United States Patent

Mazelsky

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[54] **SAFETY CUSHION AIR SYSTEM**

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[73] Assignee: **Ara, Inc.,** West Covina, Calif.

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[52] **U.S. Cl.**.....**280/150 AB,** 220/89 A, 220/3

[51] **Int. Cl.**.....**B60r 21/10**

[58] **Field of Search**.....280/150 AB; 220/89, 71, 72, 220/3; 206/47 A, 63.5; 222/3, 5, 85

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[57] **ABSTRACT**

The device is an inflatable safety air cushion for use as a safety device to protect passengers in vehicles. A gas such as nitrogen or helium is maintained at moderate pressure in an elongated container. It is transferred to a similarly elongated inflatable bag through an elongated nozzle type diffuser between the container and bag. The diffuser has a throat portion in which is positioned explosive opening or valve means in the form of a relatively thin membrane for opening the passageway to rapidly transfer the gas to the bag for inflating it without damaging the bag. The device, practically and effectively makes possible inflation of the bag in a sufficiently limited number of milliseconds to be fully operative for its purpose.

11 Claims, 11 Drawing Figures

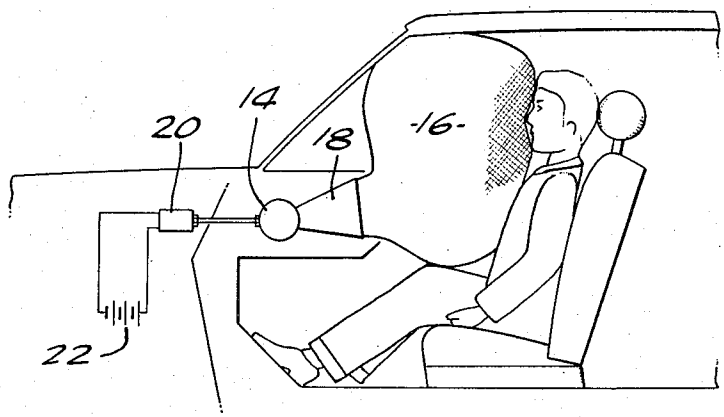
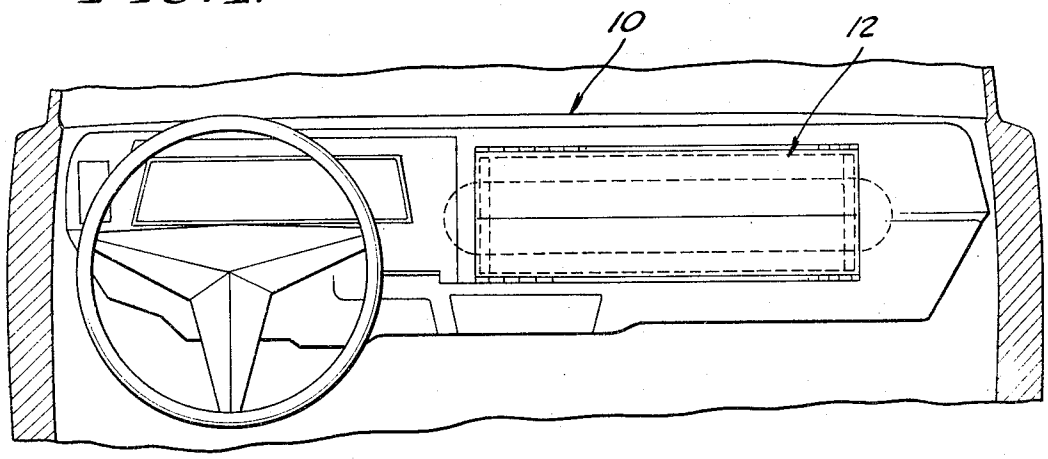


FIG. 1.



