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LOW-POWER GAS CARTRIDGE ACTUATION SYSTEM

STATEMENT OF GOVERNMENT INTEREST

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

(1) Field of the Invention

The present invention relates generally to systems for actuating gas cartridges, and more particularly to a gas cartridge actuation system that requires very little electrical power.

(2) Description of the Prior Art

Currently, torpedoes and other vehicles launched from a surface vessel utilize the vessel's high pressure air for the launching energy source and for disabling the weapon securing mechanism just prior to launch. More recently, development efforts have focused on eliminating the use of the vessel's high pressure air for these functions. Specifically, automotive airbag inflator systems have been selected to provide the launch energy source while gas cartridges have been selected to provide the energy to disable the weapon securing mechanism just prior to launch.

With respect to the use of gas cartridges, for safety reasons it is desirable to open such a gas cartridge remotely, i.e., puncture a sealed end of the gas cartridge as is known in the art. To do this, development efforts have focused on using a solenoid-driven puncturing device that can be remotely actuated to puncture a gas cartridge's sealed end. Unfortunately, the amount of force required to puncture a standard gas cartridge is fairly substantial (e.g., generally in excess of 50 pounds of force). Commercially-available solenoid-driven puncture systems capable of delivering the requisite amount of force also require a substantial amount of electrical power (i.e., on the order of several thousand watts). However, many surface vessels have power availability that is only on the order of 100-200 watts.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a low-power gas cartridge actuator system.

Other objects and advantages of the present invention will become more obvious hereinafter in the specification and drawings.

In accordance with the present invention, a low-power gas cartridge actuation system includes a housing adapted to hold a gas cartridge with a sealed end thereof being in fluid communication with a chamber within the housing. The housing further defines a cylinder aligned with the sealed end of the gas cartridge with the cylinder also being in fluid communication with the chamber. A piston, disposed in the cylinder, has a puncture pin coupled to a first end thereof opposing the sealed end of the

gas cartridge. A spring assembly, coupled to a second end of the piston that is in axial opposition to its first end, supplies an axial spring force to the piston such that the first end is biased to move towards the sealed end of the gas cartridge. A solenoid assembly including a retractable pin has (i) a non-actuated state defined as the retractable pin being in engagement with the spring assembly to keep the puncture pin spaced apart from the sealed end of the gas cartridge, and (ii) an actuated state defined as the retractable pin being withdrawn from engagement with the spring assembly so that the piston experiences a sliding movement in the cylinder as driven by the axial spring force. The puncture pin punctures the sealed end of the gas cartridge to release gas stored therein into the chamber. The piston's sliding movement is arrested when the puncture pin has punctured a sealed end.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects, features and advantages of the present invention will become apparent upon reference to the following description of the preferred embodiments and to the drawings, wherein corresponding reference characters indicate corresponding parts throughout the several views of the drawings and wherein:

FIG. 1 is a part schematic, part cross-sectional view of a low-power gas cartridge actuation system prior to the activation thereof according to an embodiment of the present invention;

FIG. 2 is an enlarged view of a portion of the system illustrated in FIG. 1;

FIG. 3 is a part schematic, part cross-sectional view of the gas cartridge actuation system of FIG. 1 subsequent to activation thereof; and

FIG. 4 is a top cross-sectional view of a low-power multiple gas cartridge actuation system prior to the activation thereof.

DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

Referring now to the drawings, simultaneous reference will be made to FIGs. 1-3 where an embodiment of a low-power gas cartridge actuation system is shown and is referenced generally by numeral 10. FIG. 1 illustrates system 10 prior to gas cartridge actuation, FIG. 2 is an enlarged view of a portion of the system illustrated in FIG. 1, and FIG. 3 illustrates system 10 after gas cartridge actuation. System 10 is designed to work with a conventional gas cartridge 100. By way of illustrative example, system 10 will be explained for use with a single gas cartridge 100. However, the present invention is not so limited as the present invention can be used to actuate multiple gas cartridges as will be explained further below.

