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Allemann

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[54] **TWO-STAGE, PRESSURE AUGMENTED INFLATOR ASSEMBLY**

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[52] **U.S. Cl.** **222/3**; 222/5

[51] **Int. Cl.** **B67b 7/24**

[58] **Field of Search** ..... 222/3, 5, 541; 280/150 AB; 9/316–320, 321, 314, 324–325

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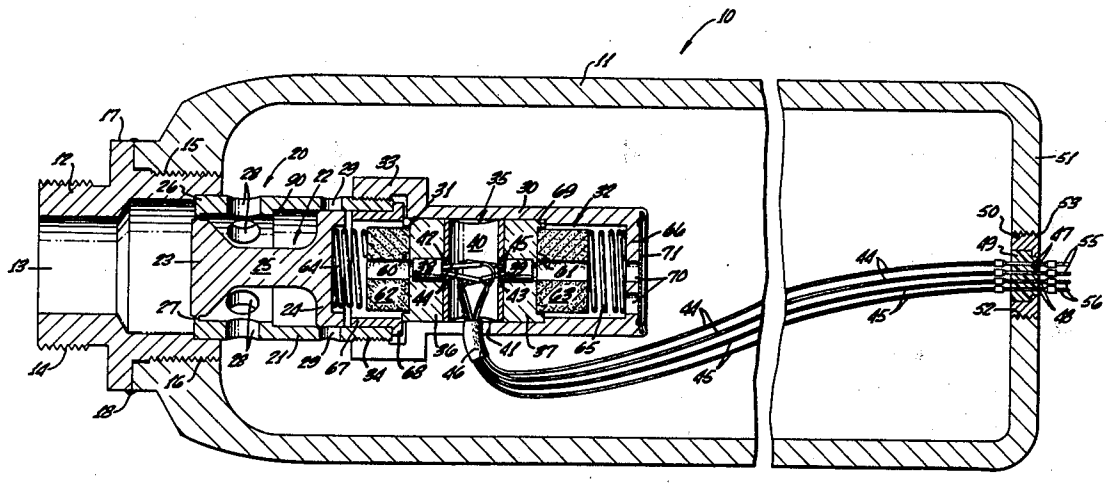
[57] **ABSTRACT**

Apparatus for augmenting the pressure of a gas stored in a container and for releasing the stored gas on command. First and second ignitable, pressure augmenting compositions are stored within the container, the first composition being ignited under a first predetermined set of circumstances and both compositions being simultaneously or sequentially ignited under a second predetermined set of circumstances. The container has positioned therein a movable shuttle valve which is activated directly by the pressure produced by the first pressure augmenting composition without relying upon a rupturable member or a separate firing mechanism. The shuttle valve has incorporated therein a mechanism whereby the stored gas is permitted to escape in the event of a build-up of excessive pressure within the container.

18 Claims, 4 Drawing Figures



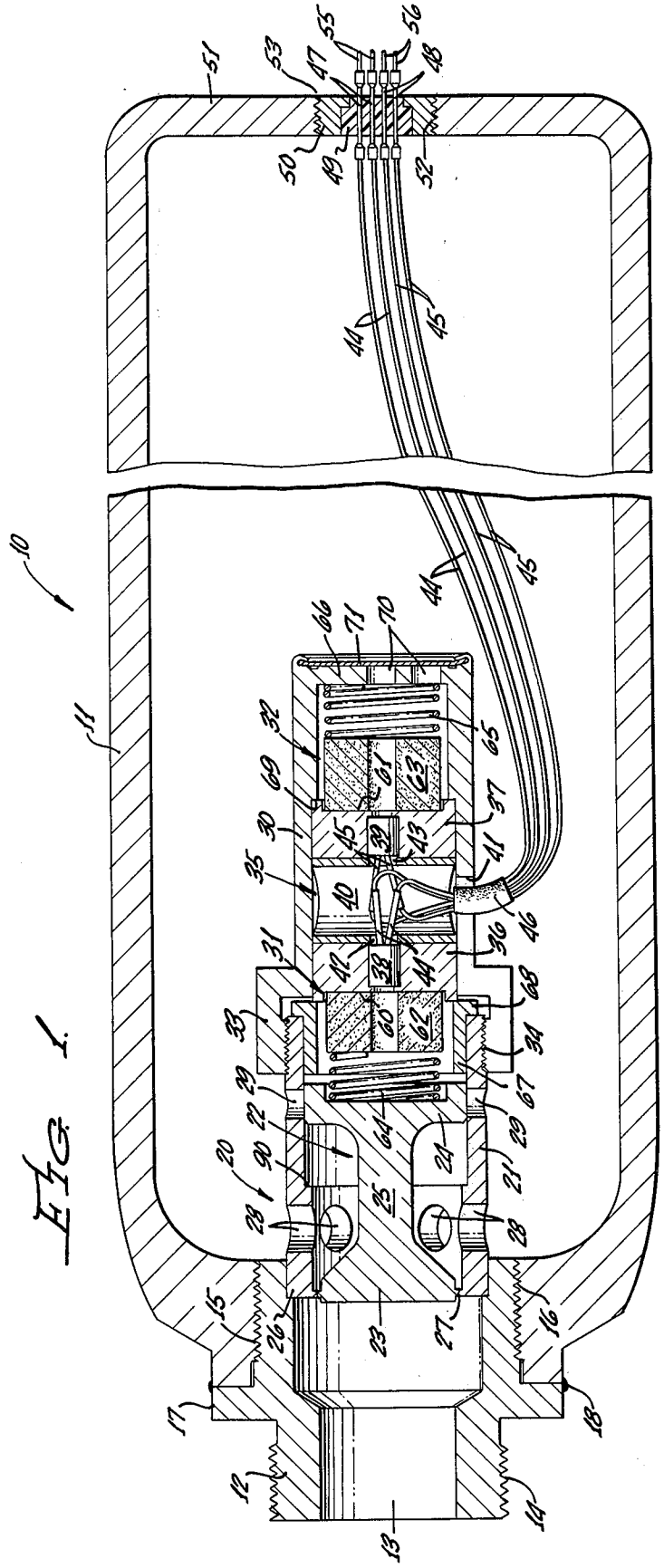


FIG. 1.

