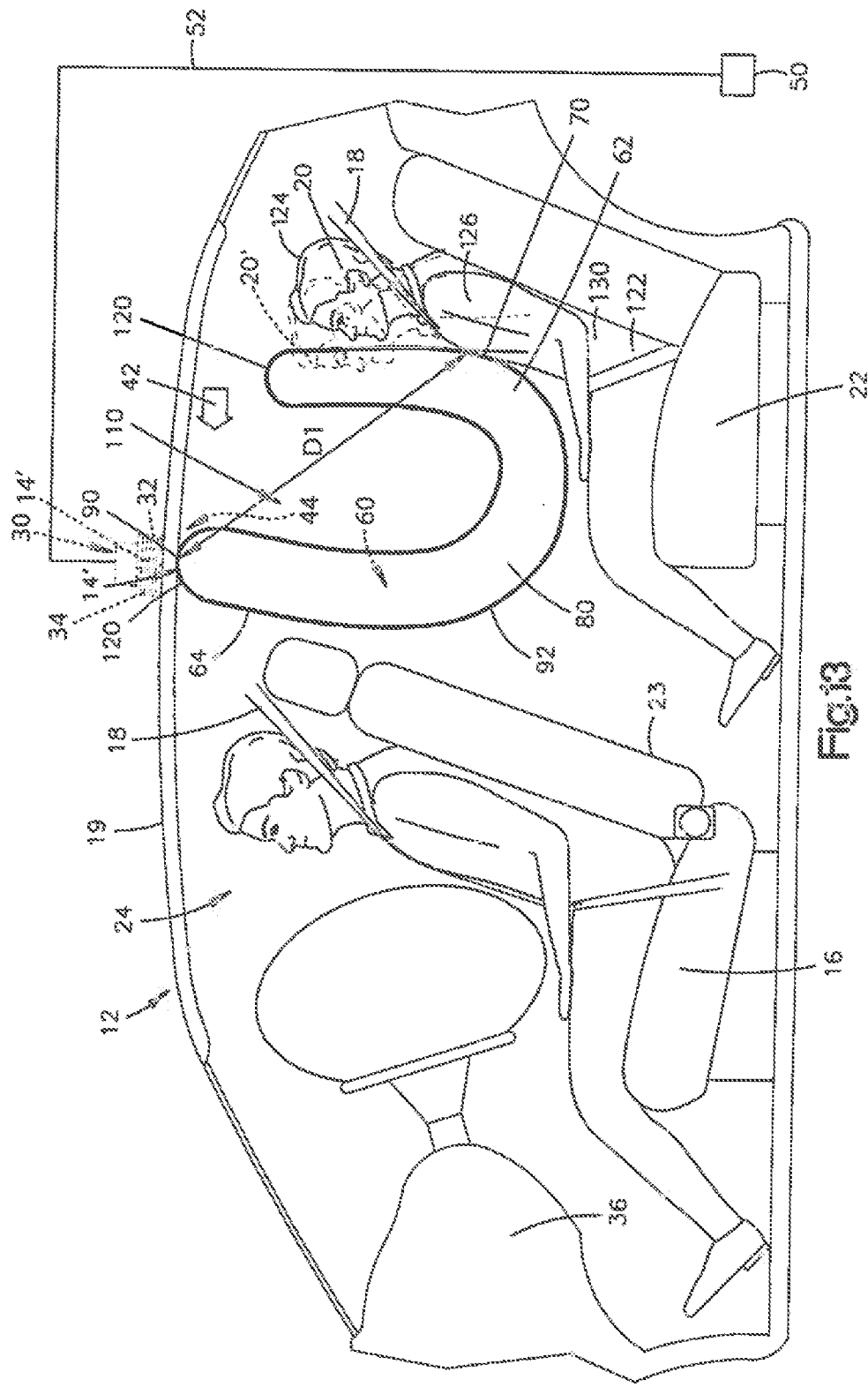