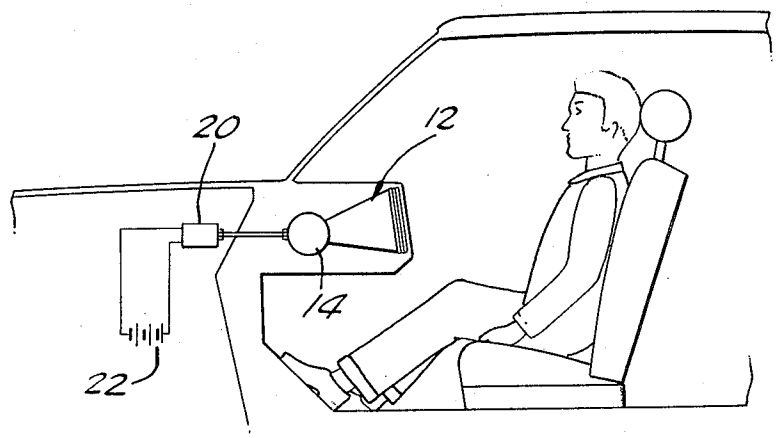


FIG. 2.

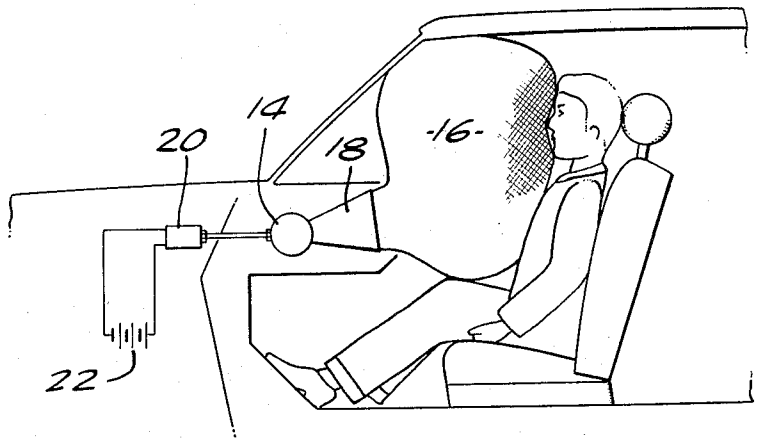


FIG. 3.

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FIG. 4.

