Sept. 15, 1970 G. A. EKSTROM 3,528,681

EXPLOSIVE RUPTURING OF FLUID CONTAINER

Filed Aug. 31, 1967 2 Sheets-Sheet 1

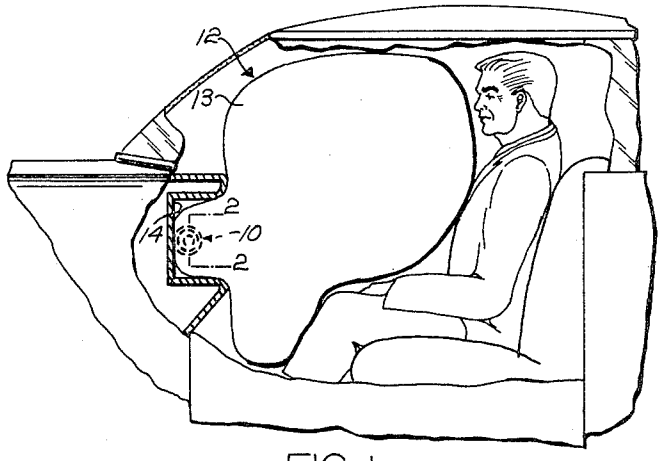


FIG. 1

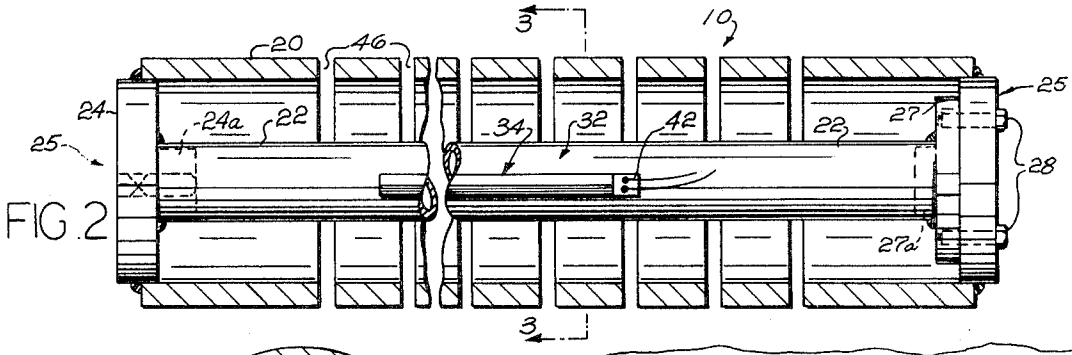


FIG. 2

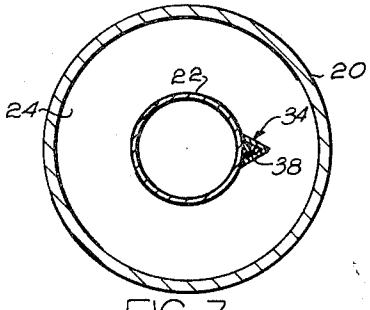


FIG. 3

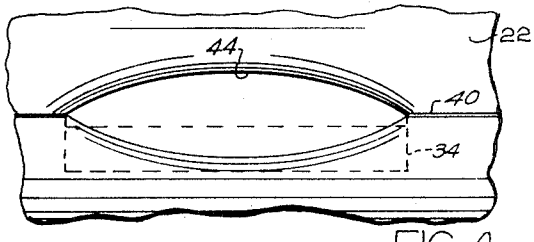


FIG. 4

