



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<p>(51) International Patent Classification 5 : A42B</p>	<p>A2</p>	<p>(11) International Publication Number: WO 93/07772 (43) International Publication Date: 29 April 1993 (29.04.93)</p>
<p>(21) International Application Number: PCT/US92/10636 (22) International Filing Date: 4 September 1992 (04.09.92) (30) Priority data: 07/755,927 6 September 1991 (06.09.91) US (71)(72) Applicant and Inventor: ARCHER, Shreve, McLaren, III [US/US]; P.O. Box Z-1, Carmel, CA 93921 (US). (74) Agents: LaRIVIERE, F., David et al.; Davis & Schroeder, 215 W. Franklin Street, 4th Floor, Monterey, CA 93942 (US).</p>		<p>(81) Designated States: JP, KR, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, SE). Published <i>Without international search report and to be republished upon receipt of that report.</i></p>
<p>(54) Title: CERVICAL PROTECTION SYSTEM</p>		
<p>(57) Abstract</p> <p>Effective support of the head and neck during high impact accidents or rapid or sudden acceleration or deceleration of riders of motorcycles, ski-mobiles, jet skis and power boats, is provided by a cervical protection system having a gas-filled bag (110) rapidly deployable from a collar (105) disposed around the base of a helmet (101). When deployed, the bag (110) extends to the mid sternal area anteriorly, to approximately the fourth or fifth thoracic vertebrae posteriorly, and laterally on the shoulders to a point approximately midway between the sternomastoid muscle group and the lateral tip of the scapula, and holds the wearer's head in slight extension to mitigate physical harm.</p>		

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CERVICAL PROTECTION SYSTEM
TECHNICAL FIELD

5 This invention relates to protection of the head and upper spine from
severe injury owing high impact accidents. In particular, the invention relates
to a system for protecting the head and cervical spine of motorcycle riders, as
well as drivers of power boats, jet skis, snow mobiles, and the like, when
subjected to high speed crashes. The system of the present invention is also
effective for protecting the head and cervical spine of pilots of private and
10 military aircraft, especially, in the miliary application, when subject to the
shock and stress loading encountered during ejection from disabled aircraft.

BACKGROUND ART

Injuries of the head and neck are among the most devastating suffered
by human beings. Despite great advances in safety equipment, they remain
15 a leading cause of death and disability in our society.

Since many, if not most of these injuries occur during adolescence and
young adulthood, such events may be considered even more costly to society
in terms of productivity lost and medical costs endured. Indeed, a recent
article in The Journal of the American Medical Association cites the great cost
20 to society of motorcycle injuries alone.

Improvements in the ability of protective headgear to insulate the skull
and its contents from trauma seem to have reached a plateau. Changes in
helmet design are now oriented more toward comfort and weight savings.
While these changes seem appropriate, typically any blow severe enough to
25 overwhelm a modern helmet's defense would probably produce devastating
damage to the neck, or cervical spine. Therefore, a system to protect the
cervical spine is the next step in the evolution of safety equipment. Only
when a practical system for protecting the cervical spine is achieved will
further improvement of head protection be worthwhile.

30 The cervical portion of the spine is somewhat unique in that it lacks the
extensive supporting musculature of the rest of the vertebral column. As the
skull is carried close to its center, and hence, supported against the pull of

gravity, neck muscles are mainly designed to facilitate movement. The principle neck muscles are the sternomastoid, which flex and rotate the head, and the trapezius, which extends it.

Figure 1 is an exploded view of human cervical vertebrae, comprising:
5 posterior arch: posterior tubercle 10; groove for vertebral 11; anterior arch
facet for dens 12; interior tubercle 13; inferior articular process 14; transverse
process 15; superior articular facet 16; dens (odontoid process) 17; transverse
process posterior tubercle 18; costo-transverse bar 19; anterior tubercle 20; path
10 of the vertebral artery (blood supply) 21; foramen transversarium 22; spine 23;
lip 24; articular process inferior 25 and superior 26; carotid tubercle 27;
vestigial anterior tubercle 28; body 29; lateral mass tubercle for transverse
ligament 30; superior articular process 31; atlas 34; axis 35; third cervical
vertebrae 36; fourth cervical vertebrae 37; fifth cervical vertebrae 38; sixth
cervical vertebrae 39; and seventh cervical vertebrae 40.

15 Figure 2 is a front view of human articulated cervical vertebrae. Figure
2 comprises many of the elements of Figure 1, and further includes:
transverse process anterior tubercle 41; and gutter for nerve 42. Figure 3 is a
side view of human articulated cervical vertebrae. Figure 3 includes many of
the elements of Figures 1 and 2, and further comprises: vertebral artery 43;
20 spinous processes or spines 44; column of articular processes 45, and lamina
46.

Figure 4 is a cut-away side view of the intervertebral disc and ligaments
in humans. Figure 4 includes some of the elements in Figures 1-3, and further
comprises: anterior longitudinal ligament of the bodies of the vertebrae 47;
25 posterior longitudinal ligament of the bodies of the vertebrae 48; ligamentum
flavum 49; interspinous ligament 50; supraspinous ligament 51; bursa 52;
nucleus pulposus 53; intervertebral discs 54; cavity for nucleus pulposus 55;
anulus fibrosus 56; hyaline plate 57; nucleus pulposus protruding into bodies
58; canal for basi-vertebral vein 59; ventral and dorsal nerve roots 60; and
30 dura mater 61.

Referring to Figures 1-4 cervical vertebrae can be visualized as two short,
adjoining cylinders, the larger of which is the vertebral body. This is the

load-bearing structure of the spinal column. Cervical vertebrae are solid and separated from adjacent members by resilient fibrocartilaginous structures called intervertebral discs.

5 The spinal cord is carried in the adjacent, hollow cylinder formed by the laminae (arch) in a space known as the spinal foramen. The blood supply to the spinal cord, the vertebral artery, is carried in holes through bony projection lateral to the vertebral bodies. Additionally, there is a bony projection posteriorly from the arch called the spinous process. Ligaments connect these and the other structures, contributing to the strength of this system.

