Aug. 12, 1969 R. CHUTE 3,460,853

SAFETY APPARATUS

Filed Oct. 13, 1967 3 Sheets-Sheet 1

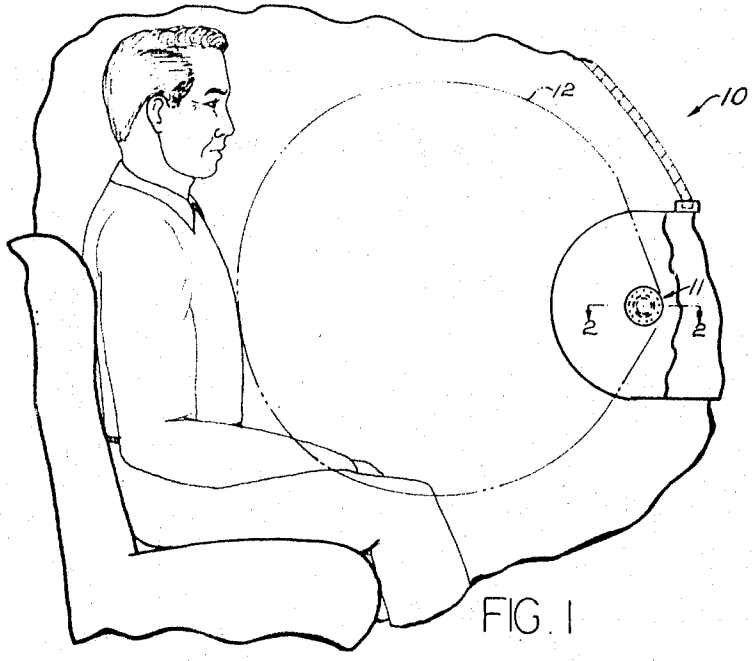

FIG. 1

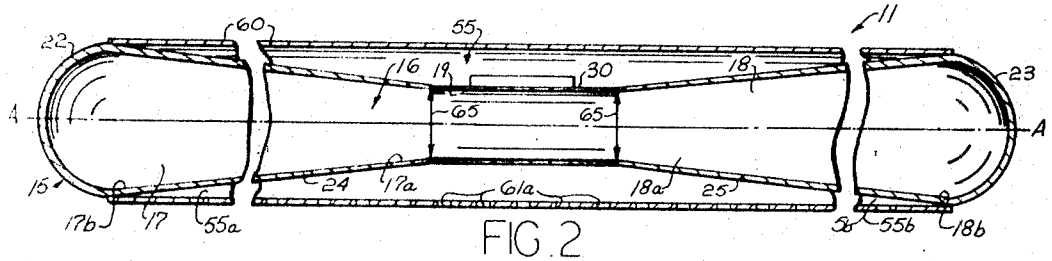

FIG. 2

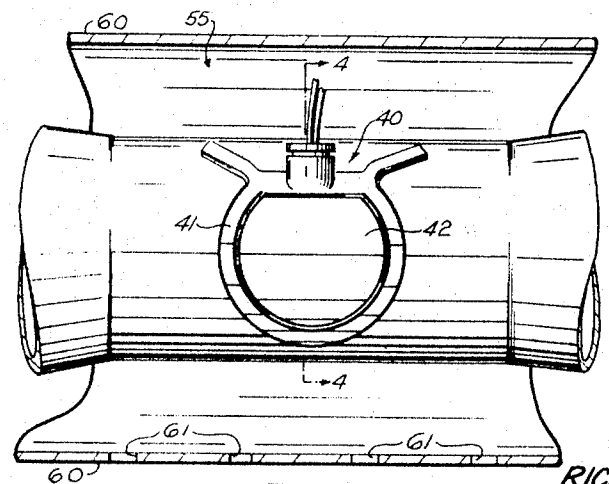

FIG. 3

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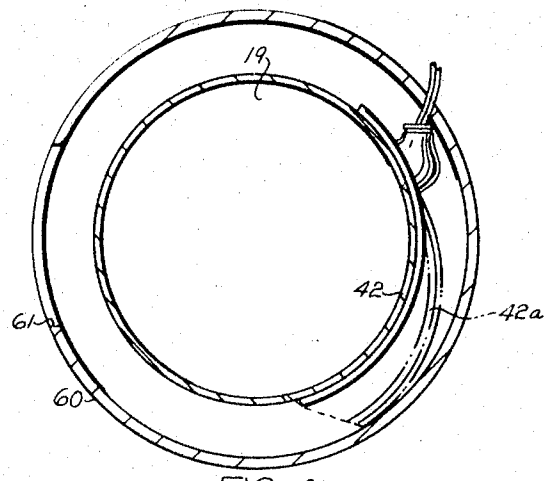