Fig. 2.

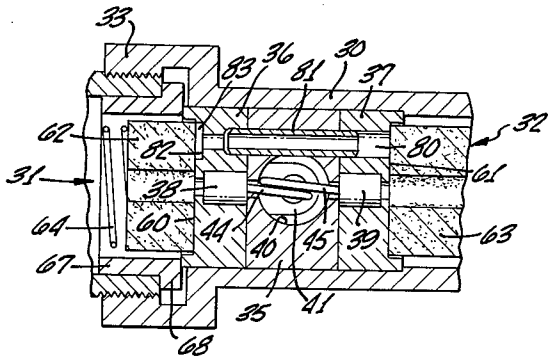


Fig. 3.

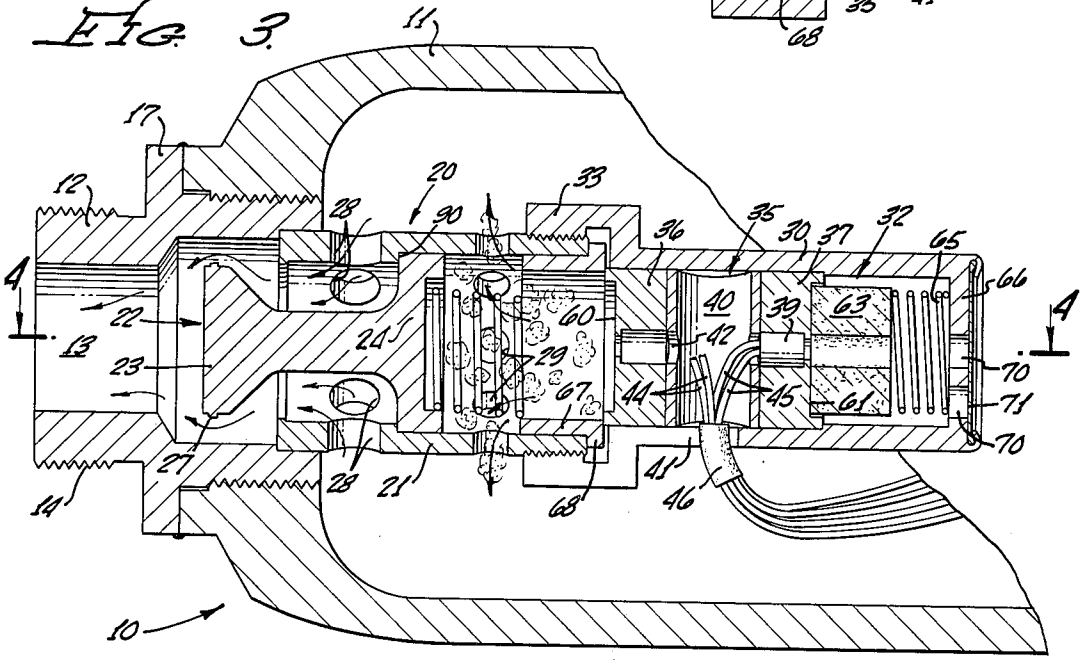
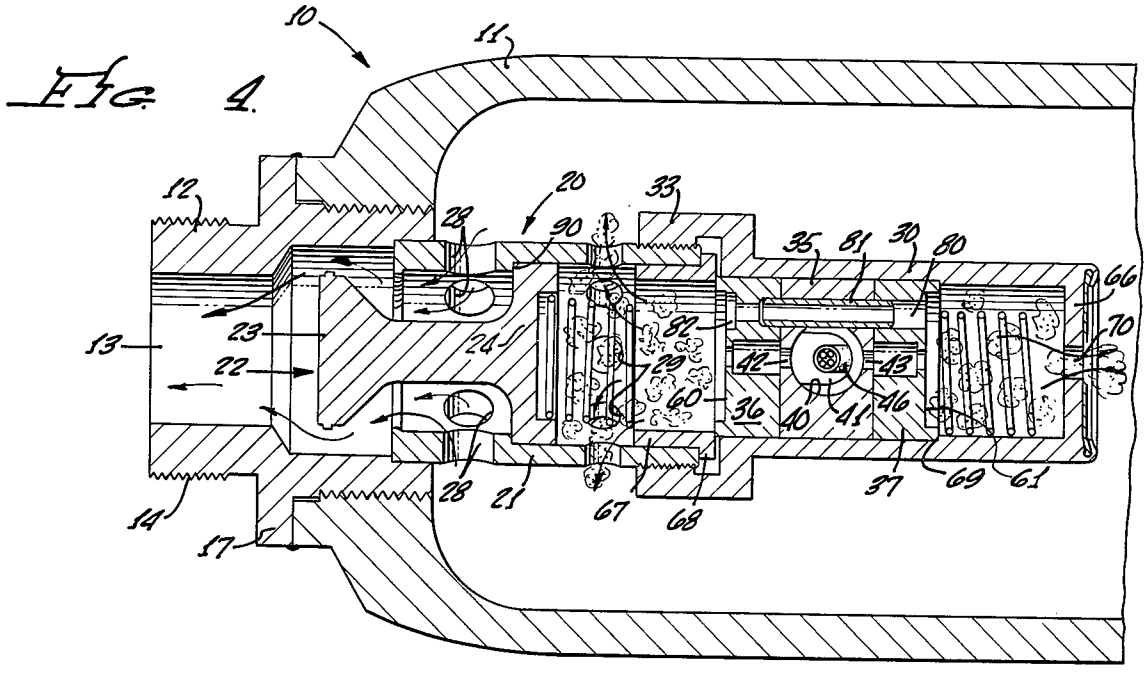