10 The areas of the spinal column most often affected by injury are the fourth and fifth cervical vertebrae, and the eleventh and twelfth thoracic. In the latter, the intrinsic strength of muscle groups in the area provide considerable support. The cervical spine, as previously noted, has little muscle support. Therefore, the considerable mass of the head acts as a pendulum or dead weight during impact to or sudden movement of the body.

15 In instances of spinal cord trauma, rapid and excessive movement and/or compression of the cervical spine occurs, tearing intervertebral ligaments, compressing and rupturing discs and vertebral bodies. The spinal cord, trapped in the spinal foramen, may be compressed by bone fragments or an extruded disc, or it may be stretched, interrupting its blood supply or tearing its nerves. In a series of cervical spine injuries studied by Bohlman and Boada, described in their work Fractures and Dislocations of the Lower Cervical Spine, one third of such injuries were due to motor vehicle accidents; their incidence is highest in adolescents and young adults.

25 Disc injuries were found to be most common. Brain injuries associated with spinal cord lesions in 61% of cases and the spinal cord lesions with brain injuries in 63% of cases, indicate the close association of cord injuries with head trauma. In very few cases was total spinal cord disruption noted. Instead, significant nerve damage was found to be primarily due to ischemia (interruption of the blood supply), and was improved most by early stabilization and reduction.

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Immobilization should be carried out as soon as possible after a cervical spine injury is recognized since continuous movement may accentuate the pathologic processes that are already underway within the spinal cord as a result of the injury. Thus, often a soft collar with spinal traction is recommended as soon as possible after trauma.

The most common forces causing spinal cord injury are:

- 1) Flexion
- 2) Flexion rotation
- 3) Vertical (axial) loading with slight flexion
- 4) Extension

1) Flexion

Straight flexion injury is by far, the most common injury in the cervical spine, often together with crumbling of a large portion of the superior anterior portion of the lower vertebrae, and also involving tearing of the ligaments between vertebral processes and stretching the spinal cord, as shown in Figures 5 and 6. There is interruption of the blood supply to the tissues, microscopic hemorrhage, and swelling. Since the swelling occurs in a confined space, increased pressure further impairs the blood supply and further tissue damage ensues.

2) Flexion rotation

The head is turned at the time of flexion resulting in unilateral ligamentous and bone injury and tissue injury similar to those in pure flexion.

3) Vertical or axial loading with slight flexion

In this instance, with reference to Figures 7-11, the vertebral body may be crushed and squeezed into the spinal foramen. This causes damage to the spinal cord both by direct pressure and indirectly by impairing its blood supply. The vertebral disc may be extruded into the foramen with similar results.

Figure 11 shows an interior wedge fracture. In Figure 8, crushing of the whole body is shown. Figure 9 shows a posterior fragment of the vertebrae pushing out against the spinal cord. Finally, in Figure 10, final displacement with a crushed body in flexion with posterior displacement of the vertebral body fragments is shown.

4) Extension

In cervical cord hyperextension injury 62, intervertebral ligaments and discs are torn as shown in Figure 12. Spinous processes are jammed together and fractured at the base, decreasing the cervical spine's resistance to flexion injury and spinal cord 63 stretching as the head rotates forward in reaction.

Flexion-extension injuries are the type most commonly occurring in automobile accidents.

Plainly, some sort of support system used in conjunction with a helmet is required to prevent or lessen the severity of these injuries. Currently, the only devices available are of the fixed type, usually consisting of a fabric-covered resilient foam collar between the helmet and shoulders. This design has gained wide acceptance in automotive racing but has some distinct drawbacks, as discussed elsewhere in this specification.

Note that there is virtually no use of such devices among motorcyclists and pilots. The restriction of head mobility that "collars" produce is typically unacceptable to them. Unfortunately, however, such people are at significant risk for spinal cord trauma. Even though a number of safety and protective devices are provided for pilots of military and private aircraft, there is no system for restricting head mobility at impact of a crash or during ejection from disabled aircraft.

Other disadvantages with fixed devices go beyond their limited acceptance. Rotational and flexion-extension injuries are the most prevalent in auto accidents. Current designs do not provide significant protection against extreme flexion, and the limited areas of contact with that helmet may

actually provide a fulcrum, raising the center of rotation and increasing traction forces on the spinal cord and exacerbating injury.

The prior art includes U.S. Patent number 3,900,896, which relates to a neck brace for athletes, such as football players, for protecting the athlete from possible neck fractures or spinal cord injuries. The neck brace described generally comprises a rigid member vertically disposed immediately posterior and parallel to the neck of the athlete, with the upper end secured to the protective helmet and the lower end supported on a bracket constituting a part of the suit or shoulder pad of the athlete. While coupling of the rigid member and the lower bracket is described as providing for free rotation of the member around a vertical axis generally parallel to the neck, the amount of actual free rotation is uncertain. In addition, this invention unequivocally teaches limited forward and backward tilting of the head. Finally, to the obvious discomfort of the wearer, the neck brace must be used with a lower supporting member. The restriction of head mobility is simply unacceptable to most sports participants, including motorcyclists and drivers of other similar vehicles such as power boats, jet skis, snow mobiles and the like.

In U.S. Patent 3,930,667, an inflatable garment for crash protection to be worn by a motorcycle rider is described. The garment is detachably connected to a source of pressurized gas operative to inflate the suit in response to a predetermined deceleration of the motorcycle or manual operation when a crash or spill appears inevitable. The source of pressurized gas is disposed on the motorcycle. Thus, if the rider jumps or is thrown from the motorcycle before the garment or suit is fully inflated, protection for the rider from the first or multiple impacts thereafter is compromised. Moreover, while the garment or suit described may be effective for protecting the back and spine, it appears to be ineffective for protecting the cervical portion of the spine or the head of the rider.