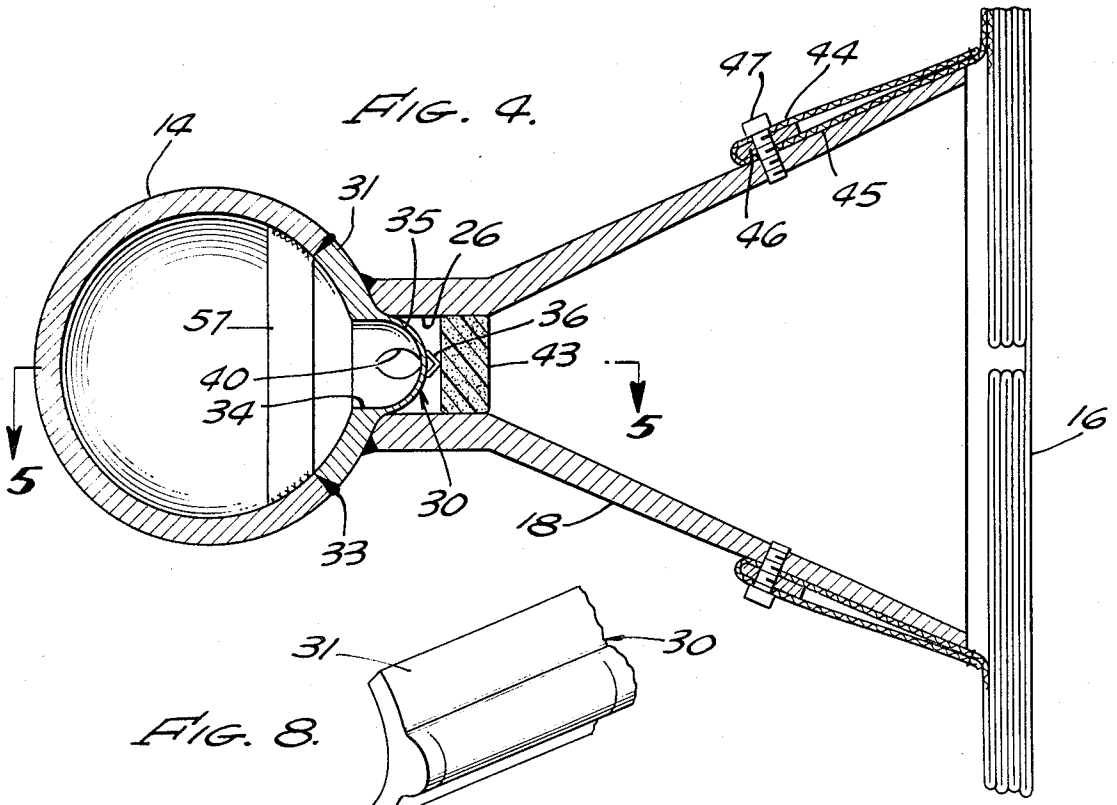
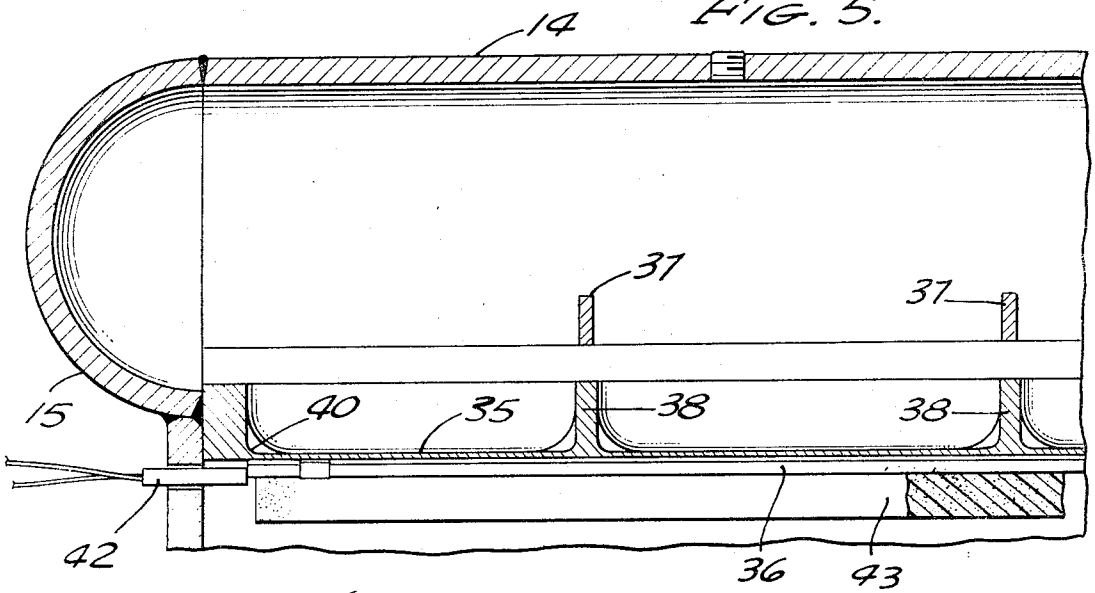


FIG. 8.

FIG. 5.



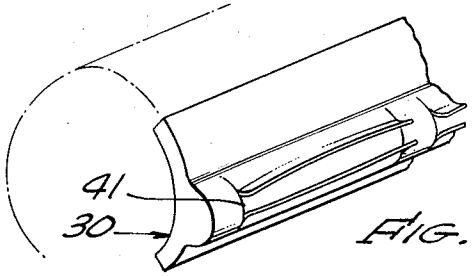


FIG. 9.