Fig. 4.



TWO-STAGE, PRESSURE AUGMENTED INFLATOR ASSEMBLY

BACKGROUND OF THE INVENTION

1. Field of the Invention.

The present invention relates to a two-stage, pressure augmented inflator assembly and, more particularly, to a two-stage apparatus for augmenting the pressure of a stored gas media and to a valve assembly for automatically releasing the stored gas media upon activation of the pressure augmenting apparatus.

2. Description of the Prior Art.

Many situations exist which require the use of inflatable bag-type members. Life rafts and life jackets are common examples. Another example which has become common in the last decade is flotation devices for preventing sinking of space capsules returning to the earth for water landings and other ocean-going vessels in distress. Signal balloons which are operated automatically or manually to locate crash sites of airplanes is another example. A still further use of inflatable bag-type members is in crash restraint systems for minimizing injuries to vehicle passengers during accidents. Such crash restraint systems typically operate to release the contents of a pressure vessel into an inflatable confinement located in front of a vehicle passenger for the purpose of safely decelerating and preventing serious injury to the passenger during an accident.

In each of these situations, it becomes necessary to store the bag-type member in a deflated condition and to provide apparatus for inflating the member when necessary. Inflation may be manual or may be automatic and controlled by various known types of gravity accelerometers, inertia sensing devices, and other mechanical sensors. In any event, whether inflation is actuated manually or automatically, rapid actuation is usually required. This is especially the case in crash restraint systems where from the time the onset of an accident is sensed to the time that the bag must be inflated is in the order of milliseconds.

In order to fill an inflatable bag-type member rapidly and to the volume necessary in each of the situations discussed above, it is necessary to store a suitable gas media at relatively high pressures in a pressure vessel or container. Typically, an explosive device in the container is actuated when inflation is desired, which explosive device ruptures a sealing device or actuates a valve permitting the pressurized gas to escape into the inflatable member to cause the inflation thereof.

Since the volume of gas required and the rapidity with which it must be available often makes the storage of gas at high pressure alone inadequate, it has generally been proposed to provide apparatus within the pressure container for augmenting the pressure of the gas at the moment of use. Thus, it has been suggested to position within the pressure vessel a suitable enclosure for receiving a gas generating composition. Apparatus is then provided for igniting the gas generating composition, the gas resulting therefrom increasing the mass of the gas stored in the container, thereby assisting in the inflation of the bag-type member.

In co-pending U.S. Pat. application Ser. No. 308,172, filed concurrently herewith, entitled Heat Augmented Inflator Assembly, by Thomas J. Glad, and assigned to Aerojet-General Corporation, the assignee of the present application, it is proposed to position within the enclosure a heat generating composition. Apparatus is then provided for igniting the composition, the heat resulting therefrom increasing the pressure of the gas stored in the container thereby assisting in the inflation of the bag-type member.

In all of these prior systems, the gas or heat generator has provided only a single mode of operation. Thus, in a crash restraint system, for example, whether a crash occurs at a speed of 10 miles per hour or at a speed of sixty miles per hour, the inflatable confinement is inflated at the same rate and to the same volume even though a substantially lower volume would be more appropriate and safer during low speed collisions. Furthermore, in a high speed collision, it is generally necessary to maintain the pressure augmentation process for a substantially longer time than is necessary in a low speed collision.

Still further, prior pressure augmented inflator assemblies have used a rupturable diaphragm for sealing the output of the pressure vessel, which diaphragm is designed to break upon sensing an over pressurization condition in the pressure vessel. However, the use of such rupturable members creates difficult and expensive manufacturing procedures to critically adjust the breaking point of the member so that it does not break under normal use but always breaks prior to rupture of the pressure vessel itself. To solve this problem, it has been proposed to use an explosive actuated valve which is activated not by the pressure within the vessel but independently by a firing squib. However, prior uses of such a valve have generally required a separate firing device and a separate relief device which is automatically activated in the event of excessive pressures in the vessel.

SUMMARY OF THE INVENTION

According to the present invention, these problems are solved by providing a two-stage, pressure augmented inflator assembly which permits instantaneous inflation of a bag-type member and may be actuated manually or automatically. The present inflator assembly is a two-stage device which provides different operating characteristics in low mode and high mode operating conditions. Thus, in a crash restraint system, for example, only a first pressure augmentor is activated for low speed conditions and first and second pressure augmentors are activated for high speed collisions so as to increase the rate, volume, and time duration of inflation of the inflatable confinement. The present inflator assembly incorporates a novel shuttle valve which is activated directly by the pressure produced by the pressure augmenting stages without relying on a rupturable diaphragm. Furthermore, the valve incorporates directly therein a high pressure relief device which automatically activates the valve if an over pressurization condition occurs.