Finally, U.S. Patent 4,825,469 also teaches motorcycle safety apparel, which in the event of an impending or actual accident will inflate to provide a protective enclosure for parts of the body most susceptible to critical or fatal injury. However, again the source of compressed or liquified gas is disposed

on the motorcycle which compromises the overall effectiveness of the garment in the same way discussed with respect to U.S. Patent 3,930,667. Several different embodiments of the safety apparel are described and typically include an inflatable hood which expands upward and then forward around the top and sides of the head. However, it is uncertain that flexion and flexion rotation injuries are prevented upon impact, or that damage from axial loading or extension injuries are even reduced.

DISCLOSURE OF INVENTION

Ideally, a system for preventing excessive movement of the head and the resulting cervical spine damage should be present only when needed and not before. Only then could significant use by motorcyclists, or others, be expected. In addition, such a system should be designed to provide superior protection to current designs without limiting head mobility. Therefore, according to the above-described mechanisms of injury to the cervical spine, the cervical protection system of the present invention provides:

- 1) Effective limitation of the speed and extent of head movement;
- 2) Rapid, timely and complete deployment;
- 3) Comfort in undeployed form to maximize use;
- 4) Sustained support after initial deployment to minimize subsequent movement and further injury; and
- 5) Light weight and low center of mass to minimize forces acting on the head and neck.

In order to meet these design goals, a cervical protection system constructed according to the principles of the present invention provides effective support of the head and neck by a gas-filled bag rapidly deployable from a hollow collar that is disposed around the base of an impact-resistant helmet. In deployed configuration, the bag extends to the mid-sternal area in front, to approximately the fourth or fifth thoracic vertebrae behind, and laterally on the shoulders to a point approximately midway between the sternomastoid muscle group and the lateral tip of the scapula. These dimensions should effectively limit flexion-extension and rotation about a horizontal axis. In addition, the anterior and posterior contour of the

deployed bag is as wide as possible at its base to help prevent rotation about a vertical axis.

Rapid deployment is produced by filling the collapsed bag with gas under pressure. The source of gas may be provided by a pressurized capsule
5 or other chemical agents.

Replaceable capsules would thread into a sealed system so that pressure in the bag is maintained after deployment. The capsule and coupling device has a wide opening to allow the quickest possible release of its charge into the
10 bag.

Bag deployment is initiated by breaking the capsule's seal by a spring-driven piercing mechanism that allows charge escape. Similarly, systems for rapidly initiating chemical reactions for producing gas with which to fill the
15 bag may also be used.

The discharge mechanism itself could be activated in a variety of ways.
15 A purely mechanical version might use a simple pull-pin to release the spring-loaded piercing device. In the case of motorcycle riders, the pull-pin could be attached to the vehicle by a cable so that the system would be activated if the rider became separated from his machine. A more sophisticated and expensive system uses accelerometers to initiate deployment of the bag when
20 head and/or body acceleration exceeded some predetermined rate.

Ideally, the bag in collapsed form fits in the chin-bar and neck roll of the helmet, possibly extending slightly below it. In this way, normal head movement is unrestricted.

Location of the charge container and its activating device is in the low
25 occipital area, outside but integral to the helmet. The charge container should be easily accessible so that the bag may be deflated by its removal.

Realistically, it is probably not possible to protect against vertical impact and axial loading with the present invention. Studies show injuries to the spinal cord from axial loading seem to be produced primarily from the
30 extrusion of the inter-vertebral discs or the remnants of crushed vertebral bodies into the spinal foramen. Since this type of damage occurs only if the impact happens while the cervical spine is in flexion, it is desirable to design

the system of the present invention so that the head is held in a slight extension by the deployed bag to mitigate the damage caused by axial loading. This position is also best for maintaining airway patency.

5 The weight of the bag and its deployment mechanism's must be minimal, and their location at the base of the helmet minimizes the polar moment of the head and neck. For motorcycle riders, the bag must be constructed of an abrasion-resistant material.

BRIEF DESCRIPTION OF DRAWINGS

10 For fuller understanding of the present invention, reference is made to the accompanying drawing in the following detailed Description of the Preferred Embodiment of the invention. In the drawing:

Figure 1 is an exploded view of cervical vertebrae in humans.

Figures 2 and 3 are the front and side views, respectively, of articulated cervical vertebrae in humans.

15 Figure 4 is a cut-away side view of the intervertebral disc and ligaments in humans.

Figure 5 illustrates mechanisms of flexion injury in humans.

20 Figure 6 is a cut-away side view showing flexion injury with gradual posterior tearing, posterior joint subluxation, posterior longitudinal ligament tearing and eventual disc disruption.

Figure 7 illustrates mechanisms of a burst fracture (vertical axial loading).

Figures 8-11 illustrate the progression of the vertical loading and slight flexion injury.

25 Figure 12 illustrates hyperextension injury of the cervical cord in humans.

Figure 13 is a side view of a cervical protection system constructed to the principles of the present invention.

Figure 14 is a perspective view of the cervical protection system of Figure 13 with the air bag fully deployed.

30 Figure 15 is a bottom view of the cervical protection system of Figure 13.

Figure 16 is a cross-sectional view of the containment for the undeployed bag in the cervical protection system of Figure 13 along A-A'.

Figures 17 and 18 are back and front views, respectively, of the cervical protection system of Figure 13.

Figures 19 and 20 are cross-sectional views of the initiator system for the cervical protection system of Figure 13.

5 Figure 21 illustrates a use of the present invention.
Reference numbers refer to the same or equivalent parts of the present invention throughout the several figures of the drawing.

BEST MODE FOR CARRYING OUT THE INVENTION

10 Referring now to Figure 13, cervical protection system 100 constructed according to the principles of the present invention comprise impact-resistant helmet 101 having visor 102 and hollow collar 105 for housing air bag 110 (not shown). Gas capsule 115 is mounted at the rear of helmet 101 and is coupled to air bag 110 via a gas release and flow control coupler (not shown).

15 Referring now to Figure 14, air bag 110 is shown fully deployed from collar 105. The anterior portion of air bag 110 extends to the mid-sternal area of the wearer. The posterior portion of air bag 110 extends to approximately the fourth or fifth thoracic vertebrae of the wearer. Air bag 110 also extends over the shoulder to a point approximately midway between the sternomastoid muscle group and the lateral tip of the scapula. Flexible seal
20 120, attached to the outer surface of deployed air bag 110 is used to repack and seal air bag 110 into collar 105 when deflated as described elsewhere in this specification. Flexible seal 120 is sewn or glued, or is otherwise suitably attached to, the outer surface of air bag 110.