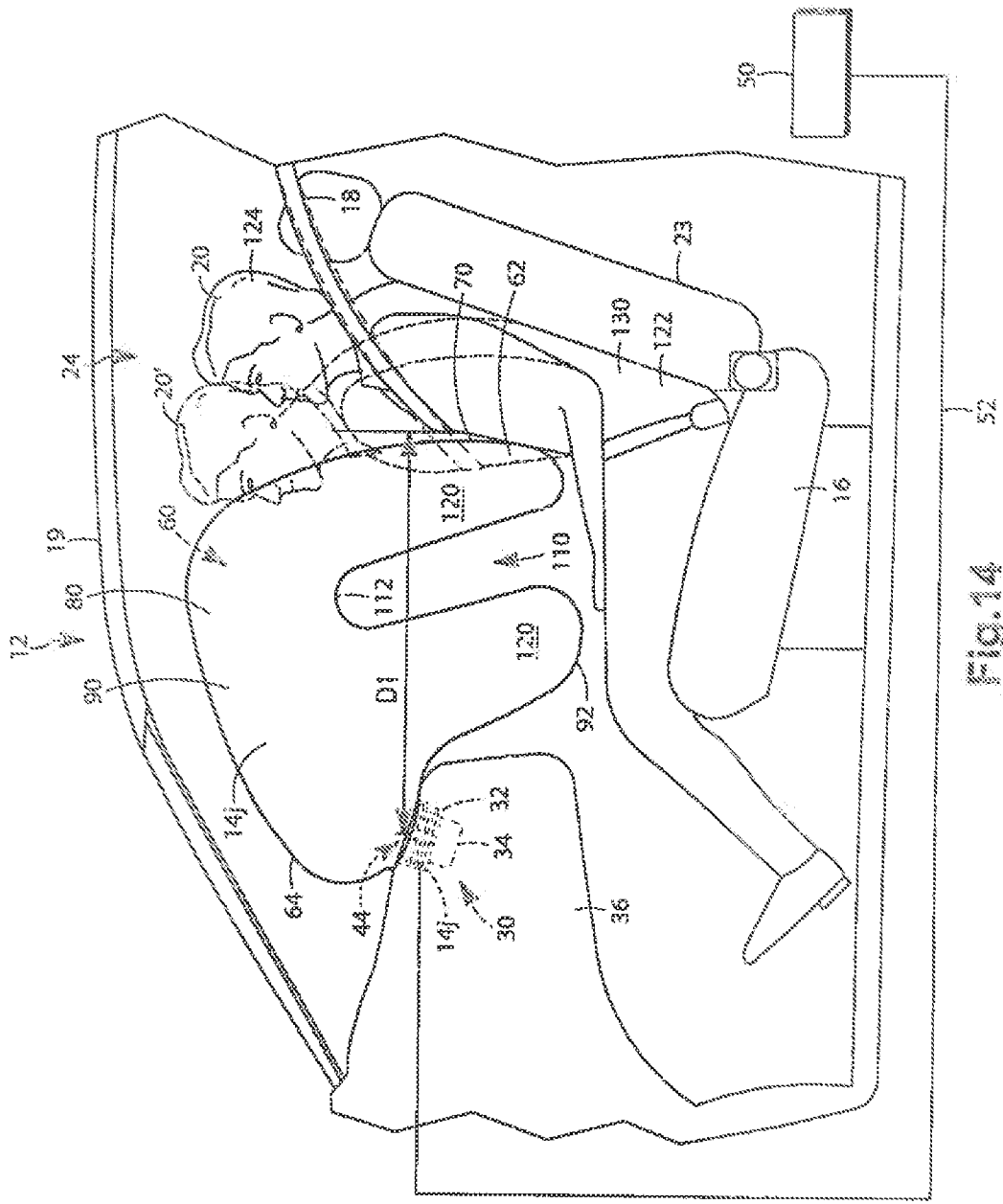