OBJECTS

It is therfore an object of the present invention to provide a two-stage, pressure augmented inflator assembly.

It is a further object of the present invention to provide a two-stage apparatus for augmenting the pressure of a stored gas media and to a valve assembly for automatically releasing the stored gas media upon activation of the pressure augmenting apparatus.

It is a still further object of the present invention to provide an inflator assembly having different modes of operation for different operating conditions.

It is another object of the present invention to provide a two-stage, pressure augmented inflator assembly including a valve which is activated directly by the pressure produced by the inflator assembly.

It is still another object of the present invention to provide a two-stage, pressure augmented inflator assembly which eliminates the reliance on rupturable members designed to respond to over pressurization in a pressure vessel.

Another object of the present invention is the provision of an inflator assembly including a valve having incorporated therein a high pressure relief mechanism.

Still other objects, features, and attendant advantages of the present invention will become apparent to those skilled in the art from a reading of the following detailed description of the preferred embodiment constructed in accordance therewith, taken in conjunction with the accompanying drawings wherein like numerals designate like parts of the several figures and wherein:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a longitudinal sectional view taken along the axis of a two-stage, pressure augmented inflator assembly constructed in accordance with the teachings of the present invention, prior to ignition of either of the augmentor stages;

FIG. 2 is a partial longitudinal sectional view similar to FIG. 1 but taken through a plane rotated 90° relative to the plane of FIG. 1;

FIG. 3 is a partial longitudinal sectional view similar to FIG. 1, after ignition of the first augmentor stage and activation of the shuttle valve; and

FIG. 4 is a partial longitudinal sectional view similar to FIG. 2, after ignition of the second augmentor stage and activation of the shuttle valve.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings and, more particularly, to FIG. 1 thereof, there is shown an inflator assembly, generally designated **10**, constructed in accordance with the teachings of the present invention. In all figures, all parts are cylindrical except as stated otherwise.

Inflator assembly **10** is designed for use with a container **11** for storing a suitable nontoxic, non-noxious gas under pressure. The gas may be air, argon, nitrogen, or the like. Container **11** includes an outlet fitting **12** including an axial bore **13** defining an outlet passage for container **11**. The portion of outlet fitting **12** external to container **11** is externally threaded, at **14**, to permit connection to a suitable manifold for conducting the stored gas to an inflatable member. The neck of container **11** is internally threaded, at **15**, to receive the external threads **16** on the inner portion of outlet fitting **12**. Outlet fitting **12** includes a circumferential collar **17** which abuts against the end of container **11** and which is hermetically sealed thereto, at **18**, by welding or brazing.

Inflator assembly **10** includes openable means, generally designated **20**, for sealing outlet passage **13** to prevent gas flow from container **11** therethrough. According to the preferred embodiment of the invention, sealing means **20** includes an elongated, hollow housing **21**, one end **26** of which extends partially into axial bore **13** in fitting **12** and which may be welded therein to provide a hermetic seal. Mounted within housing **21** is a slidable shuttle valve **22**. Shuttle valve **22** includes first and second ends **23** and **24** having outside diameters approximately equal to the inside diameters of valve housing **21** and a central portion **25** of substantially reduced diameter. End **23** of shuttle valve **22** is normally aligned adjacent end **26** of valve housing **21** and is connected along the circumference thereof to the inner surface of housing **21**, at **27**, to provide a predictable shear area. The connection between end **23** of valve **22** and end **26** of housing **21** may be provided by undercutting or by a controlled welding or brazing. In any event, interface **27** is designed to provide a known shear area which will always assure valve opening at a pressure threshold well below the burst pressure of container **11**.

Valve housing **21** has a plurality of radial passages **28** extending therethrough, in the central portion thereof, passages **28** functioning as outlet orifices to permit fluid communication between the gas in container **11** and the interior of valve housing **21**. Thus, when shear area **27** is broken, the gas within container **11** is permitted to escape via outlet orifices or ports **28** and outlet passage **13**.

Valve housing **21** further has a plurality of radial passages **29** extending therethrough, which are positioned to intersect end **24** of shuttle valve **22**. Passages or ports **29** function as outlet nozzles for the first stage pressure augmentor, as will be explained more fully hereinafter. End **24** of shuttle valve **22** normally prevents fluid communication between the interior of housing **21** and container **11** via passages **29**.

Inflator assembly **10** further comprises a housing **30** in which is positioned first and second stages, generally designated **31** and **32**, respectively, for augmenting the pressure of the gas stored in container **11**. Housing **30** is an elongated, hollow, generally cylindrical member having an internally threaded collar **33** at one end thereof for engaging the external threads **34** on valve housing **21**. Positioned within housing **30** is a spacer **35** which separates augmentor stages **31** and **32**. Positioned on opposite sides of spacer **35** are retainers **36** and **37** having hollow central cavities for receiving electrical firing squibs **38** and **39**, respectively. Spacer **35** has a hole **40** extending laterally therethrough and housing **30** has a slot **41** in one side thereof, slot **41** extending from the end of collar **33** to a point beyond the axis of hole **40** in spacer **35**. Spacer **35** further has axial holes **42** and **43** therein which connect with the central cavities in retainers **36** and **37**, respectively. Thus, one end of a first pair of electrical leads **44** may be extended through slot **41** in housing **30** and holes **40** and **42** in spacer **35** for connection to squib **38** and one end of a second pair of electrical leads **45** may be extended through slot **41** in housing **30** and holes **40** and **43** in spacer **35** for connection to squib **39**. Slot **41** is provided to permit assembly of stages **31** and **32** in housing **30**. Leads **44** and **45** may be held together and protected by a sleeve **46**, as shown.