FIG. 4

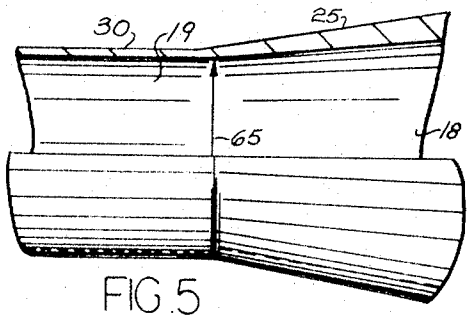

FIG. 5

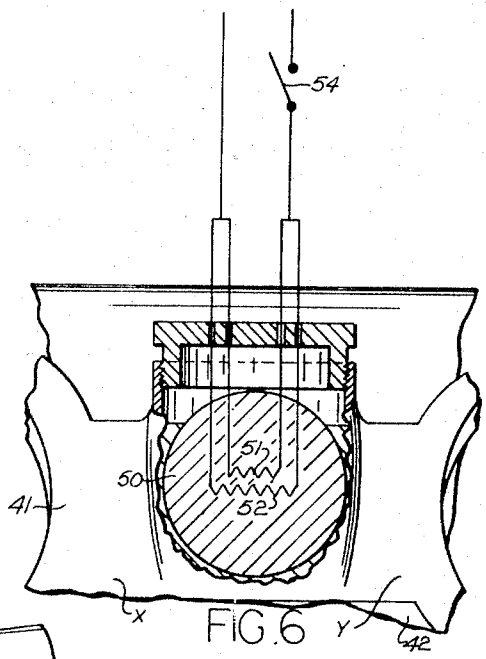

FIG. 6

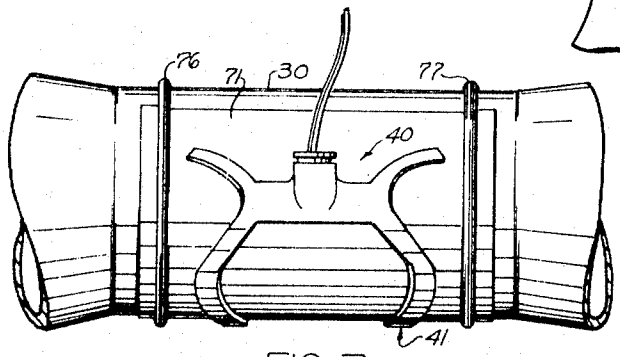

FIG. 7

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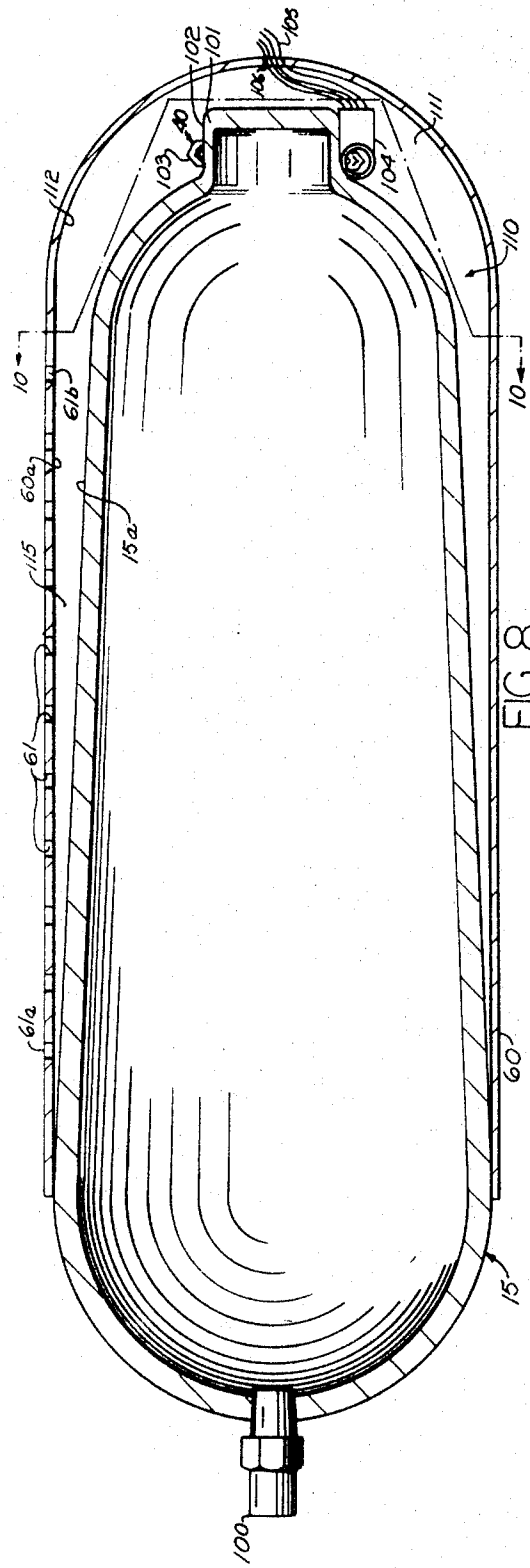