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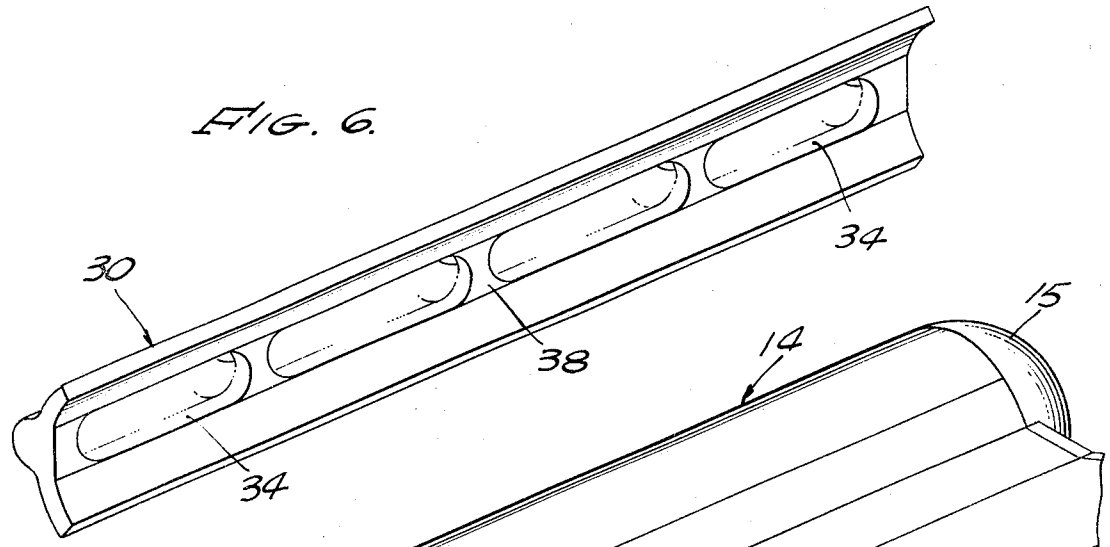
FIG. 6.



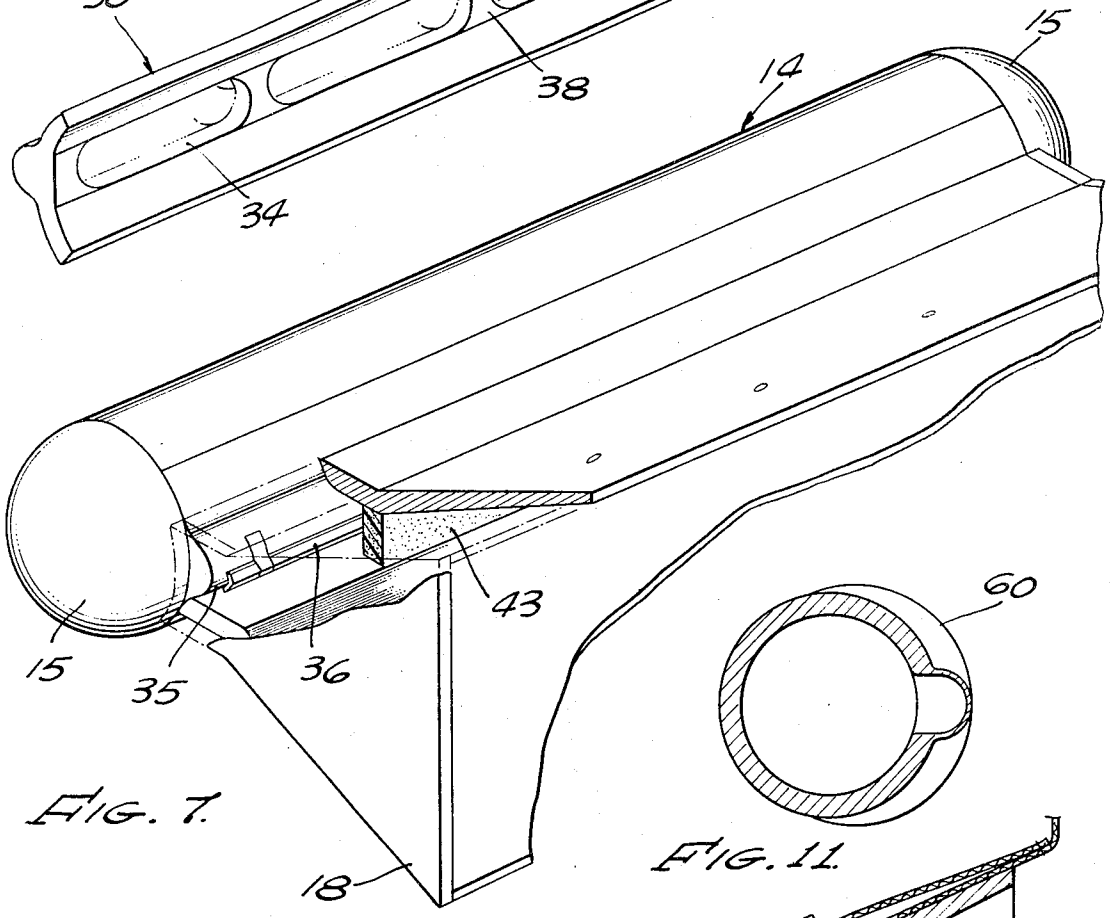


FIG. 7.