The other ends of leads **44** and **45** are connected to one ends of first and second pairs of terminals **47** and **48**, respectively, which are imbedded within a suitable non-conductive material **49** made integral with an externally threaded plug **50**. Base **51** of container **11** may have an internally threaded hole **52** which engages the

external threads on plug 50. After plug 50 is positioned within hole 52, the structure may be welded, at 53, to provide a hermetic seal. The other ends of terminals 47 and 48 are adapted to be connected to electrical leads 55 and 56, respectively, for connection to separate sources of electrical firing signals, as will be explained more fully hereinafter.

Retainers 36 and 37 have recesses 60 and 61, respectively, therein for receipt of ignitable pressure augmenting compositions 62 and 63, respectively. According to the present invention, compositions 62 and 63 may be any suitable ignitable composition for augmenting the pressure of the gas in container 11 when ignited. Thus, compositions 62 and 63 may be gas generating materials known to those skilled in the art or may be a heat generating composition as described in the beforementioned copending application of Thomas J. Glad. As described in that application, compositions 62 and 63 may be in the form of discshaped grains which are stacked side-by-side and held in that position in recesses 60 and 61 by springs 64 and 65, respectively. Spring 64 is positioned between composition 62 and end 24 of shuttle valve 22 whereas spring 65 is positioned between composition 63 and end 66 of generator housing 30.

A spacer-sleeve 67 is positioned within valve housing 21 and has a collar 68 at one end thereof which abuts against the end of valve housing 21. Spacer-sleeve 67 provides a seat for squib retainer 36. Furthermore, the inside surface of housing 30 is provided with a shoulder 69 which provides a seat for squib retainer 37. Thus, the tightening of housing 30 onto housing 21 firmly positions retainers 36 and 37 in contact with the opposite sides of spacer 35, between sleeve 67 and shoulder 69. Thereafter, spring 64 firmly retains composition 62 against recess 60 in squib retainer 36 and spring 65 firmly retains composition 63 against recess 61 in squib retainer 37.

End 66 of generator housing 30 has a plurality of outlet nozzles or ports 70 extending therethrough, the number and size of nozzles 29 and 70 being commensurate with the volume of vessel 11, the stored gas pressure, and the desired blow-down characteristics of inflator assembly 10. Nozzles 70 are normally sealed by a rupturable diaphragm 71 retained within end 66 of housing 30, for reasons which will appear more fully hereinafter.

Referring now to FIG. 2, inflator assembly 10 includes a hole 80 which extends through spacer 35 and retainers 36 and 37, thereby connecting recess 60 in retainer 36 to recess 61 in retainer 37. A pin 81 extends through the portion of hole 80 in spacer 35 and partially through the portions of hole 80 in retainers 36 and 37 to prevent rotation of one part relative to the other and to insure constant alignment between the portions of hole 80 in parts 35, 36, and 37. In addition, the portion of hole 80 in retainer 36 has an enlarged portion 82 in contact with recess 60, in which is positioned a disc 83. Thus, disc 83 may be moved toward composition 62 but may not be moved in the direction of composition 63, for reasons which will appear more fully hereinafter.

In operation, FIGS. 1 and 2 show the condition of inflator assembly 10 prior to ignition of either of stages 31 or 32. Application of an electrical firing signal, through firing leads 44, to first stage squib 38 causes squib 38 initiation. When squib 38 ignites, the heat therefrom passes through the central cavity in retainer 36 to ignite the grains of composition 62 nearby, which results in the entire exterior surface of composition 62 being engulfed in flame. Ignition of composition 62 results in an immediate pressure build-up in the chamber defined essentially by spacer-sleeve 67. The increased pressure is prevented from leaving this chamber since nozzles 29 are substantially blocked by end 24 of shuttle valve 22. Thus, the increased pressure acts entirely upon end 24 of valve 22, thrusting the valve axially by shearing the brazed or undercut interface at 27. This condition is shown in FIG. 3. Valve 22 moves axially until end 24 contacts an abutment 90 centrally located in valve housing 21.

In the position shown in FIG. 3, valve 22 allows the stored gas media in container 11 to escape through outlet orifices 28, around end 23 of valve 22, and through outlet passage 13. In addition, the combustion products from composition 62 are permitted to escape into vessel 11 through nozzles 29. The escaping combustion products of first stage pressure augmentor 31 raise the temperature and/or mass of the stored gas media, which results in pressure augmentation.