FIG. 8

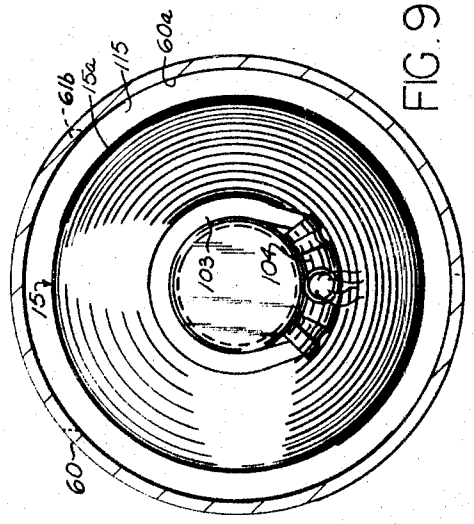

FIG. 9

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United States Patent Office 3,460,853 Patented Aug. 12, 1969

3,460,853

SAFETY APPARATUS

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Filed Oct. 13, 1967, Ser. No. 675,133
Int. Cl. B60r 27/00; F17c 5/00
U.S. Cl. 280—150 22 Claims

ABSTRACT OF THE DISCLOSURE

A container for pressurized fluids has a relatively thin wall portion. Means, preferably in the form of an explosive, is associated with the thin wall portion of the container and operates to effect the formation of an opening in the relatively thin wall portion to provide for release of fluid from the container. A linear flow distributor is associated with the container and distributes the fluid flow substantially equally.

The present invention relates to apparatus for storing a high pressure fluid, and particularly relates to a container for storing high pressure fluid which is released to effect inflation of a confinement for protecting an occupant of a vehicle during a collision.

Inflatable confinements for protecting an occupant of a vehicle during a collision are known. Such confinements are inflatable from a contracted position to an expanded position. A fluid container is provided and is opened to provide for flow of fluid into the confinement. The fluid is released from the fluid container by an explosive which effects the formation of an opening in the wall of the container. Due to the fact that the pressures within the container are relatively high, the thickness of the walls of the container has been relatively great. The thickness of the walls of the container has complicated the problem of opening the container. Moreover, while diffuser members having a plurality of openings providing for fluid flow into the confinement at various locations are known, such flow has not been substantially uniform from each opening and the confinement has thus not been as uniformly inflated as desirable.

An important object of the present invention is the provision of a new and improved vehicle safety apparatus whcih includes an inflatable confinement and a supply of fluid for inflating the confinement, and wherein the apparatus is constructed to operate reliably after a substantial period of storage in the vehicle, is compact, and thus takes a minimum of space in the vehicle, and provides for substantially uniform inflation of the confinement within the necessary time to protect a vehicle occupant during a collision.

Another important object of the present invention is the provision of a new and improved fluid pressure container for storing a fluid under pressure and which container may be readily opened to provide for fluid flow therefrom.

A more specific object of the present invention is the provision of a fluid pressure container of substantial volume and containing a fluid under pressure and which is constructed so as to have a relatively thin wall portion in which an opening may be readily formed to provide for release of fluid from the container.

A further object of the present invention is the provision of a new and improved apparatus which includes a

fluid pressure container having a fluid storage chamber of different transverse dimensions and wherein a relatively thin wall portion defines a portion of the chamber of a relatively small transverse dimension and means is associated with the thin wall portion to effect the formation of an opening therein to provide for flow of fluid from the storage chamber.