25 Figure 15 is a bottom view of cervical protection system 100 which illustrates the assembly of flexible seal 120 into hollow collar 105. Hollow collar 105 includes an elongated opening 116 which conforms generally to the bottom periphery of hollow collar 105. Flexible seal 120 actually comprises two half moon or horseshoe shaped strips, the ends of which abutting at points A and A' and diametrically opposed from one another along the bottom
30 periphery of hollow collar 105.

As shown in Figure 16, the bottom periphery of hollow collar 105 incorporates channels 117 formed in the opposing edges of elongated opening

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116 of hollow collar 105 for receiving each half of flexible seal 120. As gas fills air bag 110, flexible seal 120 disengages from channels 117 in hollow collar 105 to facilitate rapid deployment of air bag 110. Assuming no damage to air bag 110 after deployment, flexible seal 120 may be reinstalled in channels 117 for repacking deflated air bag 110 into hollow collar 105 for reuse.

Referring now to Figures 17 and 18, gas capsule 115 is mounted at the rear of helmet 101, together with a gas release and flow control coupler (not shown). Gas capsule 115 may contain either compressed gas, such as CO₂, or the like, or may contain chemical agents for producing gases when intermixed by the coupler mechanism for explosively initiating deployment of air bag 110. Well-known chemical agents such as sodium azide or zirconium potassium perchlorate produce gases of the type required for this application. Other similar discharge mechanisms which are common in on-board fire retardant systems currently used in automotive racing may also be used. Of course, a smaller size is required in this application.

Impact resistant helmet 101 may be of standard configuration and construction conforming to the highest standards of the industry for providing maximum structural integrity and protection to the wearer during single and multiple impact accidents. Such helmets are manufactured by Bell, Showei and Arai. Such helmets typically include visor 102 and a chin strap (not shown).

Collar 105, flexible seal 120 and air bag 110 are constructed of abrasion resistant flexible material such as Kevlar, manufactured by Dupont, or the like. It should be noted that the upper portion of hollow collar 105 also may be part of the molded outer shell of helmet 101 such that both can be manufactured into one molded form, and incorporate a bottom periphery constructed of flexible material to receive deflated air bag 110 and flexible seal 120.

It should be clear that the cervical protection system of the present invention may be designed and constructed as an integral part of impact resistant helmets or as a retro-fit kit for attachment to already existing helmets. Thus, hollow collar 105 including gas capsule 115, may be rigidly mounted to

helmet 101 to facilitate retro-fit to helmets already being used by motorcycle riders, drivers of other vehicles, or any application where the body and the head of the wearer of the helmet are exposed to the risk of high speed, high impact accidents.

5 Referring now to Figure 19, explosive initiator 130 includes housing 131, actuator 132, prior restraint 134, spring 134, tube 135 and tether 136. Housing 131 includes threaded portion 138 for receiving gas capsule 115 and for controlling flow of gas therefrom into air bag 110. Gas capsule 115 is a self-contained capsule, not unlike a CO₂ cartridge, having breakable seal 139 for
10 explosively discharging its contents, whether compressed gas or gas produced by chemical agents.

With reference to Figure 20, actuator 132 breaks seal 139 of gas capsule 115 when activated by tether 136 which pulls pin 133 as the wearer becomes separated from the vehicle in or on which the wearer is riding. Actuator 132
15 also may be activated by a system of one or more accelerometer sensors when acceleration of the wearers head exceeds a predetermined rate or exceeds a predetermined rate with respect to the wearer's body or the vehicle in which or on which the wearer is riding. It should also be noted that deflation of air bag 110 is initiated by merely removing gas capsule 115.

20 The design of hollow collar 105, gas capsule 115 and explosive initiator 130 must be compatible with light weight and low center of mass of the overall cervical protection system to minimize forces acting on the head and neck.

Referring to Figure 14, wearer 220 is shown attached to vehicle 210.
25 Vehicle 210 forms no part of the present invention. Wearer 220 is wearing helmet 101 having hollow collar 105. Hollow collar 105 is coupled to vehicle 210 via tether 136 and pin 133 as shown in Figure 20. When helmet 101 becomes separated from vehicle 210 by a distance greater than the length of tether 136, pin 133 is uncoupled from hollow collar 105, activating actuator
30 132. Thus, air bag 110 is subsequently inflated to deploy as described elsewhere in this specification for significantly limiting excessive movement of the head of wearer 220.

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The present invention has been particularly shown and described with respect to a best mode and features thereof. However, it should be readily apparent to those of ordinary skill in the art that various changes and modifications in form and details may be made without departing from the spirit and scope of the invention as set forth in the appended claims.

5

CLAIMS

1. A cervical protection system for a human wearer using a vehicle comprising:
- an impact resistant helmet, said helmet having a bottom periphery;
- 5 a hollow collar generally conforming and removably mounted to the bottom periphery of said helmet, said hollow collar having an elongated opening generally conforming to the bottom periphery of said collar;
- a deployable air bag coupled to and housed within said hollow collar;
- and
- 10 a source of gas coupled to said deployable air bag for rapid inflation thereof;
- said deployable air bag when fully deployed extending to the mid-sternal area in the front of the wearer, to approximately the fifth thoracic vertebrae in the back of the wearer and laterally on the shoulders of the
- 15 wearer to a point approximately midway between the sternal mastoid muscle group and the lateral tip of the scapula, said deployable air bag holding said wearer's head in slight extension.
2. A cervical protection system as in Claim 1 wherein said source of gas includes initiator means for rapidly initiating and controlling gas flow into the
- 20 deployable air bag.
3. A cervical protection system as in Claim 1 further including flexible sealing means for containing said deployable air bag in said hollow collar.
4. A cervical protection system as in Claim 3 wherein said deployable
- 25 air bag may be deflated and repacked into said hollow collar.
5. A cervical protection system as in Claim 3 wherein said flexible sealing means is coupled to said deployable air bag.
6. A cervical protection system as in Claim 5 wherein:
- said flexible sealing means comprises front and rear portions; and
- 30 said air bag comprises front and back portions;

said front portion of said flexible sealing means being coupled to said front portion of said air bag and said rear portion of said sealing means being coupled to said back portion of said deployable air bag.