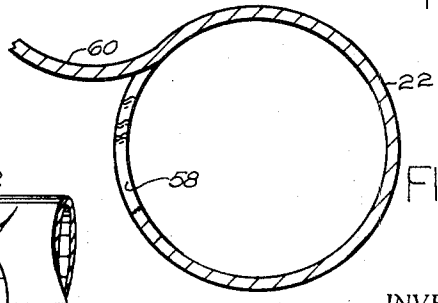


FIG. 8

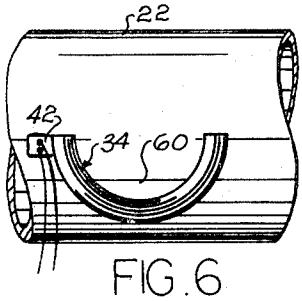


FIG. 6

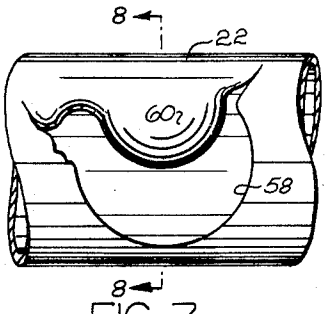


FIG. 7

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EXPLOSIVE RUPTURING OF FLUID CONTAINER

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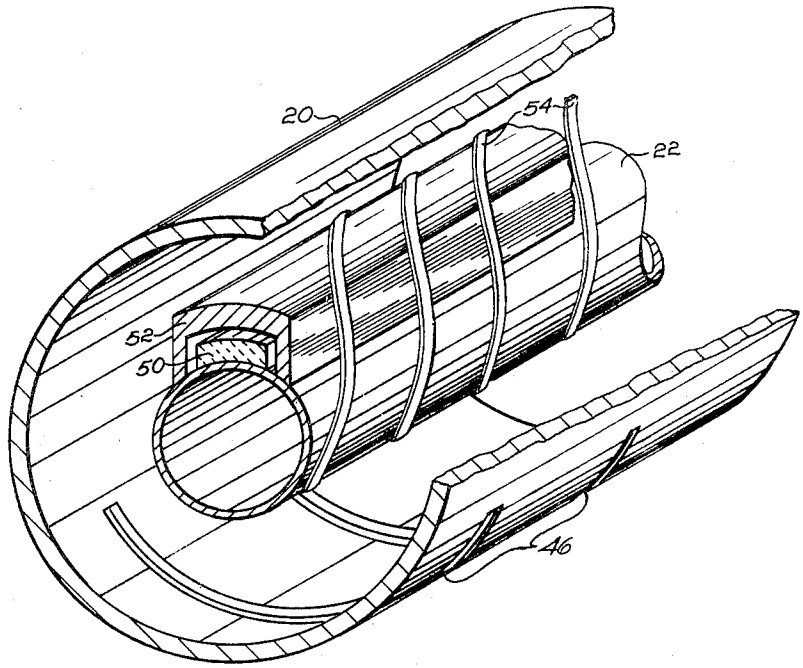