FIG. 11.

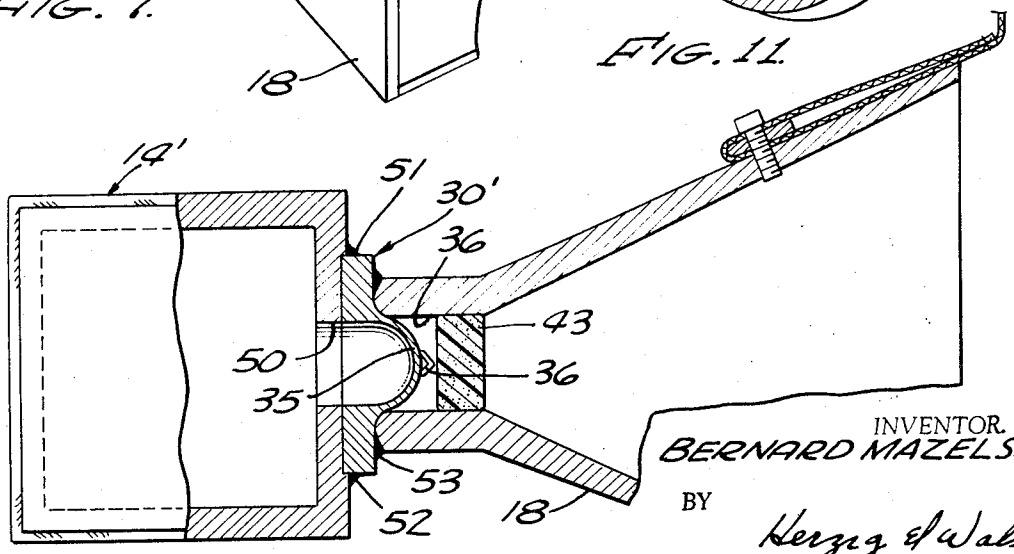


FIG. 10.

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SAFETY CUSHION AIR SYSTEM

SUMMARY OF THE INVENTION

The invention is an inflatable safety air cushion in the form of an inflatable envelope adapted for use in vehicles to protect passengers in the event of accidents involving high rates of deceleration. Various developments and systems have been evolved in the prior art to realize a device or system of this type. Of paramount significance in a device of this type is, of course, the amount of time the device requires to effectively inflate the air cushion since, of course, inflation is to be initiated automatically after the vehicle is already into the accident or situation requiring use of the safety device. Preferably the inflation process is initiated in response to deceleration forces and a significant amount of time is required for the sensor to respond. Time is then required to actuate a device capable of releasing a gas under pressure from a container and further time is, of course, required for the transfer of the gas under pressure to the envelope to inflate it sufficiently to perform its purpose. It can readily be seen, therefore, that any improvements capable of reducing the time in milliseconds required for effectively inflating the safety cushion are extremely significant and contribute greatly to the practical effectiveness of the device and system. The herein improvements make it possible to realize a reduction in total time to less than ten milliseconds.

It is of course also highly desirable to provide the capability of effectively inflating the bag without resorting to excessively high pressures because the size, weight, and cost of the tank and release valve can then be minimized. In addition the use of lower storing pressures in the tank results in lower noise levels during actuation.

In the preferred form of the herein invention the gas used is preferably nitrogen or helium for reasons which will be made clear hereinafter. The pressurized gas is contained in an elongated container, the air cushion envelopes itself being elongated with the gas being transferred from the container to the envelope by way of a nozzle type diffuser having a throat which can be opened by way of explosive means for making possible the transfer of gas in a minimum of time. The opening means may be referred to as an explosive valve, the throat in the diffuser nozzle being similarly elongated and the explosive valve being in the throat. In the description of a preferred embodiment of the invention hereinafter typical design parameters will be referred to and the detail nature of the device will be made clear.

In the light of the foregoing, the primary object of the invention is to improve safety inflatable air cushion devices or systems by reducing the total time required for effective inflation of the envelope, reducing the noise level, and by reducing the costs for manufacture by utilizing lower storage pressures.