7. A cervical protection system as in Claim 2 wherein:

5 said wearer is using a vehicle; and

 said initiator means includes means for detachably coupling said cervical protection system to said vehicle, said gas flow into said deployable air bag being initiated by said initiator means when said wearer becomes suddenly separated from said vehicle.

10 8. A cervical protection system as in Claim 2 further including accelerometer means for determining the acceleration rate of said cervical protection system and for deploying said deployable air bag when said acceleration rate exceeds a specified value.

15 9. A cervical protection system as in Claim 8 wherein said accelerometer means determines the acceleration rate of said cervical protection system relative to said wearer's body for deploying said deployable air bag when said relative acceleration rate exceeds a specified value.

10. A cervical protection system as in Claim 1 wherein said gas is CO₂.

20 11. A cervical protection system as in Claim 1 wherein said gas is derived from sodium azide.

12. A cervical protection system as in Claim 1 wherein said gas is derived from zirconium potassium perchlorate.

13. A cervical protection system comprising:

25 an impact resistant helmet having housing means generally conforming to the bottom periphery of said helmet, said housing means having an elongated opening generally conforming to the bottom periphery of said housing;

 a deployable air bag coupled to and housed within said housing means; and

30 a source of gas mounted on said impact resistant helmet and coupled to said deployable air bag for rapid inflation thereof, said air bag extending to the mid-sternal area in the front of the wearer, to approximately

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the fifth thoracic vertebrae in the back of the wearer and laterally on the shoulders of the wearer to a point approximately midway between the sternal mastoid muscle group and the lateral tip of the scapula, said deployable air bag holding said wearer's head in slight extension.