FIG. 5

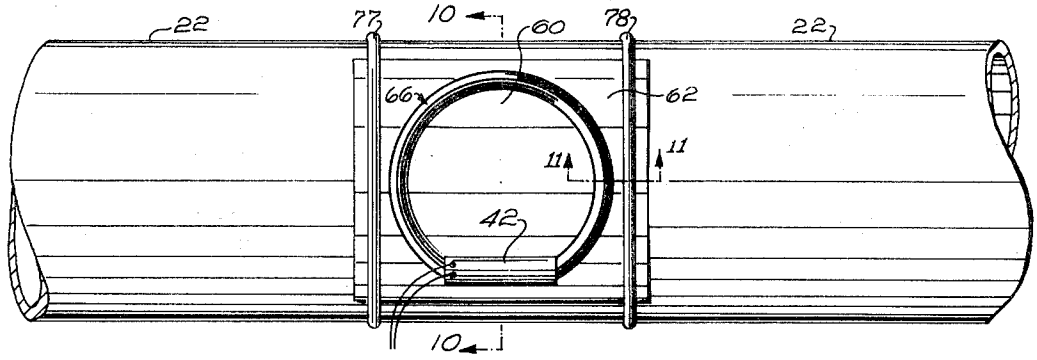


FIG. 9

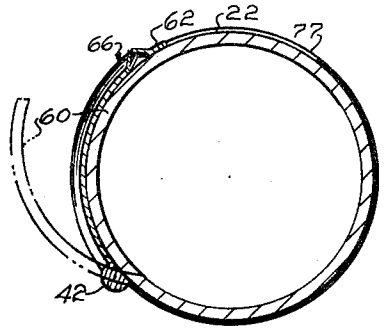


FIG. 10

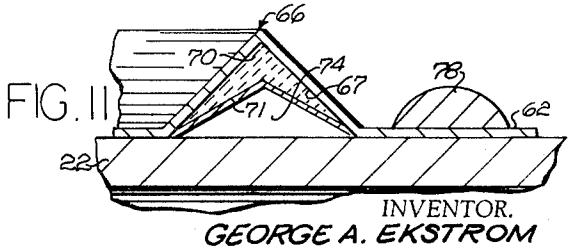


FIG. 11

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EXPLOSIVE RUPTURING OF FLUID CONTAINER

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Int. Cl. B60r 21/00
U.S. Cl. 280—150 4 Claims

ABSTRACT OF THE DISCLOSURE

A fluid pressure container maintains or stores fluid under pressure for operating a safety device, such as a flexible restraint confinement or bag. The fluid container is opened upon detonation of explosive material and the escaping fluid inflates the confinement. The explosive material is associated with the container so that the forces produced by the explosion cooperate with the fluid pressure acting interiorly of the container to produce an opening in the container. According to one embodiment of the invention the explosive force is provided by a unidirectional linear-shaped explosive strip arranged on a surface of the fluid pressure container. When the linear-shaped strip is detonated, the force of the explosion is directed to the container and opens the container to release the fluid. In another embodiment, a multidirectional strip of explosive is posioned relative to the fluid pressure container and a backup member is provided in overlying relationship to the strip. The backup member contains the force generated by the explosion which is directed other than toward the container. In still another embodiment, a flexible explosive strip is arranged in a semicircle about the container. When detonated, the charge opens a generally semicircular-shaped tab in the container and the fluid pressure inside the container bends the tab outwardly to permit the fluid to escape. According to a further embodiment of the invention, the explosive strip is arranged in the form of a loop on a plate which is positioned on the container. When detonated, the explosive opens a generally semicircular-shaped tab in the container and the fluid bends the tab out and the fluid is released through the opening formed by the bent tab.

The present invention relates to an apparatus for storing and selectively releasing fluid under pressure, and in particular to an apparatus in which fluid under pressure is released from a container by opening of the container and wherein the fluid operates a safety mechanism to protect an occupant of a vehicle when the vehicle encounters a crash condition.

It is an important object of the present invention to provide new and improved apparatus which includes a fluid container which is reliably and simply opened by the cooperative action of explosive means on the container and the fluid pressure in the container to provide a flow of fluid from the container to actuate a device such as a safety device for a vehicle.

Another object of the present invention is the provision of new and improved apparatus in which explosive means for opening a fluid container is in the form of a strip of explosive material which is arranged on the fluid container so that detonation thereof produces an opening in the container of a size to provide an acceptable fluid flow rate from the container.

A further object of the present invention is the provision of new and improved apparatus in which explosive means in the form of a multidirectional charge strip is positioned on a pressurized fluid container and ignited to effect opening of the container and a backing member is suitably retained in overlying relation to the charge strip to contain the forces produced by the explosion which are directed other than onto the fluid container.

A further object of the present invention is the provision of new and improved safety apparatus for a vehicle in which a safety mechanism is operated by the flow of fluid from a fluid container and wherein the container is explosively opened by an explosive charge strip which is so arranged on the container that upon detonation of the charge strip a portion of the container is moved outwardly by the fluid pressure in the container to provide a fluid release opening in the container.

A still further object of the present invention is the provision of new and improved apparatus, as noted in the next preceding paragraph, wherein the charge strip is substantially semicircular in shape and forms a tab upon detonation thereof, which tab is bent outwardly by the fluid pressure in the container.

Another object of the present invention is the provision of new and improved apparatus in which an explosive means in the form of an arcuate-shaped explosive strip is utilized in association with a fluid pressure container to effect opening of the pressure container upon detonation of the strip.