A still further object of the present invention is the provision of new and improved apparatus, as noted in the next preceding paragraph, wherein explosive means is associated with the relatively thin wall portion and is ignited to effect the formation of an opening in the relatively thin wall portion and as a result of the explosive being associated with the relatively thin wall portion, the magnitude of the explosive may be relatively small.

A further object of the present invention is the provision of a new and improved apparatus including a fluid container and a diffuser member associated in such a manner that the size of the fluid container and diffuser member as a unit may be maintained at a minimum and substantially uniform flow may be achieved through various openings in the diffuser member.

Another object of the present invention is the provision of a new and improved apparatus which includes a fluid container having means associated therewith to provide an opening in the container to provide for fluid flow therefrom, and the fluid flows from the opening and into a chamber defined by a diffuser member and the container, and wherein the diffuser member has a plurality of spaced discharge openings communicating with the chamber and the chamber has a cross-sectional dimension proportional to the amount of fluid flow therethrough.

A still further object of the present invention is the provision of a new and improved apparatus including a fluid container and a diffuser member which, in part, encircles the fluid container and wherein an opening is provided in the fluid container and fluid flows from the opening into a chamber which tapers so as to provide a decreased cross-sectional flow area as the fluid flows away from the opening.

Another object of the present invention is the provision of a new and improved apparatus which includes a container having a chamber therein for storing fluid under pressure and wherein the container has a relatively thin wall portion which is opened by an explosive means to provide for the flow of fluid from the chamber, and wherein the probability of circumferential tearing of the walls of the container is minimized.

A still further object of the present invention is the provision of new and improved apparatus which includes a pressurized container having a chamber with a relatively thin wall portion, and wherein explosive means is utilized for effecting formation of an opening in the relatively thin wall portion to provide for release of fluid from the chamber and which includes means for constraining the wall portions of the container to limit tearing thereof and thereby control the size of the opening in the container.

Further objects and advantages of the present invention will be apparent to those skilled in the art to which it relates from the following detailed description of preferred embodiments thereof made with reference to the accompanying drawing and in which:

FIG. 1 is a schematic view illustrating a safety device for a vehicle embodying the present invention;

FIG. 2 is a sectional view, taken approximately along the section line 2—2 of FIG. 1, and with parts omitted;

FIG. 3 is an enlarged fragmentary elevational view of a portion of the apparatus shown in FIG. 2;

FIG. 4 is a sectional view, taken approximately along the section line 4—4 of FIG. 3;

FIG. 5 is an enlarged fragmentary sectional view, partially in elevation, of the apparatus shown in FIG. 2;

FIG. 6 is an enlarged fragmentary sectional view of another portion of the apparatus shown in FIG. 3;

FIG. 7 is a view of a modified form of the present invention;

FIG. 8 is a view of a further modified form of the present invention; and

FIG. 9 is a sectional view, taken approximately along section line 10—10 of FIG. 9.

The present invention provides an improved fluid supply including a container for storing a pressurized fluid and which may be readily opened to provide for release of fluid therefrom. The container may be utilized in association with different devices which utilize the fluid stored within the container. For purposes of illustration, the container is shown as incorporated in a safety apparatus for protecting an occupant of a vehicle, such as a truck, an automobile, or airplane, during a collision.

Referring to FIG. 1, a vehicle **10** is shown in the form of an automobile having a fluid supply **11** supported in the dashboard thereof in a suitable manner. The fluid supply **11** is associated with a confinement **12** which has a collapsed condition located in the dashboard of the vehicle **10** and which is inflated to an expanded condition as shown in dot-dash lines in FIG. 1. The confinement **12** is inflated by the fluid contained in the fluid supply **11**. The fluid is released from the fluid supply **11** in response to a collision condition being experienced by the vehicle **10**, and the confinement **12** is rapidly inflated to restrain and control the movement of an occupant of the vehicle relative to the dashboard of the vehicle as a result of the collision. The confinement **12** could be utilized in other locations in the vehicle **10**, such as in the back of the front seat for protecting rear passengers, or in any other suitable location.