FIG. 13



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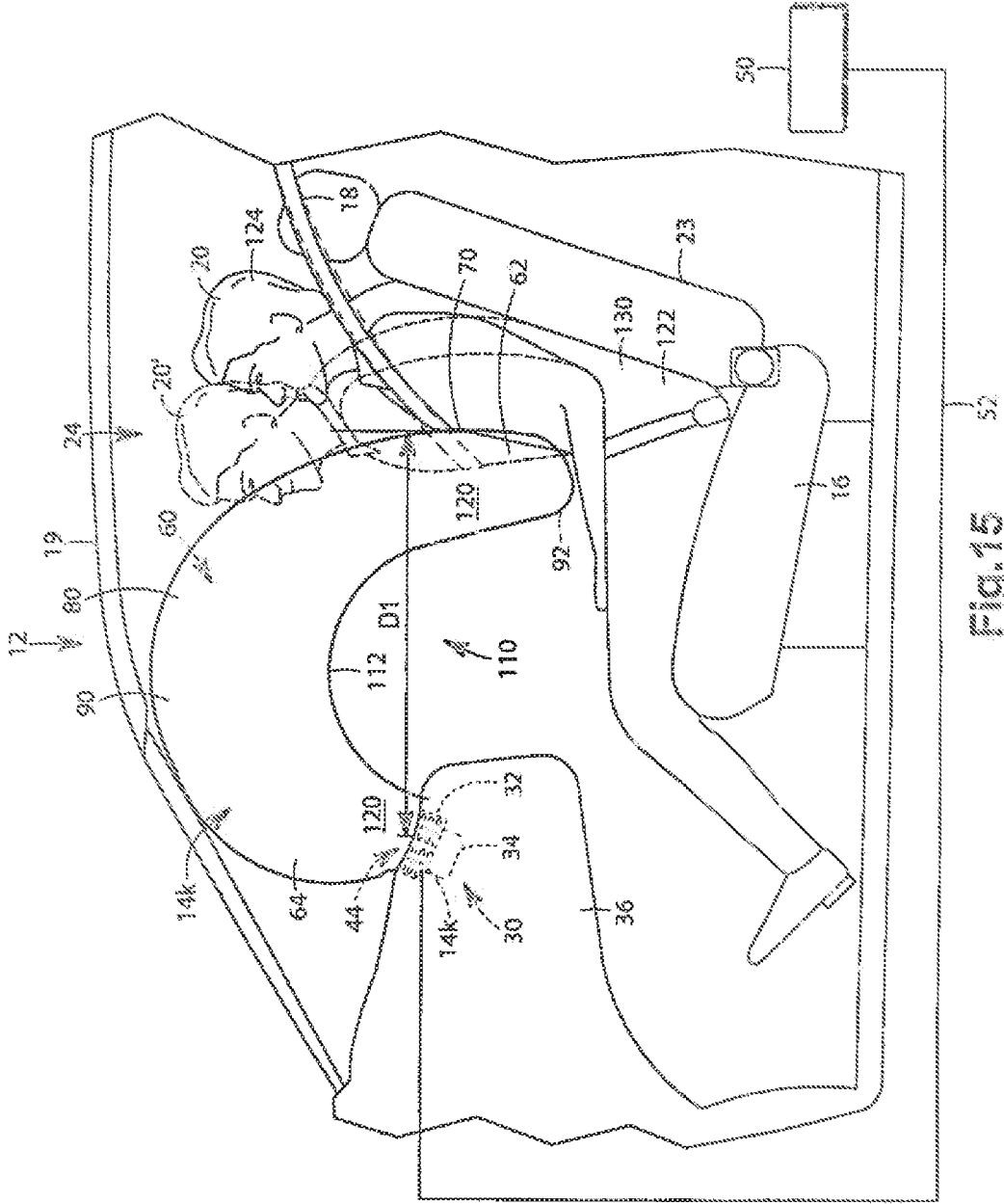