Still another object of the present invention is the provision of new and improved apparatus in which a plate member is located exteriorly of a fluid pressure container and wherein an explosive is mounted on the plate member and upon ignition effects an opening in the container member to provide for release of the fluid from the pressurized container and wherein the plate member does not detrimentally interfere with the flow of fluid from the container.

Yet another object of the present invention is the provision of new and improved apparatus, as noted in the next preceding paragraph, wherein the plate member has a chamber therein which opens toward the fluid pressure container and receives a strip of explosive material.

A still further object of the present invention is the provision of new and improved apparatus in which the explosive strip is positioned adjacent the seam of the fluid storage container so that the longitudinal axis of the explosive strip is substantially parallel to the seam of the container but offset slightly therefrom so that the resulting explosion causes the fluid container to open along the seam.

These and other objects will become apparent from the following description of preferred embodiments of the present invention made in conjunction with the accompanying drawing and in which:

FIG. 1 is a fragmentary side elevational view with parts removed of a vehicle embodying the present invention;

FIG. 2 is a sectional view taken approximately along the line 2—2 of FIG. 1;

FIG. 3 is a sectional view taken substantially along the line 3—3 of FIG. 2;

FIG. 4 is a fragmentary plan view of a portion of the container shown in FIG. 3 and illustrating the opening in the container produced by the arrangement of the explosive means in FIG. 3;

FIG. 5 is a fragmentary perspective view showing parts in section and parts broken away and showing another embodiment of the present invention;

FIG. 6 is a fragmentary plan view of another embodiment of the present invention;

FIG. 7 is a fragmentary plan view of a portion of a container illustrating the opening formed in the container as a result of the explosion of the explosive arrangement shown in FIG. 6;

FIG. 8 is a sectional view of the container of FIG. 7 taken approximately along line 8—8 of FIG. 7;

FIG. 9 is a fragmentary plan view of another embodiment of the present invention;

FIG. 10 is a sectional view taken approximately along line **10—10** of FIG.9; and

FIG. 11 is a sectional view taken approximately along line **11—11** of FIG. 9.

The present invention relates to an improved means for explosively opening a fluid pressure container. The fluid when released from the container, may be used to operate various devices. Preferably and as illustrated, the fluid, when released, operates a vehicle safety device. The safety device may be used in any type of vehicle, such as an airplane, truck or automobile.

Referring to the drawing, FIG. 1 discloses an apparatus **10** for storing and releasing fluid under pressure. In the illustrated embodiment, the apparatus **10** operates a vehicle safety apparatus **12**. The safety apparatus **12** includes an inflatable confinement **13** or bag **13** which has a collapsed condition wherein the confinement **13** is stored in a receptacle **14**. In the illustrated embodiment, the receptacle **14** is formed in the dash of the vehicle. When collapsed, the confinement **13** is out of sight and is inflated when the vehicle encounters a crash condition and is so shown in FIG. 1. When inflated, the confinement **13** restrains the occupant of the vehicle from impacting against a structural part of the vehicle.

The confinement **13** is inflated by the apparatus **10**. The apparatus **10** may be positioned within the confinement **13** and is suitably secured along one side to the receptacle **14**, as shown in FIG. 1. The inflating apparatus **10** as shown in FIG. 2 includes an outer fluid diffusion tube **20** and an inner fluid container **22** mounted concentrically with respect to the outer tube **20**.

The outer tube **20** is closed by closure members **24** and **25** which are welded to the tube **20**. The closure member **24** has a plug portion **24***a* which projects into an opening in the container to seal the container **22**. A suitable weld is formed between the container **22** and the closure member **24** to provide a fluid-tight seal therebetween. A fill hole and a one-way valve, generally designated **25**, are associated with the end closure member **24** and plug member **24***a* and provide for filling of the container **22**. The closure member **25** is suitably secured to a plate member **27** by fasteners **28**. The plate **27** has a projecting portion **27***a* which projects into the interior of the container **22** and closes the right end of the container. The right end of the container **22** is welded to the plate **27** in order to provide a fluid-tight seal therebetween.