As shown in FIG. 2, the fluid supply **11** comprises a container **15** having wall means defining a closed fluid chamber **16**. The fluid container **15** and chamber **16** has, what may be termed, an "hour-glass" shape. More specifically, the chamber **16** has spaced frusto-conical chamber portions **17, 18**. The frusto-conical chamber portions **17, 18** are interconnected by a substantially cylindrical chamber portion **19**. The substantially cylindrical chamber portion **19** has an internal diameter substantially equal to the smallest internal diameter of the frusto-conical chamber portions **17, 18**. The axes of the chamber portions **17, 18** and **19** lie on a common line A—A, shown in FIG. 2. The narrow ends **17***a* and **18***a*, respectively, of the chambers **17** and **18**, communicate with the cylindrical chamber **19**. The wide ends **17***b* and **18***b* which are located at the opposite ends of the container **15** are closed by spherical wall means **22** and **23**, respectively. A suitable fill valve, not shown, may be associated with the container **15** for filling purposes.

In view of the fact that the transverse dimensions of the chamber **16** vary, the thickness of the wall means defining the chamber **16** may also vary. Those portions of the chamber **16** which have the greatest transverse dimension have the greatest fluid forces acting thereon and, thus, must have the greatest wall thickness for strength purposes. As a result, the thickness of the wall means **24, 25** defining the frusto-conical chamber portions **17, 18**, respectively, decreases as the transverse dimension, namely, the diameter of the frusto-conical chamber portions, decreases. This should be particularly clear from FIG. 5 wherein it can be readily seen that wall means **25** defining the frusto-conical chamber portion **18** decreases in thickness as the wall means **25** extends toward the cylindrical chamber portion **19**.

The substantially cylindrical chamber portion **19**, in view of the fact that it has a relatively small transverse dimension or diameter, is defined by a wall portion **30** which is relatively thin. In view of the fact that the wall portion **30** is relatively thin, an opening is more readily formed therein to provide for flow of fluid from the chamber **16**. Accordingly, means **40** for effecting the formation of an opening in the container **15** is associated with the relatively thin wall portion **30** defining the chamber portion **19**.

The means **40** for effecting the formation of an opening in the relatively thin wall portion **30** may take many different forms. As illustrated in the drawing, the means **40** preferably is explosive means. The explosive means illustrated comprises an explosive strip of material **41** which is shown schematically and preferably as a flexible linear-shaped charge which, as is well known, is constructed to direct the explosive force toward the wall portion **30**. Upon ignition of the explosive, a portion **42** of the wall portion **30** opens, enabling the pressure of the fluid in the chamber **16** to force the portion **42** outwardly of the container **15** and in the event that the explosive material **41** does not form a complete circle, the portion **42** will be bent outwardly to the position designated **42***a*, as shown by dot-dash lines in FIG. 4, to thereby provide an opening for the flow of fluid from the chamber **16**.

The strip of explosive material **41** is ignited by a suitable igniting or detonating explosive material **50**, best shown in FIG. 6. The material **50** is detonated by the flow of current through either a resistance wire **51** or a resistance wire **52**, both of which are positioned in the material **50**. The flow of current through both or either wire **51** or wire **52** results in detonation of the material **50** which, in turn, causes detonation of the strip explosive **41**. The explosive material **50** is associated with the explosive strip **41** at two spaced locations X and Y and is adapted to ignite the explosive strip at both locations. In the event that the strip **41** is not ignited at one of the locations X or Y, the strip **41** will still be ignited at the other location. This provides additional assurance that the explosive strip **41** will be ignited and makes the system extremely reliable.

Current flows through the wires **51, 52** upon closing of a switch **54** which is connected across a suitable power source. The switch **54** may be closed upon the vehicle's encountering a collision condition. The switch **54** may sense a collision condition being experienced by the vehicle or may be manually actuated. The fact that a current flow through either wire **51** or wire **52** effects ignition of the material **50** provides for a greater probability of actuation of the explosive **41** due to the fact that if one of the resistances is in some manner shorted or broken, the other will still effect ignition of the material **50**.

From the above, it should be apparent that when the switch **54** is closed, the strip material **41** is ignited, causing the area **42** of the wall portion **30** to be opened by the force of fluid in the chamber **19**. The fluid forces the area **42** to the position illustrated in FIG. 4, as noted above, and rushes from the opening formed in the container **15**. The fluid which is directed through the opening encounters a diffuser member or linear flow distributor **60**. The diffuser member or linear flow distributor **60** is substantially cylindrical in configuration and encircles the container **15**. The flow distributor **60** is provided with a plurality of slots **61**. The fluid flowing from the chamber **16** flows through the slots **61** in the diffuser and into the confinement **12** to effect inflation of the confinement.