A further object is to realize the purpose of the preceding object by way of a particular combination and interrelationship of parts and employment of preferred inflating gases. More particularly it is an object of the invention to realize the desired end by way of the combination of an elongated gas container, a diffuser nozzle having a diverging outlet between the container and the inflatable envelope or bag, with explosive means positioned in a throat in the diffuser nozzle for opening the nozzle and allowing rapid transfer of gas to the bag without damage to the bag.

In the preferred embodiment, the tank is cylindrical with hemispherical ends. The gas release means or valve is a membrane of semi-cylindrical cross sectional configuration which is ruptured longitudinally by a linearly shaped charge. These configurations serve to maximize the strength while minimizing the weight. The realization of these ends constitute objects of the invention.

After opening of the valve, the flow of gas to the envelope is direct and unobstructed, thus minimizing the pressure required to inflate the bag in the required time. The realization of reduction in pressure required is a further object of the invention.

A further object is to provide explosive means comprised essentially of a valve positioned in the throat of the diffuser nozzle and capable of being opened by being ruptured by an explosive charge, the valve being in the form of a membrane having a cross-sectional configuration for optimum strength and weight characteristic.

Further objects and additional advantages of the invention will become apparent from the following detailed description and drawings wherein:

FIG. **1** is a pictorial view of the dashboard of the vehicle showing the installed position of the safety inflatable air cushion device;

FIG. **2** is a further pictorial view illustrating particularly the position of the deceleration responsive sensor;

FIG. **3** is a further pictorial view illustrating the inflated position of the envelope;

FIG. **4** is a cross-sectional view of a preferred form of the device of the invention;

FIG. **5** is a sectional view taken along line **5—5** of FIG. **4** illustrating the explosive opening means in greater detail;

FIG. **6** is a perspective view of the valve or rupturable membrane or unit;

FIG. **7** is a partly broken away perspective view of the preferred form of the invention;

FIG. **8** is a partial perspective view of the valve;

FIG. **9** is a partial view illustrating the valve or membrane after explosive opening;

FIG. **10** is a sectional view of a modified form of the invention;

FIG. **11** is a cross sectional view of a modified form of tank reinforcement.

FIG. **1** illustrates a typical installation, numeral **10** illustrating an automobile dashboard having a panel trim pad with the safety device or system as indicated at **12** installed behind it. Upon being activated the device breaks through the trim pad and inflates into a position as illustrated in FIG. **3**. As shown in FIG. **2**, the gas container **14** of the device is cylindrical, the bag **16** normally being folded or collapsed as shown with the diffuser nozzle **18** between the container and the folded bag. The arrangement as shown is preferable to arrangements wherein the gas container is within the bag itself.

The system is controlled by a deceleration responsive sensor that may be mounted in a position ahead of the fire wall as shown whereby to respond rapidly to deceleration forces when the vehicle enters an impact

situation. Sensor **20** may be of conventional or typical type energizable by way of a battery **22**.

FIG. **3** shows the bag **16** inflated in a position in front of the passenger. The bag may, of course, have a transverse dimension sufficient to provide safety for one or more passengers in the front seat.

FIG. **4** shows a preferred arrangement of the parts, the diffuser nozzle **18** having a throat part **26**, the diffuser diverging as shown from the throat to the bag **16**. As may be seen the tank or container **14** is elongated as is the diffuser nozzle **18** extending at least partway along the length of the bag **16**. The gas container and diffuser nozzle can, of course, be made to be co-extensive in length with the bag. Tank **14** is cylindrical having welded hemispherical ends as shown at **15** for maximum strength.

Positioned in the throat **26** is the explosive opening means **30**. FIG. **5** is a sectional view showing a preferred form of the explosive opening means which takes the form of an arcuate segment **31** having the same radius and wall thickness as tank **14**. It is welded to a side opening in the tank as shown at **33**. The intermediate part of segment **31** is open as shown at **34**. Extending across the opening is a relatively thin, integral, semi-cylindrical membrane **35** which can be ruptured longitudinally by linearly shaped charge **36** which is a commercially available type of charge of V-shaped cross section. The charge may be attached simply by way of adhesive or adhesive tape. The unit **31** may be made by casting or machining. It is preferably, but not necessarily of integral material. The membrane **35** extended into throat **26**, segment **31** fitting against the end of the throat and being welded to it as shown.