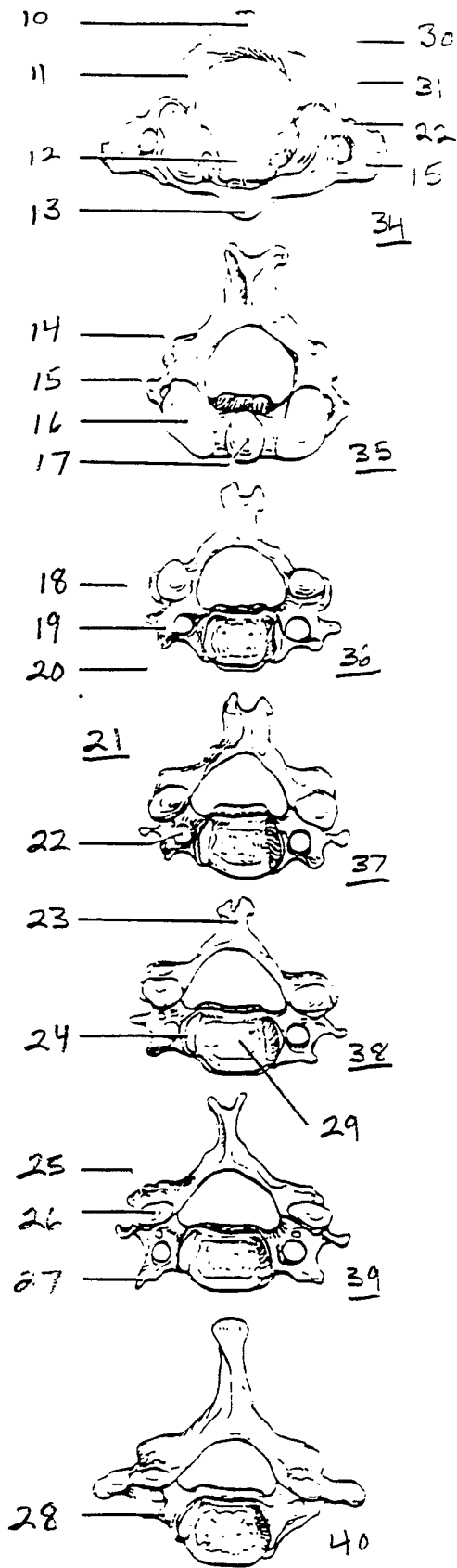


FIG. 1

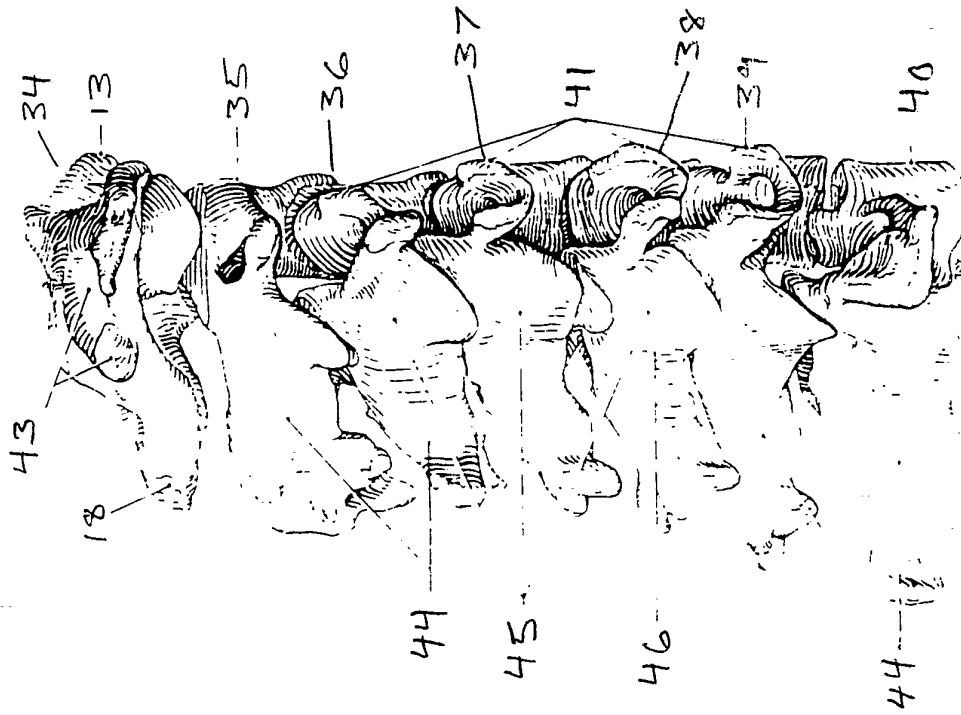


FIG. 3

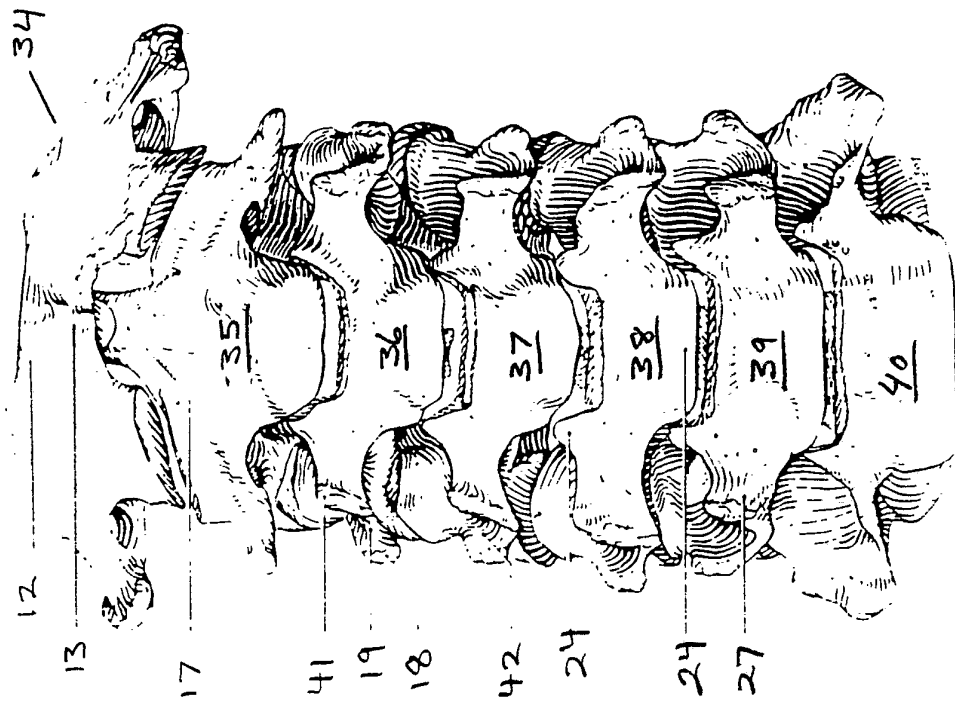
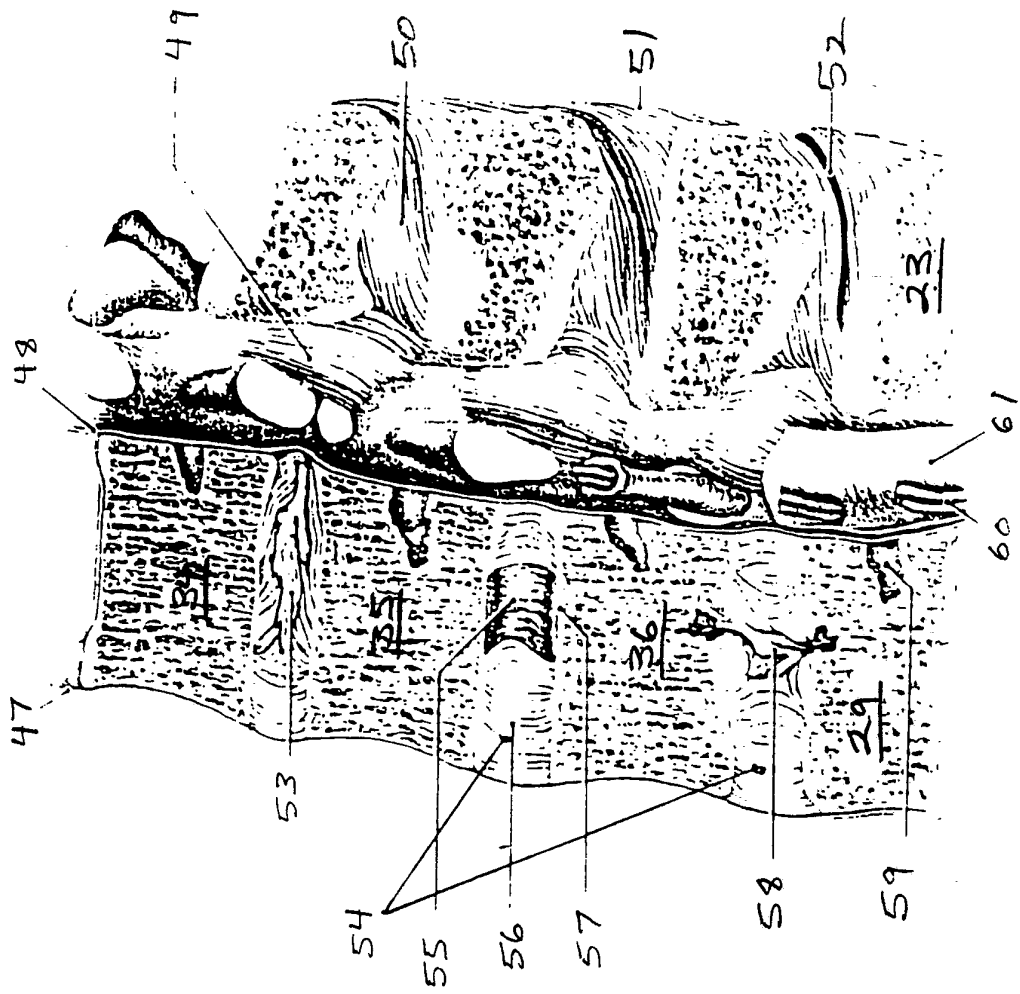