In view of the fact that the wall portion **30** of the container **15** is relatively thin, the explosive charge in the strip material **41** may be relatively small as compared to the size of an explosive which would be required to form an opening in a relatively thick wall portion of the container **15**. Thus, the noise level upon ignition of the explosive **41** is substantially lower than if more explosive were utilized as would be required to provide an opening in the relatively thick wall means **25** of the container **15**. Moreover, the overall volume of the container is not

sacrificed and is sufficiently great so as to provide the desired amount of fluid flow into the confinement **12**. This volume may be substantially in excess of the volume of the confinement **12**, as discussed in copending application Ser. No. 681,393 filed Nov. 8, 1967, of common ownership with the present application.

Upon ignition of the explosive strip **41**, fluid flows through an opening formed in the wall portion **30** of the container **15**. The fluid as it flows through the opening flows into a chamber, generally designated **55**, defined by the linear flow distributor **60** and the container **15**. Due to the shape of the linear flow distributor **60**, the chamber **55** has a tapered configuration as it extends from the central portion thereof in opposite directions toward the opposite ends of the chamber. The openings **61** in the linear flow distributor **60** are located at spaced locations along the axial extent of the linear flow distributor **60** and intersect the chamber **55** at various locations. The tapered configuration of the chamber **55** is such that a substantially uniform flow of fluid is provided from each of the openings **61** and a minimum pressure drop is experienced between the central portion of the chamber **55** immediately adjacent the opening **61***a* and the opposite ends **55***a*, **55***b* of the chamber **55**. As a result of the above-described construction, the flow through the various openings **61** in the linear flow distributor **60** is substantially equal.

Moreover, in view of the fact that the chamber **55** is constructed so as to provide a minimum pressure drop throughout, the size of the pressure container **15** may be minimized and yet the confinement **12** may be readily inflated uniformly and within the required time. The minimizing of the size of the container **15** is important since the unit comprising the container **15** and diffuser **60** is located in association with the dashboard of the vehicle and should not be of such size to interfere with other structures in the dashboard or with the comfort of the passengers.

Furthermore, the flow of fluid from the chamber **16** through the opening formed in the wall portion **30** may be controlled by the dimension **65** of the chamber **16**, as shown in FIG. 2. Fluid contained in the frusto-conical chambers **17**, **18** in order to flow from the container **15** flows into the chamber **19**. The fluid flows from the chambers **17**, **18** at a rate which is controlled by the size of the dimension **65** as long as the opening formed in the container **15** by the explosive **41** is sufficiently large. Thus, by controlling the dimension **65**, the rate of flow of fluid from the frusto-conical chambers **17**, **18** into the confinement **12** may be controlled. The smaller the dimension **65**, the more restricted the flow of fluid will be, and the larger the dimension **65**, the more freely the fluid will flow. This rate of fluid flow control is important to prevent rupture of the confinement **12** by an excessive fluid flow into the confinement.

The relatively thick wall portions **24**, **25** defining the frusto-conical chamber portions **17**, **18**, respectively, control and minimize the tendency of the material of the container **15** to tear when the container **15** is opened. The tearing of the material would provide an uncontrolled large opening in the container **15** which may permit a substantial amount of fluid to flow from the chamber **16** at a fairly rapid rate and may also cause rupturing of the confinement **12**. Thus, the thick wall portions **24**, **25** minimize the possibility of longitudinal tearing and assist in controlling the fluid flow from the container **15**.

A modification of the present invention is illustrated in FIG. 7. This modification includes means **40** in the form of a strip explosive **41** to effect the formation of an opening therein, as described above in connection with FIG. 3. The explosive strip **41** is mounted on a plate **71**. The plate **71** is of a relatively thin wall construction and supports the strip explosive between the plate **71** and the container **15**. When the explosive is ignited, the container **15** is opened and fluid rushes through the opening formed in the container. The plate **71** is either destroyed or otherwise removed from the container due to the explosion.

The plate **71** is retained on the substantially cylindrical chamber portion **19** of the container **15** by bands **76**, **77**. The bands **76**, **77** provide not only means for retaining the plate **71** on the container **15**, but also apply a constraining force, constraining the diameter of the container **15** and resisting expansion of the diameter of the container **15** upon ignition of the explosive. As a result of this constraint, the strips **76**, **77** minimize circumferential tearing of the plate **71** and the container **15** upon ignition of the explosive **41**. The specific construction is shown and described in more detail in application Ser. No. 664,822, assigned to the assignee of the present invention.