Under certain operating conditions, it may be desirable to initiate first stage 31 only. Under these circumstances, diaphragm 71 prevents the heat and pressure build-up within vessel 11 from causing sympathetic ignition of second state composition 63. However, under other operating conditions, the pressure augmentation provided by first stage 31 may be insufficient to insure the required energy for inflation and to sustain inflation for a sufficient amount of time. Thus, in a crash restraint system, for example, first stage augmentor 31 may be adequate for providing the required energy for the required amount of time for low speed collisions but may not provide the required energy for a sufficient period of time in the case of high speed collisions. Thus, second stage augmentor 32 is provided and composition 63 may be initiated simultaneously with composition 62 or after a predetermined time interval. That is, application of an electrical firing signal, through leads 45, to second stage squib 39 causes squib 39 initiation and subsequent ignition of second stage composition 63. Upon second stage ignition, the resultant pressure build-up against end 66 of housing 30 ruptures diaphragm 71, allowing the combustion products of composition 63 to escaped through nozzles 70. The escaping combustion products of second stage composition 63 raise the temperature and/or mass of the stored gas media in container 11, which results in pressure augmentation.

It should be particularly noted that the pressure within container 11 is always applied to end 23 of valve 22 via outlet orifices 28. Thus, valve 22 is directly responsive to any excessive internal pressures in container 11. Thus, in the event the pressure in container 11 exceeds a predetermined threshold value, as may occur, for example, if container 11 is surrounded by fire, the undercut or brazed interface 27 of valve 22 will shear and valve 22 will open, allowing the contents of container 11 to escape through the normal functional flowpath. However, it should be emphasized that these are the only circumstances under which valve 22 is activated by sensing an over pressurization condition in vessel 11. Under normal conditions, valve 22 is activated directly from the pressure generated by ignition of composition 62. Inflator assembly 10 also incorpo-

rates a safety mechanism to insure direct activation of valve **22** in the event of a malfunction of first stage squib **38.** More secifically, and with reference to FIGS. **2** and **4,** hole **80,** in combination with disc **83,** operates as a one way pyrotechnic check valve. In other words, assume a malfunction causes first stage squib **38** not to fire when an electrical signal is applied to leads **44,** but that second stage squib **39** does fire when a firing signal is applied to leads **45.** When this occurs, the pressure build-up in container **11** caused by second state **32** would, more than likely, cause the undercut or brazed interface **27** of valve **22** to shear, thereby opening valve **22.** However, inflator assembly **10** causes initiation of valve **22** directly. That is, the heat and pressure resulting from second stage ignition is conducted via hole **80** and pin **81** to disc **83,** blowing disc **83** off and permitting sympathetic ignition of first stage composition **62.** Thereafter, the pressure build-up around composition **62,** acting upon end **24** of valve **22,** actuates valve **22** to the open position by shearing the brazed or undercut interface **27,** as described hereinbefore. Thus, valve **22** is actuated by generator pressure rather than over pressure in container **11.**

On the other hand, first stage **31** ignition does not cause ignition of second stage **32** since hole **82** only permits movement of disc **83** in one direction. In other words, the pressure surrounding composition **62** holds disc **83** in hole **82** rather than firing it therefrom as in the case of second stage ignition.

It can therefore be seen that in accordance with the present invention, there is provided a two-stage, pressure augmented inflator assembly **10** which permits instantaneous inflation of a bag-type member and may be actuated manually or automatically. Inflator assembly **10** is a two-stage device which provides different operating characteristics under different operating circumstances. Thus, in a crash restraint system, for example, first stage pressure augmentor **31** is activated for low speed collisions and second stage pressure augmentor **32** is activated either simultaneously or sequentially for high speed collisions so as to increase the rate, volume, and time duration of inflation of the inflatable confinement. Inflator assembly **10** incorporates a novel shuttle valve **21** which is activated directly by the pressure produced by first stage pressure augmentor **31** without relying on a rupturable member intended to respond to excessive internal pressures in container **11.** Valve **21** also serves as the high pressure safety release which is automatically opened if an over pressurization condition occurs. Furthermore, malfunction of first stage augmentor **31** and subsequent ignition of second stage augmentor **32** causes automatic first stage ignition and direct activation of shuttle valve **22,** again without relying on excessive internal pressures in container **11.**

While the invention has been described with respect to a preferred physical embodiment constructed in accordance therewith, it will be apparent to those skilled in the art that various modifications and improvements may be made without departing from the scope and spirit of the invention. Accordingly, it is to be understood that the invention is not to be limited by the specific illustrative embodiment, but only by the scope of the appended claims.

I claim:

1. In an inflator assembly of the type including container means for storing a gas under pressure, said container means having an outlet passage extending therethrough; openable means for sealing said outlet passage to prevent gas flow from said container means through said outlet passage; enclosure means in said container means for storing means for augmenting the pressure of said stored gas; and means for igniting said pressure augmenting means and simultaneously opening said sealing means to permit said gas to flow from said container means through said outlet passage, the improvement comprising wherein:

said pressure augmenting means comprises first and second means for separately and independently augmenting the pressure of said stored gas;

said igniting means comprises first and second means for separately igniting said first and second pressure augmenting means, respectively;

said openable means for sealing said outlet passage comprises an elongated, generally cylindrical valve housing, one end of said housing extending partially through said outlet passage in said container means and being sealed thereto, said housing having an elongated chamber therein for communicating with said outlet passage, said housing having a first radial passage extending therethrrough, in a central portion thereof, and a second radial passage extending therethrough, in the other end thereof with a slidable shuttle valve means positioned within said chamber in said valve housing, one end of said valve means being sealed to said one end of said housing, between said first passage and said outlet passage, for preventing fluid communication therebetween, the other end of said valve means blocking said second passage through said valve housing;

means are provided for connecting one end of said enclosure means to said other end of said valve housing;

said enclosure means having a first chamber in said one end thereof in fluid communication with said chamber in said valve housing with said first pressure augmenting means being positioned within said first chamber in said enclosure means, whereby said pressure generated by said first augmenting means is directed against said other end of said valve means to cause breakage of said seal and movement of said valve means toward said one end of said valve housing thereby opening said second passage and permitting fluid communicating between said container means and said outlet passage via said first passage; and

wherein said enclosure means has a second chamber in the other end thereof, said second pressure augmenting means being positioned within said second chamber in said enclosure means, with said other end of said second enclosure means having at least a third passage extending therethrough and rupturable diaphragm means for sealing said third passage in said other end of said enclosure means for preventing sympathetic ignition of said second augmenting means upon ignition of said first augmenting means.