The fluid container **22** is shown as being generally cylindrically shaped and stores a fluid under pressure. When the vehicle encounters a crash condition which is sensed by suitable crash sensor means, such as is disclosed in the copending application Ser. No. 562,289 (now Pat. No. 3,414,292), assigned to the assignee of the present invention, the fluid container **22** is opened by explosive means, indicated generally as **32**. The opening of the container **22** permits the fluid to escape therefrom to inflate the confinement **13**.

The confinement **13** must be inflated rapidly so as to restrain movement of the occupant as a result of the force of the crash. Accordingly, the opening of the fluid container **22** must provide a fluid flow of sufficient volume to provide for inflating the confinement **13** within the prescribed time. If the opening in the fluid container **22** is too small the confinement **13** will not provide the necessary resistance to the occupant's movement, and if the opening is too large, the rate of flow of the fluid from the container may be so great that the flow would rupture the confinement **13**.

The explosive means **32** includes a linear-shaped strip of explosive material **34** which is suitably bonded, such as by gluing to the exterior of the fluid container **22**. The strip **34** is illustrated as a unidirectional charge which is shaped so that the force produced by the explosive is focused on a relatively small area of the container **22**. The linear-shaped strip **34** comprises an exterior metal sheath, preferably lead, which is shaped as shown. The explosive material **38** is contained within the sheath **36** and consists of a particular number of grains of explosive material per unit of length.

When the crash sensing switch of the vehicle is actuated by impact of the vehicle with another object, an electrical circuit is completed to a detonator charge **42** forming a part of the explosive means **32**. The detonator charge **42** may be any suitable commercial type of detonator and sets off the charge shrip **34**. The shape of the metal sheath is such that the forces of the explosion are directed thereby onto a relatively concentrated area of the container **22**. A relatively low explosive force strip **34** may be used for opening the container in view of the force focusing effect. The fluid flow through the opening provided by the explosive may assist in opening the container **22**. In fact, the explosive strip **34** may only initiate the opening and the opening may be propagated by the internal fluid pressure.

It has been discovered that when the explosive strip **34** is arranged as described, a good opening **44** is produced in the fluid container **22**. The opening **44** permits the fluid under pressure in the container **22** to escape into the outer diffuser tube **20**. The diffuser tube **20** also acts as a restrainer for the container **22** so that the opening in the container **22** is not made unnecessarily large.

The outer diffuser tube **20** has a plurality of circumferentially extending slots **46** formed along a portion of the container **22** and through which the fluid enters the confinement **13**. The fluid escaping from opening **44** impinges upon the solid side of the outer tube **20** absorbing some of the energy thereof. Thereafter, the escaping fluid flows through the slots **46** and into the confinement **13** at a controlled rate such that the confinement **13** is inflated within the allotted time and without rupturing the confinement **13**.

The fluid in the container **22** may be nitrogen under a pressure of from 1500 p.s.i. to 3000 p.s.i., depending on the extent of resistive force to be provided by the confinement **13**. The fluid escape rate provided by the opening **44** inflates the confinement **13** within the time interval required to provide for full inflation prior to the time at which the occupant begins moving relative to the vehicle dash as a result of the momentum of the crash, and thus the confinement **13** cushions and restrains the occupant from violent contact with a structural part of the vehicle.

In the event the container **22** is constructed so as to have a welded seam, the container may be opened by using a sheet explosive which is located on the container adjacent to and extending parallel to the seam. Upon detonation of the explosive an opening is provided in the container along the seam.

The invention further comprehends a multidirectional charge strip **50**, such as is shown in FIG. 5. the multidirectional strip **50** comprises a flexible sheet of explosive material known commercially as DuPont Detasheet, which is an elongated strip having an appropriate number of grains of explosive per square inch to provide the desired power level. For opening the fluid container **22**, a strip of Detasheet approximately 6 inches in length and a fraction of an inch wide and thick has been found satisfactory. The Detasheet **50** is a multidirectional explosive, which means that the forces resulting from the explosion of the sheet act in all directions. Consequently, a backup member, such as backup member **52**, shown in FIG. 5, is provided to contain and reflect the forces liberated in directions different from that in which the work is to be done, i.e. away from the surface of the container **22**.