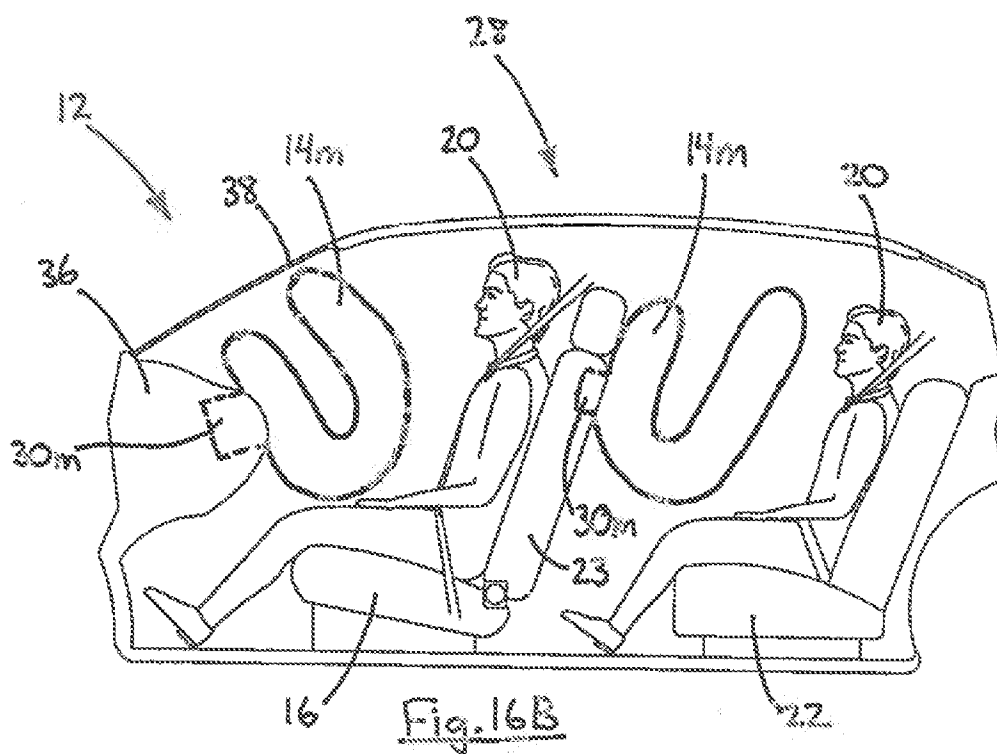
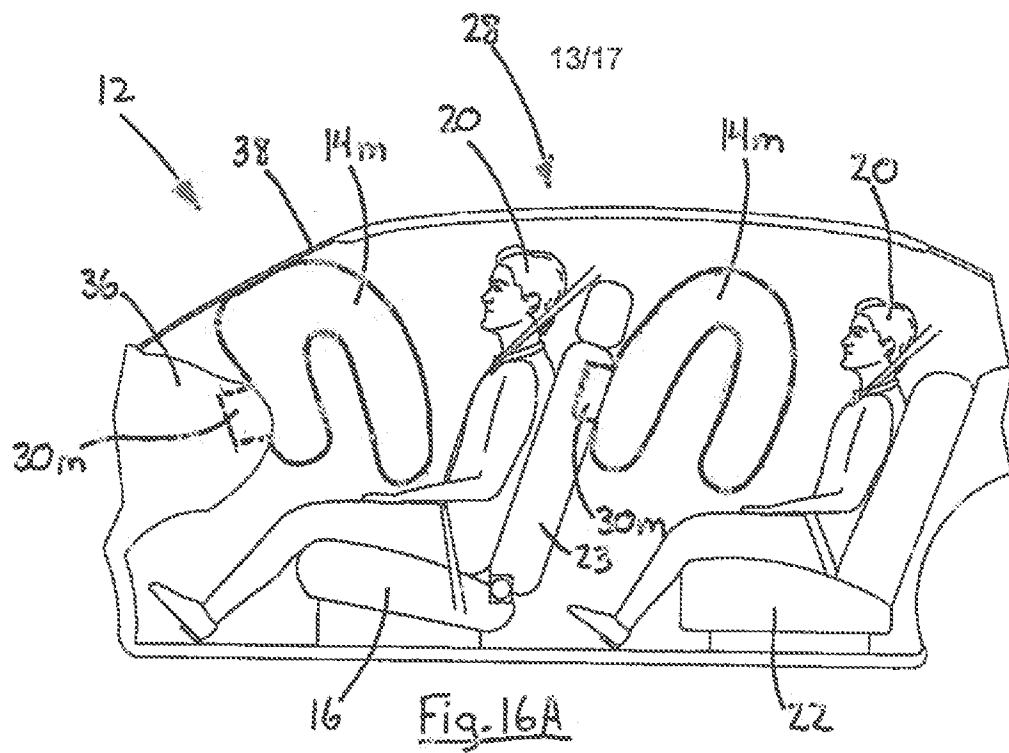