The embodiment illustrated in FIGS. 8 and 9 incorporates the structural advantages described hereinabove in connection with the embodiments described above. In the embodiment of FIGS. 8 and 9, the fluid container **15** is associated with a diffuser member **60**. The fluid container is opened by an explosive actuating means **40**. When the explosive actuating means **40** is actuated, the fluid flows from the reservoir or container **15** and through the slots **61** in the diffuser member and into the inflatable confinement **12** illustrated in FIG. 1 to effect inflation of the confinement **12**.

The reservoir **15** is provided with a fill connection **100** at one end thereof through which the reservoir **15** is filled with fluid. The reservoir **15** at the other end thereof has a neck-down portion **101**. The neck-down portion **101** includes a projecting surface portion **102** which projects outwardly from the body of the reservoir **15**. A linear-shaped strip of explosive material **103** encircles the projecting portion **101** of the reservoir **15** in order to effect the formation of an opening in the reservoir **15** upon detonation thereof. The explosive strip **103** extends around the surface **102** of the projecting portion **101** of the reservoir **15** and is ignited by the passage of a current through a detonator **104**. A current is directed through the detonator **104** by lead wires or conductors **105** which extend through an opening **106** in the diffuser member **60**.

As fluid flows from the reservoir **15**, it flows into a chamber **110** which is defined by the outer peripheral surface of the diffuser member **60**. The chamber **110** includes a chamber portion **111** adjacent the projecting portion **101** of the reservoir **15** and into which the fluid from the reservoir **15** initially flows upon detonation of the explosive strip **103**. The fluid which flows into the chamber portion **111** is directed by the internal spherical surface **112** of the diffuser member, which defines, in part, the chamber portion **111**, along the extent of the reservoir **15**.

The chamber **110** also includes a generally tapered chamber portion **115** which extends from the chamber portion **111** and which is defined by the outer surface **15***a* of the reservoir **15** and the inner surface **60***a* of the diffuser member **60**. The chamber portion **115** is tapered to such an extent that as the fluid flows along the chamber portion **115**, it is somewhat compressed. The taper of the chamber **115** is due to the fact that the reservoir **15** is tapered, while the diffuser member **60** is not, as shown in FIG. 6. The tapered chamber **115** could be provided by other constructions including a taper on the diffuser member **60**.

The fluid flows into the chamber portion **115** and then flows through the openings **61** in the diffuser member **60** and into the confinement **12**. The tapered chamber portion **115** provides for substantially the same amount of fluid flow through all the openings **61**. There is approximately the same flow rate through opening **61***a* which is located farthest from the explosive **103** as there is through opening **61***b* which is located immediately adjacent the strip **103**. Moreover, the flow of fluid through each of the openings is maintained substantially equal for a time interval so as to provide for a uniform inflation of the

confinement as described above in connection with the embodiment described above.

In view of the foregoing, it should be apparent that applicant has provided a new and improved safety apparatus for a vehicle and that certain changes, modifications, and adaptations may be made therein, and it is intended to cover all such changes, modifications, and adaptations therein which come within the scope of the appended claims.

What is claimed is:

1. Apparatus comprising first means defining a fluid chamber, said chamber having different transverse dimensions, said first means having a thickness which is relatively large where the transverse dimension of said chamber is relatively large and a thickness which is relatively small where the transverse dimension of said chamber is relatively small, and second means associated with a relatively thin portion of said first means for effecting the formation of an opening therein to provide for release of fluid from said chamber.

2. Apparatus as defined in claim **1** wherein said second means for effecting the formation of said opening comprises explosive means.

3. Apparatus as defined in claim **1** wherein said chamber has a frusto-conical shaped portion defined by a portion of said first means having a relatively large thickness and a substantially cylindrical portion defined by a portion of said first means having a relatively small thickness.

4. Apparatus as defined in claim **1** further including an expansible confinement into which said fluid flows upon release from said chamber to effect inflation of said confinement.

5. Apparatus as defined in claim **4** wherein said second means for effecting formation of said opening comprises explosive means mounted on said relatively thin portion of said first means.

6. Apparatus as defined in claim **5** wherein said explosive means comprises a strip of explosive material supported on said relatively thin wall portion.

7. Apparatus for protecting an occupant of a vehicle during a collision comprising a confinement having a contracted condition and an inflated condition, said confinement when in its inflated condition providing a restraint for controlling movement of an occupant of a vehicle during a collision, a fluid supply having first means defining a fluid chamber, said chamber having different transverse dimensions, said first means having a thickness which is relatively large where the tranverse dimension of said chamber is relatively large and a thickness which is relatively small where the transverse dimension of said chamber is relatively small, and second means associated with a relatively thin portion of said first means for effecting the formation of an opening in said relatively thin portion of said first means to provide for release of fluid from said chamber for flow into said confinement to effect inflation of said confinement.