The backup member **52** is a channel-shaped sheath member which may be associated with the Detasheet **50** in any suitable manner and may be secured to the container **22** by any suitable means, such as a flat coil spring

54. The spring 54 functions to maintain the backup member 52 in position on the container 22. The backup member 52 contains the forces resulting from the explosion acting in the directions other than in the direction toward the fluid container 22 and redirects these forces onto the surface of container 22.

The multidirectional charge 50 and the unidirectional charge 34 are suitable for use in similar applications. It should be appreciated that either type of charge may be used to open the gas container 22 in the various embodiments of the invention. One obvious advantage of using the unidirectional charge 34 is that no backup member, as such, is needed. The lead sheath 36 is shaped so that the forces resulting from detonation of explosive material 38 are directed against a relatively small area of the container 22.

In the embodiment shown in FIG. 6, a unidirectional charge 34 is arranged in a semicircular loop having in one instance a radius of approximately .75 inch. It has been discovered that by so arranging the charge 34 and providing explosive material consisting of 50 grains of explosive per linear foot of length, an opening 58 is formed in a steel container 22 having a wall thickness of approximately .083 inch. The opening 58 is generally semicircular as shown in FIG. 7.

Detonation of charge 34, as shown in FIG. 6, by detonator 42 defines an area in the form of a tab 60 in container 22 which is then bent outwardly by the fluid pressure in container 22 to form opening 58, as shown in FIG. 8. Tab 60 acts as a baffle for guiding the released fluid. The detonator 42 should be unidirectional or have means provided to prevent the force of the detonator and explosive from blowing a hole in the outer tube 20.

An opening similar to opening 58 may be made in container 22 by arranging charge 34 in the form of a substantially closed loop. The loop may have a diameter of approximately 1.5 inches and the explosive material consist of 20 grains of explosive per linear foot of length. The explosive upon detonation forms a tab, like area 60, which is bent out by fluid pressure, as shown in FIG. 8. If the loop of explosive is fully closed, the area 60 would be bodily moved outwardly of the container by the fluid rather than bent outwardly.

The embodiment of the present invention disclosed in FIGS. 9–11 also provides an improved construction for opening of a fluid pressure container 22. The embodiment shown in FIG. 9 includes a plate member 62 which has a ridge portion 66 which projects away from the container 22 and defines a chamber 67 which opens toward the container 22. Explosive material 70 is located within the chamber 67 and a liner 71 is located between the explosive material 70 and the wall of the container 22. The construction is such that an open area 74 is provided between the liner 71 and the wall of the container 22. The ridge portion 66 is semicircular in shape in FIG. 9 and the explosive material 70 extends around the ridge portion 66 and thus also extends in a semicircle. A detonator charge 42 is associated with the explosive material 70 and is readily ignited and, in turn, ignites the explosive material 70. It should be apparent from the above that the plate 62, in effect, forms a part of a shaped charge, like charge 34 described above. Alternatively, the plate 62 may function to position a shaped charge such as charge 34. In such a case, the shaped charge would be located in the chamber 67 and the liner 71 could be omitted, since its equivalent would be a part of the shaped charge.

The plate 62 is retained on the container 22 in any suitable manner. As illustrated in the drawing, preferably a pair of loop spring elements 77, 78 encircle the plate 62 and the container 22 to hold the plate 62 in position on the container. The loop spring elements 77, 78 also provide a restraining force to limit diametrical expansion of the container 22 upon detonation of the explosive and thereby minimize tearing of the wall of the container 22.

When the explosive material 70 is ignited, explosive forces are directed toward the container 22 by the plate 62. As a result of the direction of the forces, an area 60 of the container 22 is defined, and the interior wall portion of the area 60 is acted upon by the fluid pressure in the container 22. The fluid pressure in the container 22 forces the area 60 to bend outwardly in much the same manner as described above in connection with the embodiment of FIG. 8. The area 60 is illustrated in such a position in dotted lines in FIG. 10. The fluid in the container then rushes from the opening formed in the container as a result of the bending of the area 60 outwardly of the container by the fluid pressure therein. The plate 62 may be made of a relatively thin material which is either destroyed as a result of the explosion of the explosive material or forced from the container 22 by the fluid acting thereon. In either event, the plate 62 does ot detrimentally interfere with the opening of the container 22 or the flow of fluid therefrom.