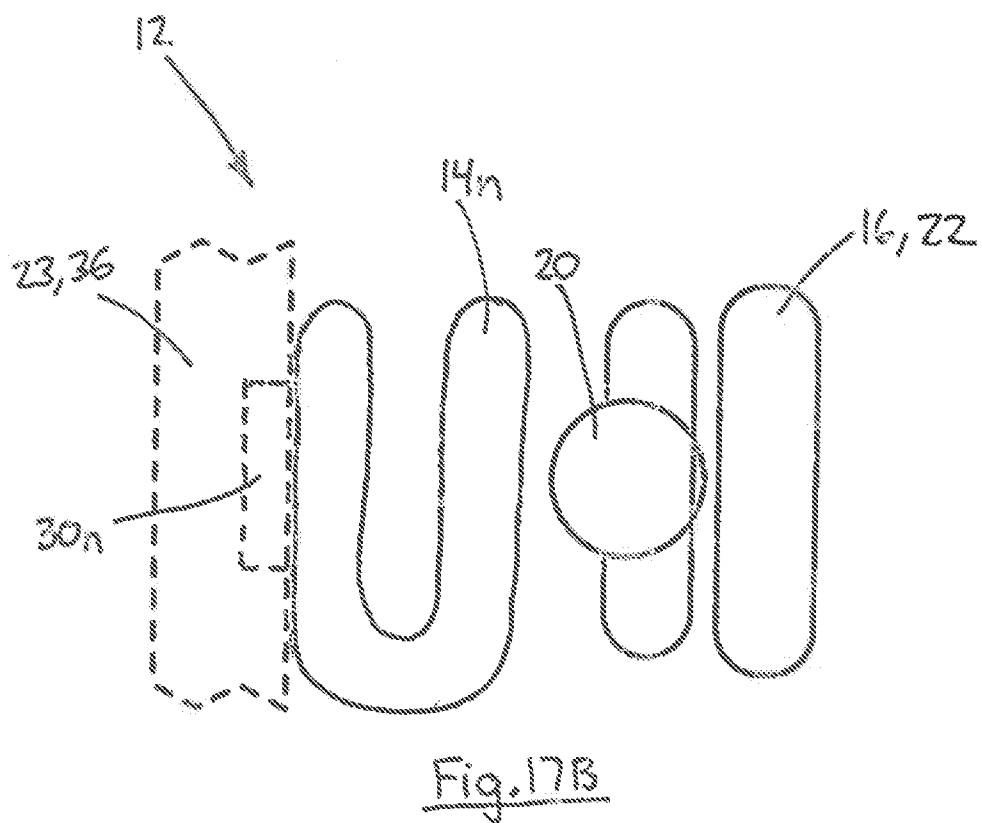
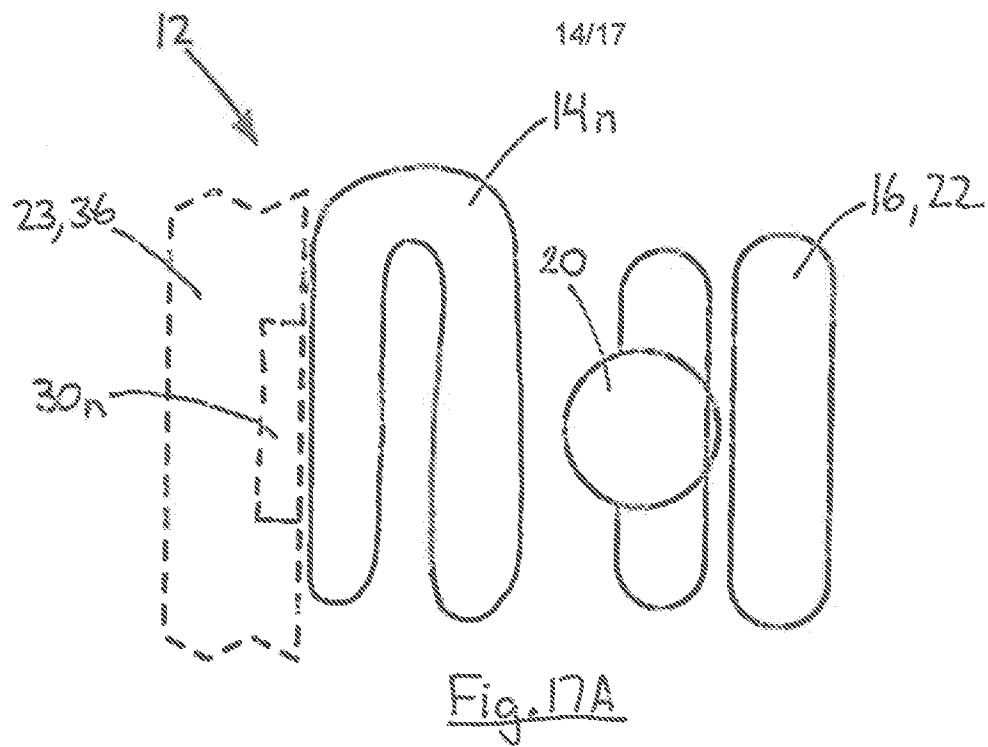