8. Apparatus as defined in claim **7** wherein said means for effecting the formation of said opening comprises explosive means mounted on said relatively thin portion of said wall means.

9. Apparatus as defined in claim **8** wherein said explosive means comprises a strip of explosive material supported on the exterior of said relatively thin portion of said wall means.

10. Apparatus as defined in claim **8** wherein said chamber comprises a pair of frusto-conical chamber portions and a substantially cylindrical chamber portion interconnecting said frusto-conical chamber portions, said cylindrical chamber portion being defined by said relatively thin portion of said wall means.

11. Apparatus comprising wall means defining a closed chamber, said chamber having at least one frusto-conical chamber portion and a substantially cylindrical chamber portion of an inner diameter less than the greatest inner diameter of said frusto-conical chamber portion, said wall means including a first wall portion defining said frusto-conical chamber portion, said first wall portion having a trickness which decreases as the inner diameter of said frusto-conical chamber portion decreases, and said wall means including a second wall portion defining said cylindrical chamber portion and having a thickness substantially less than the greatest thickness of said first wall portion.

12. Apparatus as defined in claim **11** including another frusto-conical chamber portion, said cylindrical chamber portion interconnecting said frusto-conical chamber portions and having an internal diameter substantially the same as the smallest internal diameter of said frusto-conical chamber portions.

13. Apparatus as defined in claim **12** wherein the axes of said frusto-conical chamber portions and said cylindrical chamber portion lie on a common line.

14. Apparatus for protecting an occupant of a vehicle during a collision comprising a confinement having a contracted condition and an inflated condition, said confinement when in its inflated condition providing a restraint controlling movement of an occupant of a vehicle during a collision, a fluid supply having wall means defining a closed fluid chamber, said chamber having different transverse dimensions, said wall means having a thickness which is relatively large where the transverse dimension of said chamber is relatively large and a thickness which is relatively small where the transverse dimension of said chamber is relatively small, and means associated with a relatively thin portion of said wall means for effecting the formation of an opening in said container to provide for release of fluid from said chamber for flow into said confinement to effect inflation of said confinement, said relatively thin portion of said wall means defining a generally cylindrical chamber portion, said relatively thick wall portion of said chamber defining a frusto-conical chamber portion, and the axes of said frusto-conical chamber portion and said cylindrical chamber portion lying on a common line.

15. Apparatus as defined in claim **14** wherein said means for effecting the formation of said opening comprises explosive means mounted exteriorly of said relatively thin portion of said wall means.

16. Apparatus as defined in claim **15** further including a diffuser means interposed between said chamber and said confinement and operable to diffuse the fluid released from said container as it flows into said confinement.

17. Apparatus as defined in claim **16** wherein said diffuser means and said fluid supply define a chamber therebetween, said chamber having a decreasing flow area as the chamber extends away from the location of said opening, and said diffuser means having passages communicating with said chamber at spaced locations along said chamber and through which substantially equal volumes of fluid flow.

18. Apparatus comprising a fluid reservoir for containing a supply of fluid, a diffuser member associated with said reservoir, said diffuser member and said reservoir having cooperating surfaces which define a chamber therebetween providing a flow path through which fluid from said reservoir flows, said diffuser member having passages communicating with said chamber at spaced locations along said flow path, and said chamber having a decreasing flow area as the chamber extends in the direction of fluid flow to provide substantially equal volumes of fluid flow through said passages.

19. Apparatus as defined in claim **18** wherein said cooperating surface portions include at least one tapered surface providing a chamber portion defined by said diffuser member and said reservoir of a generally tapered configuration.

20. Apparatus as defined in claim **18** wherein said res-

ervoir has a tapered surface portion thereon defining at least a part of said chamber.

21. Apparatus as defined in claim **18** wherein said flow area decreases in proportion to the decrease in flow of fluid therethrogh to provide a substantially constant pressure throughout said chamber.

22. Apparatus as defined in claim **21** further including a confinement adapted to be mounted in a vehicle and having an inflated condition, said confinement when in its inflated condition providing a restraint controlling movement of an occupant of a vehicle during a collision.

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JOEL E. SIEGEL, Assistant Examiner

U.S. Cl. X.R.

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