FIG. 2

FIG. 4



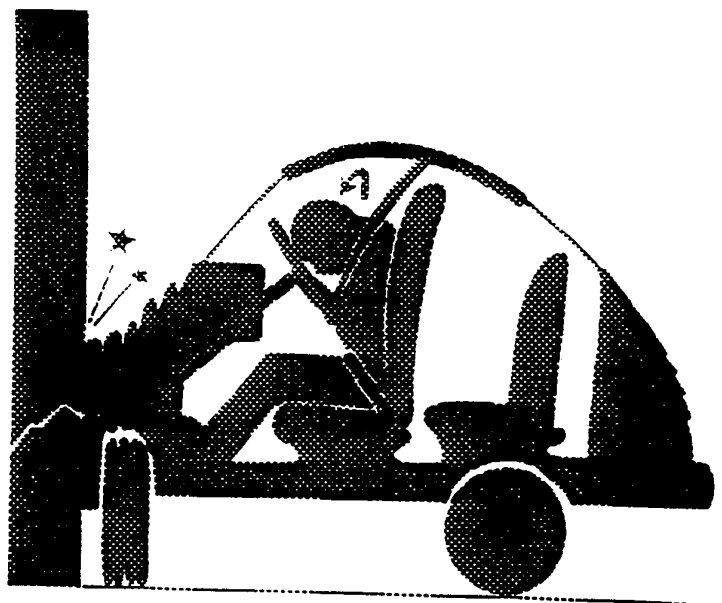


FIG. 5

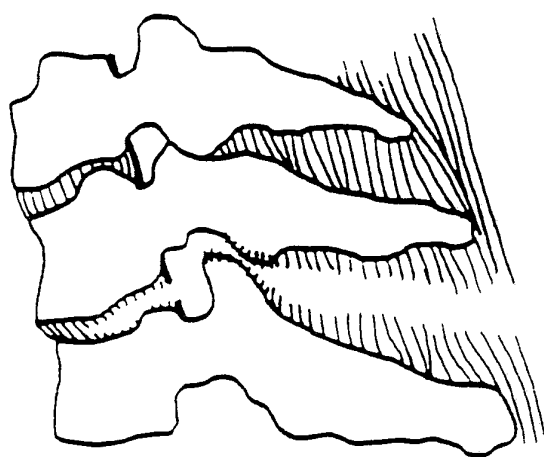


FIG. 6

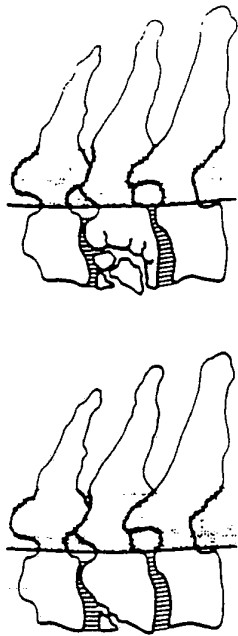


FIG. 8

FIG. 11

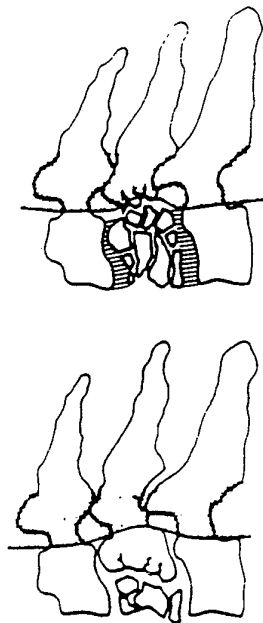


FIG. 10