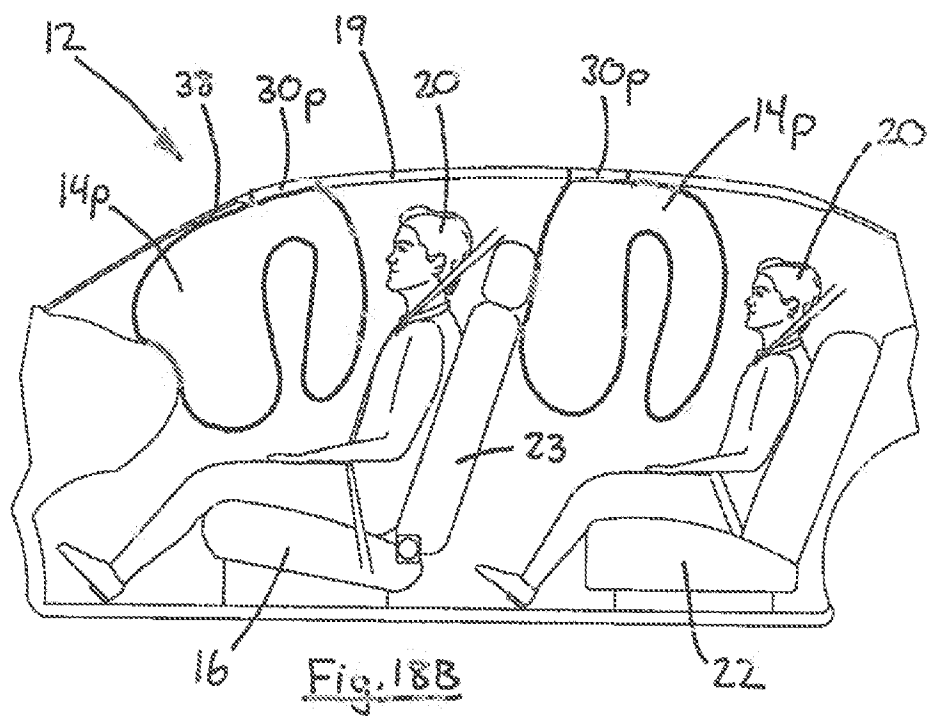
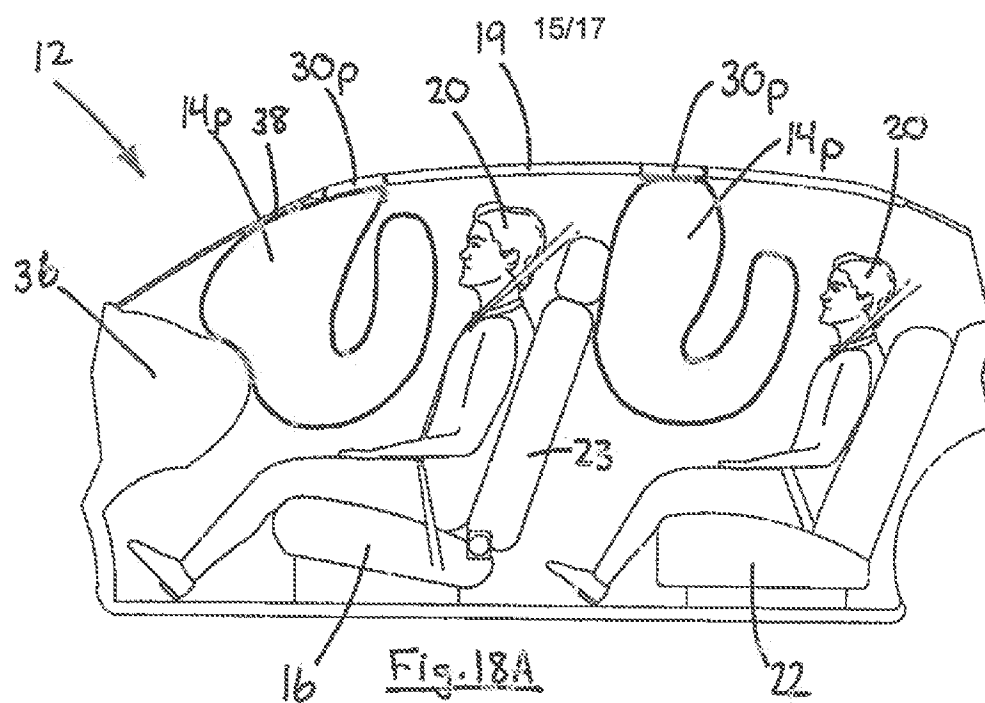