2. In an inflator assembly according to claim **1,** the improvement further comprising:

one way check valve means extending through said enclosure means, from said second chamber therein to said first chamber therein, for automatically igniting said first pressure augmenting means from the combustion products generated by said

second pressure augmenting means but preventing ignition of said second pressure augmenting means from the combustion products generated by said first pressure augmenting means.

3. An inflator assembly comprising;

container means for storing a gas under pressure, said container means having an outlet passage extending therethrough;

openable means for sealing said outlet passage to prevent gas flow from said container means through said outlet passage;

first and second enclosure means for storing pressure augmenting means, each of said enclosure means having at least one end positioned in said container means;

first and second ignitable means positioned within said first and second enclosure means, respectively, for generating heat and/or gas to increase the pressure of said stored gas;

first and second means for separately igniting said first and second generating means, respectively;

an elongated, generally cylindrical valve housing, one end of said housing extending partially through said outlet passage in said container means and being sealed thereto, said housing having an elongated chamber therein for communicating with said outlet passage, said housing having a first radial passage extending therethrough, adjacent a central portion thereof, and a second radial passage extending therethrough, adjacent the other end thereof;

said openable sealing means comprising a slidable shuttle valve means positioned within said chamber in said valve housing, one end of said valve means being sealed to said one end of said housing, between said first passage and said outlet passage, for normally preventing fluid communication therebetween, the other end of said valve means normally blocking said second passage through said valve housing;

means for connecting said one end of said first enclosure means to said other end of said valve housing for fluid communication therebetween whereby said heat and/or gas generated by said first generating means is directed against said other end of said valve means to cause breaking of said seal and movement of said valve means toward said one end of said housing thereby opening said second passage and permitting fluid communication between said container means and said outlet passage via said first passage;

means for connecting the other end of said second enclosure means to the other end of said first enclosure means; and

one way check valve means for automatically igniting said first generating means from the heat and/or gas generated by said second generating means but preventing ignition of said second generating means from the heat and/or gas generated by said first generating means.

4. An inflator assembly comprising:

container means for storing a gas under pressure, said container means having an outlet passage extending therethrough;

openable means for sealing said outlet passage to prevent gas flow from said container means through said outlet passage;

first and second enclosure means for storing pressure augmenting means, each of said enclosure means having at least one end positioned in said container means;

first and second ignitable means positioned within said first and second enclosure means, respectively, for generating heat and/or gas to increase the pressure of said stored gas;

first and second means for separately igniting said first and second generating means, respectively;

an elongated, generally cylindrical valve housing, one end of said housing extending partially through said outlet passage in said container means and being sealed thereto, said housing having an elongated chamber therein for communicating with said outlet passage, said housing having a first radial passage extending therethrough, adjacent a central portion thereof, and a second radial passage extending therethrough, adjacent the other end thereof;

said openable sealing means comprising a slidable shuttle valve means positioned within said chamber in said valve housing, one end of said valve means being sealed to said one end of said housing, between said first passage and said outlet passage, for normally preventing fluid communication therebetween, the other end of said valve means normally blocking said second passage through said valve housing;

means for connecting said one end of said first enclosure means to said other end of said valve housing for fluid communication therebetween whereby said heat and/or gas generated by said first generating means is directed against said other end of said valve means to cause breaking of said seal and movement of said valve means toward said one end of said housing thereby opening said second passage and permitting fluid communication between said container means and said outlet passage via said first passage;

means for connecting the other end of said second enclosure means to the other end of said first enclosure means, said one end of said second enclosure means having at least a third passage extending therethrough; and

rupturable diaphragm means for sealing said third passage in said one end of said second enclosure means for preventing sympathetic ignition of said second generating means upon ignition of said first generating means.

5. An inflator assembly according to claim 4 further comprising:

a plurality of said second and third passages, the number and size of said passages being selected on the basis of the desired rate of increase of pressure in said container means.

6. An inflator assembly comprising:

container means for storing a gas under pressure, said container means having an opening extending therethrough adjacent one end thereof;

an elongated, generally cylindrical valve housing positioned within said container means, one end of said valve housing extending partially into said opening in said container means and being sealed thereto, said housing having an elongated chamber therein in fluid communication with said opening in said container means, said housing having a first

radial passage therethrough, adjacent a central portion thereof, and a second radial passage therethrough, adjacent the other end thereof;

slidable shuttle valve means positioned within said chamber in said valve housing, one end of said valve means being sealed to said one end of said housing, between said first passage and said opening in said container means for preventing fluid communication therebetween, thereby preventing gas flow from said container means, the other end of said valve means blocking said second passage through said valve housing;

a second elongated, generally cylindrical housing positioned within said container means, one end of said second housing being connected to said other end of said valve housing, said second housing having a chamber in said one end thereof in fluid communication with said chamber in said valve housing;

ignitable means positioned within said chamber in said second housing for augmenting the pressure of said stored gas within said container means;

explodable squib means positioned within said second housing, adjacent said pressure augmenting means, for ignition thereof, the pressure generated by said augmenting means being directed against said other end of said valve means to cause breaking of said seal and movement of said valve means toward said one end of said valve housing; and

said valve housing including means for stopping said movement of said valve means with the other end thereof between said first and second passages whereby the combustion products of said pressure augmenting means pass via said second passage in said valve housing into said container means to augment the pressure of the gas therein and said stored gas passes out of said container means through said first passage, around said one end of said valve means, and through said opening in said container means.