FIG. 9



FIG. 7

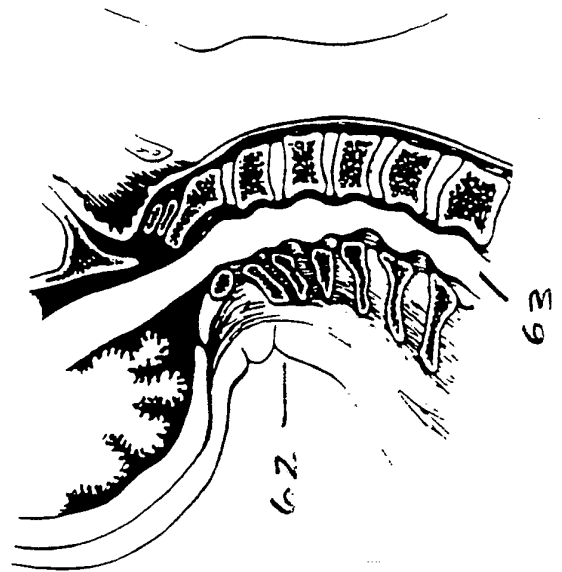


FIG. 12

FIG. 14

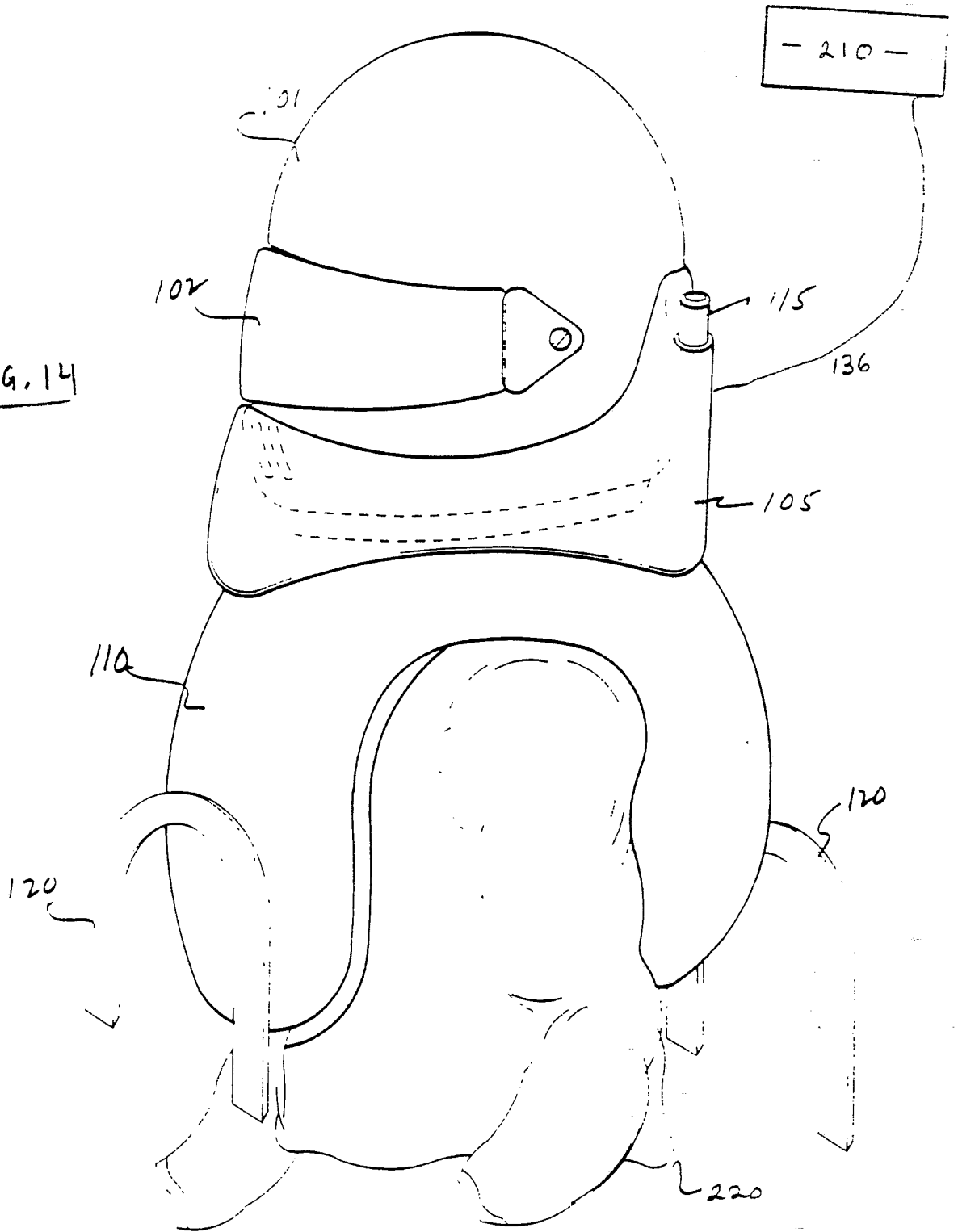


FIG. 16

A-A'

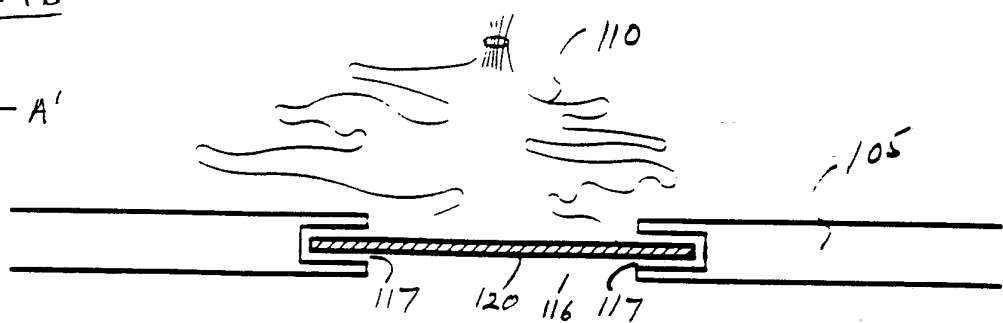


FIG. 17

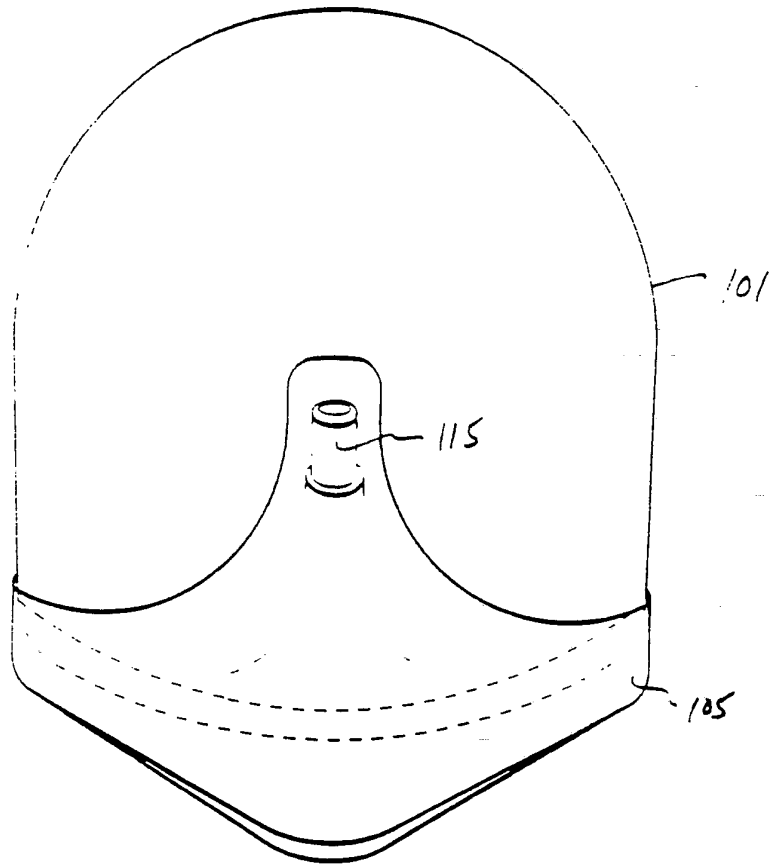


FIG. 18