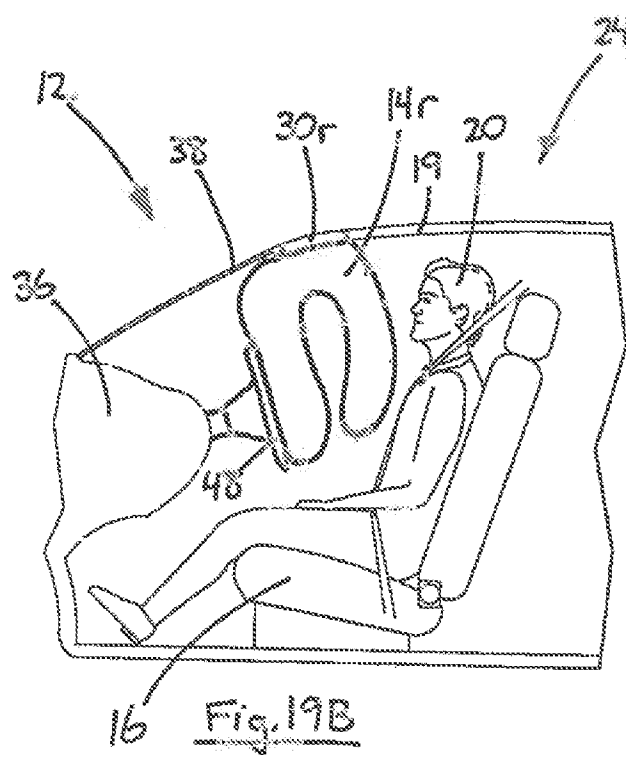
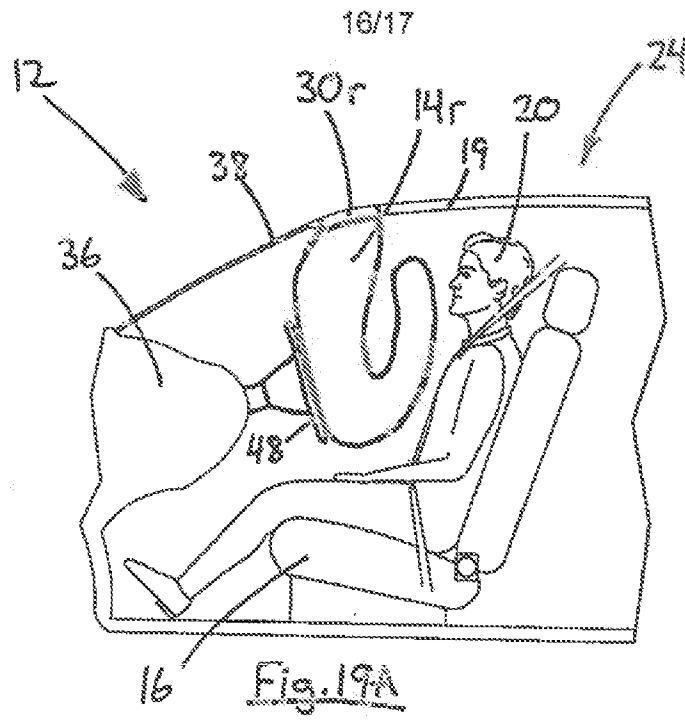