7. An inflator assembly according to claim **6** wherein the inside diameter of said valve housing at said one end thereof is smaller than the inside diameter at the other end thereof, wherein the outside diameters of said ends of said valve means are approximately equal to the adjacent inside diameters of said valve housing, and wherein said means for stopping said movement of said valve means comprises a shoulder between said areas of different diameters in said valve housing.

8. An inflator assembly according to claim **6** wherein said valve means is sealed to said one end of said housing by welding or brazing the periphery of said one end of said valve means to the inner surface of said valve housing.

9. An inflator assembly according to claim **6** wherein said valve housing has a plurality of said first radial passages therethrough, adjacent said central portion thereof, the number and size of said first passages being selected to determine the rate of escape of said stored gas from said container means.

10. An inflator assembly according to claim **6** wherein said valve housing has a plurality of said second radial passages therethrough, adjacent said other end thereof, the number and size of said second passages determining the rate of increase of pressure in said container means.

11. An inflator assembly according to claim **6** wherein said valve means is sealed to said one end of said housing by undercutting the area between the periphery of said one end of said valve means and the inner surface of said valve housing.

12. In an inflator assembly of the type utilizing a high pressure gas vessel having an interiorally-disposed elongated subassembly carried in cantilever support from the vessel outlet with the subassembly having a first position closing the vessel outlet and a second position opening the vessel to gas flow therefrom, said elongated subassembly having an axially-extending cylindrical chamber opening into the vessel outlet, with a radial port through the chamber wall connecting the chamber interior to the vessel space surrounding the subassembly and with a pressure-movable valve member within the cylindrical chamber closing the vessel to gas flow in said first position and with a pressure augmenting means carried by the subassembly in a compartment in fluid communication with the unsupported end of the cylindrical chamber and means for igniting the pressure augmenting means to move the valve member to said second position, thus opening the vessel and cylindrical chamber to gas flow, wherein the improvement comprises:

the cylindrical chamber of the elongated subassembly being provided with a first radial port adjacent the supported end of said subassembly and a longitudinally-spaced, second radial port adjacent the unsupported end of said cylindrical chamber;

the pressure-movable valve in said first position having a first end in sealed closure with the supported end of the cylindrical chamber, spaced outwardly from the first radial port, and a second end of slightly less diameter than the cylindrical chamber, closing the second radial port in the first position of the valve with a longitudinally-extending central portion of reduced dimension connecting the first and second ends of the valve, said reduced dimension central portion together with the interior surfaces of the two valve ends defining a void within the cylindrical chamber which void connects to the vessel space surrounding the subassembly via the first port; and

a blocking means for stopping the valve in its outward movement to its second position, where the second end of the valve is positioned between the first and second radial ports and wherein the seal of the first end of the valve is broken and said first end is moved outwardly into its second position, whereby the combustion product of the pressure augmenting means passes via said second radial passage into the chamber interior surrounding the subassembly to augment the pressure of the gas therein and the stored gas passes out of the vessel through the first radial passage into the cylindrical chamber and thence, around the unsealed said one end of the valve means to the exterior of the inflator assembly.

13. An inflator assembly in accordance with claim **12** wherein the pressure augmenting means comprises a first augmenting segment and a second augmenting segment which two segments are respectively housed in a first section and a spaced second section of the compartment at the unsupported end of the elongated subassembly with the first section of the compartment being in fluid communication with the unsupported end

of the cylindrical chamber and the second section of the compartment having an outwardly opening third port into the vessel interior with a rupturable diaphragm sealing the third port to forestall sympathetic ignition of the second augmenting segment upon ignition of said first augmenting segment, and a first and second means permitting separate ignition of said first and second augmenting segments.

14. An inflator assembly in accordance with claim **13** wherein there is a plurality of both the second and third ports, the number and size of said ports being selected on the basis of the desired rate of increase of pressure in the vessel with ignition of the first and second augmenting segments.

15. An inflator assembly in accordance with claim **13** having a passageway connecting the two sections of the pressure augmenting compartment, with a one-way check valve being provided in the connecting passageway permitting automatically ignition of the first augmenting segment from the heat and/or gas generated by said second augmenting segment but preventing ignition of said second augmenting segment from the heat and/or gas generated by said first augmenting segment.

16. An inflator assembly in accordance with claim **12** wherein there is provided a plurality of the second radial ports, the number and size of said openings being selected on the basis of the desired rate of increase of pressure in the vessel with ignition of the pressure augmenting means.

17. An inflator assembly in accordance with claim **12** wherein there is provided a plurality of the first radial ports, the number and size of said ports being selected to determine the rate of escape of the stored gas from said vessel.

18. An inflator assembly according to claim **12** wherein the first end of the pressure-movable valve in said first position is sealed by welding or brazing the periphery of said first end of the valve to the inner surface of the cylindrical chamber.

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