What is claimed is:

1. Safety apparatus for protecting an occupant of a vehicle during an accident, said safety apparatus comprising a confinement expandable from a collapsed condition to an expanded condition to restrain movement of an occupant of a vehicle during an accident, a source of fluid for effecting expansion of said confinement, said source of fluid including a container for holding fluid under pressure and having an imperforate side wall with an uninterrupted cross sectional configuration, diffuser means for directing a flow of fluid into said confinement, explosive means mounted on an outer surface of said imperforate side wall of said container for opening said container during an accident, said explosive means including a member having a base with an inner surface positioned in abutting engagement with said imperforate side wall of said container and an outwardly projecting arcuate rib portion defining an inwardly opening recess, explosive material mounted in said recess and arranged in a generally semicircular configuration relative to said imperforate side wall of said container, mounting means extending at least partially around said container and operatively connected with said member for clamping said member on said imperforate side wall of said container with said recess facing said sidewall, and detonator means mounted on said member for activating said explosive material during an accident to form a tab in said imperforate side wall of said container, said tab being bent outwardly by the pressure of the fluid in said container to thereby enable fluid to flow from said container and through said diffuser to effect expansion of said confinement.

2. Safety apparatus for protecting an occupant of a vehicle during an accident, said safety apparatus comprising an expandable confinement, a source of fluid for effecting expansion of said confinement, said source of fluid including a container having an imperforate side wall with an uninterrupted cross sectional configuration, explosive means mounted on an outer surface of said imperforate side wall of said container for opening said container during an accident, said explosive means including a member mounted in engagement with said imperforate side wall of said container and defining an inwardly opening recess, explosive material mounted in said recess and located relative to said container so that upon detonation of said explosive material a tab is formed in the container, said tab being bent generally outwardly by the pressure of fluid within said container to thereby provide the aforesaid opening in said container, mounting means extending around said container and operatively connected with said member for retaining said member on said imperforate side wall of said container with said recess facing said side wall, and detonator means

operatively connected with said explosive material for effecting activation thereof.

3. Safety apparatus for protecting an occupant of a vehicle during an accident, said safety apparatus comprising an expandable confinement, a source of fluid for effecting expansion of said confinement, said source of fluid including a container having an imperforate side wall with an uninterrupted cross sectional configuration, explosive means mounted on an outer surface of said imperforate side wall of said container for opening said container during an accident, said explosive means including a member mounted in engagement with said imperforate side wall of said container and defining an inwardly opening recess, said member including a base mounted in abutting engagement with said imperforate side wall of said container and an outwardly projecting rib portion defining said recess, explosive material mounted in said recess, mounting means extending around said container and operatively connected with said member for retaining said member on said imperforate side wall of said container with said recess facing said side wall, and detonator means operatively connected with said explosive material for effecting activation thereof.

4. Safety apparatus for protecting an occupant of a vehicle during an accident, said safety apparatus comprising an expandable confinement, a source of fluid for effecting expansion of said confiinement, said source of fluid including a container having an imperforate side

wall with an uninterrupted cross sectional configuration, explosive means mounted on an outer surface of said imperforate side wall of said container for opening said container during an accident, said explosive means including a member mounted in engagement with said imperforate side wall of said container and defining an inwardly opening recess, explosive material mounted in said recess, mounting means extending around said container and operatively connected with said member for retaining said member on said imperforate side wall of said container with said recess facing said side wall, said mounting means including a plurality of loop elements which encircle said container and clamp said member against said imperforate side wall of said container, and detonator means operatively connected with said explosive material for effecting activation thereof.

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KENNETH H. BETTS, Primary Examiner

U.S. Cl. X.R.

102—24; 222—85