Fig. 15









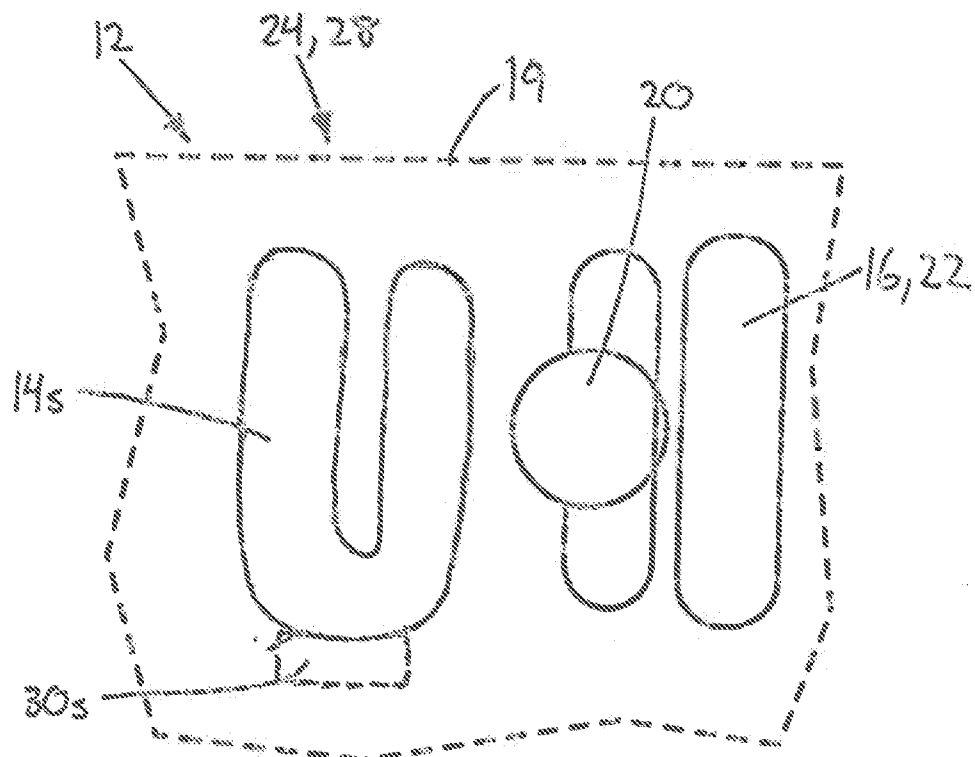


Fig. 20A

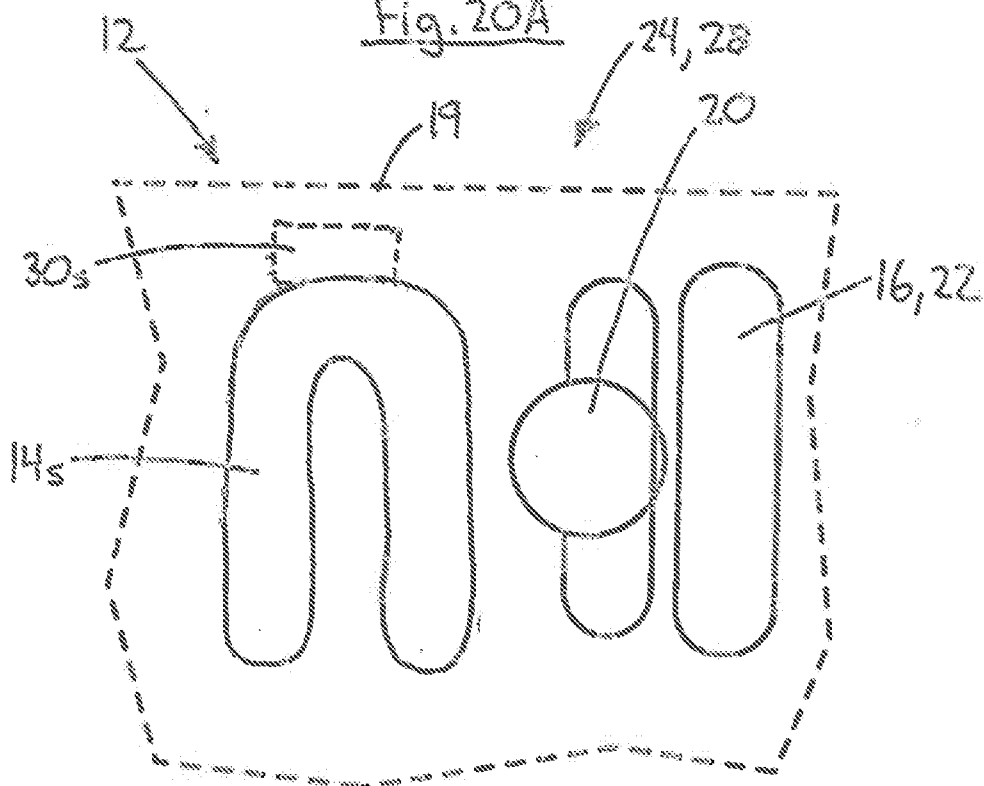


Fig. 20B

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2015/056543

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - B60R 21/231 (2015.01)

CPC - B60R 2021/23153 (2015.12)

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(8) - B60R 21/00, 21/02, 21/16, 21/20, 21/203, 21/205, 21/207, 21/213, 21/214, 21/231 (2015.01)

CPC - B60R 21/00, 21/02, 21/16, 21/20, 21/203, 21/205, 21/207, 21/2078, 21/21, 21/213, 21/214, 21/23, 21/231, 2021/23153 (2015.12)

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

USPC - 280/727, 728.1, 729, 730.1, 731, 732, 743.1, 743.2 (Keyword delimited)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Orbit, Google Patents, Google.

Search terms used: airbag, roof, u-shaped, restraint, loop, back, seat, passenger, wheel, vehicle.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2012/0193896 A1 (TURNBULL et al) 02 August 2012 (02.08.2012) entire document	1-14, 18
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Y		15-17, 19, 20
Y	US 7,607,683 B2 (FISCHER et al) 27 October 2009 (27.10.2009) entire document	15
Y	US 8,651,522 B2 (HIRTH et al) 18 February 2014 (18.02.2014) entire document	16, 17
Y	US 2003/0052476 A1 (ROSE) 20 March 2003 (20.03.2003) entire document	17, 19, 20
A	US 8,511,710 B2 (FUKAWATASE) 20 August 2013 (20.08.2013) entire document	1-20
A	US 5,427,410 A (SHIOTA et al) 27 June 1995 (27.06.1995) entire document	1-20

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

14 December 2015

Date of mailing of the international search report

08 JAN 2016

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