The tank **14** is reinforced by several transverse braces or gussets **37** interiorly welded to the tank adjacent segment **31** as shown.

Across the interior of unit **30** are webs as shown at **38**. Adjacent the webs **38** and the ends of unit **30**, the material of the membrane is thinner as shown at **40**. To facilitate opening of the valve, membrane **35** has score lines as shown at **41** and axially between webs **38**.

The combination and arrangement of parts adapts itself ideally to the use of commercially available explosive devices. The detonator for the shaped charge is designated at **42** and it may be a standard commercially squib. The elongated explosive member **36** is of the type sold commercially under the name Linear Shaped Charge.

Numeral **43** designates a means preferably in the form of a bar of light plastic material such as Styrofoam positioned in throat **26** to prevent explosive fragments from blowing into bag **16**. Upon opening of the valve it is moved away and does not obstruct passage of gas into the bag.

The bag is preferably secured to the nozzle diffuser **18** as shown in FIG. **4**. Its edge parts as shown at **44** and **45** are doubled back over a holding member **46** which is secured to the diffuser by screws **47**.

The invention as described herein is calculated to realize improvement of 200 to 300 percent in systems of this type. The following will make more clear the specific characteristics of the device and its operation and performance. The gas used may be air, nitrogen or helium. The rapidity of transfer of gas is limited by the speed of sound in the gas this being 1,126 feet per second for air, 1,135 feet per second for nitrogen; and 3,218 feet per second for helium. The bag may be made of various fabric materials, the gas container **14** being generally cylindrical as shown. In a typical embodiment of the invention the gas container **14** is charged with nitrogen at a pressure which may be as low as 450 pounds per square inch. The sensor **20** may be set to respond at a deceleration force of approximately 5 to 10 g's, the sensor then closing the circuit and exploding the explosive charge. The bag must be inflated before the passenger feels the accident, that is, before he leans forward. The time duration allowable for the entire process to be effective can be considered limited to approximately 30 milliseconds which is approximately half of that presently being realized in the known types of devices. This time duration includes time for the sensor to act, the explosion of the opening means and the transfer of gas to the bag for inflating it. Ten milliseconds is considered to be the upper limit of time for inflating the bag. Upon activation of the sensor **20** the explosive charge **36** detonates, rupturing diaphragm **35** as shown in FIG. **9** whereby transfer of gas through the diffuser nozzle to the bag begins. A shock wave propagates into the bag causing the pressure in the bag to build up and it starts to inflate while at the same time an expansion wave propagates into the pressure tank tending to reduce its pressure. The time to inflate the bag includes the time for the shock wave to reach the bag and the time for the required amount of gas to transfer to build up the desired pressure. Accordingly the diffuser nozzle is made short and is arranged to provide for a maximum rate of discharge therethrough. The divergence of the nozzle prevents the shock wave from damaging the bag without the necessity of a retarder or obstructing device positioned beyond the explosive means. Once the valve opens, there is no obstruction to transfer of gas. In a typical system it is desired that the bag be inflated to a pressure of approximately 17 pounds per square inch absolute within the allowable time. For typical parameters as to gas containers, size, diffuser nozzle, size including throat area, and bag size, the time required for inflation to the desired pressure can be calculated mathematically. Typically in the preferred embodiment, the inflation pressure of approximately 17 pounds per square inch absolute is reached before transfer of gas, that is, flow has completely subsided. With the combination and arrangement of parts as described herein the total elapsed time for effecting satisfactory inflation of the bag can be reduced to a fraction of the minimum required time for the device to be useful, particularly when helium is the inflating gas. This is achieved in a relatively simplified device using standard commercially available explosive material. It is not necessary that the gas container be installed within the bag itself and the combination of parts avoids there being a strong jet of gas impinging on the bag which would possibly damage it. The bag inflates to a configuration as pictorially indicated in FIG. **3** wherein the passenger is protected since inflation incurs before the passenger begins to lean forward.

FIG. **10** shows a modified form of the invention utilizing a square tank **14'**. It has a side opening **50**. The unit **30'** has a flat part **51** welded to the side of tank **14'** over opening **50** as shown at **52**. The membrane **35** is

like that of the previous embodiment. Unit **30'** is welded to the end of throat **26** as shown at **53**.

FIG. **11** shows a modified way of providing tank reinforcement accommodating it to fabrication by various methods and techniques. Instead of the braces **57** as shown in Figure, one or more ribs, such as shown at **60** are provided on the outside of tank **14** at the positions of the ribs **38**. Preferably these ribs are of varying radial dimension.

In one specific embodiment of the herein invention which was reduced to practice, the tank such as **14'** had a wall thickness of approximately one-fourth inch, comprising low carbon steel; it had an internal wall to wall dimension of 5.5 inch. The tank had a length of approximately 20 inches. The tank was pressured to 450 pounds per square inch. The membrane **35** was also formed of low carbon steel having a thickness of 0.030 inch, and having a radius of one-half inch. The linear shaped charge as previously described was used. It was linear shaped charge No. 10 available commercially from Ensign-Bickford Company. The reinforcing webs **38** were one-fourth inch thick and the distances between the intermediate webs was 4¾ inch while the distances between webs adjacent to the ends of the tank and the ends of the tank were 3⅞ inch. The walls at the ends of the tank were one-half inch thick. The transverse dimension of the opening or openings **34** in the unit **31** was 1 inch. The transverse dimension of the throat **26** was 1 inch. The throat **26** was approximately 1 inch in length. The density of the foam **43** was approximately 2 lbs. per cubic foot. The Styrofoam member **43** was three-fourths inch in thickness. The nozzle was 5.8 inch in length from the throat to its extremity, its diverging wall diverging at an angle of 25°. The transverse dimension at the mouth of the diffuser nozzle was 6.4 inch. The bag was Neoprene coated Nylon having a weight or gauge of 5 ounces per square yard. The bag was secured as previously described by 10 screws **47** spaced along the perimeter of the diffuser nozzle. The bag had a volume of 10 cubic feet. The bars **46** were made of aluminum about a one-fourth inch thick, about 1 inch wide and 18 inch long on the sides of the diffuser and about 5 inches long on the ends of the diffuser extending substantially continuously around the diffuser nozzle. The bag was folded as illustrated in FIG. **4**.

From the foregoing those skilled in the art will understand the nature and characteristics of the invention and the manner in which it achieves and realizes the objects as set forth in the foregoing. The disclosure of the preferred embodiments is intended to be illustrative of various equivalents that may be resorted to particularly with respect to the exact configuration of the explosive opening means.

What is claim is:

1. A safety device for human protection comprising an envelope inflatable with a gas whereby to form a resilient cushion, an elongated container for gas under pressure, means whereby to provide elongated passageway means along the length of the container for transferring gas from the container to the envelope for inflating it, said first means comprising an explosive actuator positioned to open said passageway means, and an elongated gas transfer nozzle extending from the container to the envelope, said nozzle being formed to provide a single unobstructed channel for gas transfer from the container to the envelope, said nozzle having upper and lower portions closely adjacent said passageway means.

2. A device as in claim **1**, including means normally positioned transversely of the direction of flow of gas that transfers to the inflatable envelope, said explosive charge being positioned to move said transversely positioned means out of said channel to prevent explosive fragments from entering the envelope without obstructing the channel.

3. A device as in claim **2** wherein the gas transfer nozzle includes a relatively restricted throat, said obstructing means normally being positioned across said passageway.

4. A device as in Claim **1**, wherein said first means comprises relatively thin membrane means which is arcuate in cross section extending lengthwise of the container, the explosive actuator being adjacent said membrane.

5. A device as in claim **4** wherein the said membrane is of semi-circular shape.

6. An article as in claim **4**, wherein the membrane means is formed as part of a closure member providing opening means in the container when the membrane means is ruptured.

7. An article as in claim **4** wherein the membrane means is formed as part of a closure member secured to the container in a position to close an opening in it.

8. An article as in claim **4**, including reinforcing means positioned to reinforce the container adjacent to the position of said membrane means.

9. An article as in claim **8** wherein the reinforcing means is within the container.

10. An article as in claim **8** wherein the reinforcing means is external of the tank.

11. A device as in claim **1** wherein said nozzle comprises a diffuser capable of avoiding damage to the inflatable envelope by shock wave.

* * * * *