Gas cartridge actuation system 10 has a housing 12 designed to receive and support gas cartridge 100 such that the penetrable sealed end 100A of gas cartridge 100 is in communication with a chamber 12A defined by housing 12. Housing 12 should form an airtight seal with gas cartridge 100. In this way, when sealed end 100A is punctured, gas from cartridge 100 enters chamber 12A.

A piston cylinder 14 formed by housing 12 is contiguous with chamber 12A or can be used, in part, to define chamber 12A.

Piston cylinder 14 has a longitudinal axis 16 aligned with sealed end 100A of gas cartridge 100. In the illustrated embodiment, piston cylinder 14 is defined by a (i) first cylinder portion 14A adjacent or contiguous with chamber 12A, and (ii) a second cylinder portion 14B adjacent first cylinder portion 14A. The diameter of second cylinder portion 14B is greater than that of first cylinder portion 14A so that an annular shoulder 14C is formed by the interface between portions 14A and 14B.

A piston 18 is disposed in piston cylinder 14 and is configured for axial sliding movement therein. More specifically, piston 18 has (i) a first piston portion 18A disposed partially in first cylinder portion 14A and partially in second cylinder portion 14B, and (ii) a second piston portion 18B slidingly disposed and fit in second cylinder portion 14B. As a result, second piston portion 18B has a larger diameter than first piston portion 18A so that second piston portion 18B essentially defines an annular flange 18C that opposes annular shoulder 14C. An o-ring 20 would typically be disposed about first piston portion 18A.

A puncture pin 22 is coupled to the outboard end of first piston portion 18A and extends axially therefrom. As best seen in FIG. 2, puncture pin 22 is defined by an outboard tip 22A and a shaft 22B coupled to first piston portion 18A. For reasons that will become clearer below, tip 22A and shaft 22B will differ in axial cross-sectional shape and/or area.

Coupled to second piston portion 18B is a spring assembly 24 for applying a spring force to piston 18 along longitudinal axis

16 so that piston 18 is biased towards sealed end 100A of gas cartridge 100. It is to be understood that the particular construction of spring assembly 24 is not a limitation of the present invention. Accordingly, the illustrated construction of spring assembly is provided by way of example only. Spring assembly 24 includes a housing 24A coupled to housing 12 and a spring 24B seated in and against housing 24A and against piston 18. Spring 24B is selected such that it can provide a spring force to piston 18 that is sufficient to drive piston 18/puncture pin 22 so that pin 22 punctures sealed end 100A at the time of actuation as will be explained further below.

Prior to actuation (FIGs. 1 and 2), piston 18 is positioned such that annular shoulder 14C and annular flange 18C are spaced apart from one another by an axial distance L. By doing so, an annular notch 26 is defined between piston 18 and housing 12. Axial distance L should be such that tip 22A of puncture pin 22 is spaced apart from sealed end 100A by an axial distance D that is less than axial distance L. In addition, puncture pin 22 should be configured such that axial distance L also defines a distance from the outboard end of tip 22A to a position along shaft 22B.

To retain piston 18 in its pre-actuation state, a retaining block or pin 30 extends through housing 12 and transverse to piston 18 to engage a portion of notch 26, as shown. A solenoid actuator 32 coupled to pin 30 is capable of retracting pin 30 from its engaged position shown in FIGs. 1 and 2. The disengagement force required to be applied to pin 30 is, in general, substantially less than the force being supplied by spring 24B.

Therefore, a low-power solenoid actuator 32 can be used while the stronger cartridge puncturing force is supplied by non-powered spring 24B.

When gas cartridge 100 is to be punctured/actuated, solenoid actuator 32 is activated so that pin 30 is retracted/disengaged from notch 26 as illustrated in FIG. 3. Once pin 30 has been disengaged from notch 26, spring 24B is free to act on piston 18 to drive piston 18 towards sealed end 100A. Under the force of spring 24B, piston 18 along with tip 22A travels axial distance L at which point contact between annular shoulder 14C and annular flange 18C arrests movement of piston 18 and tip 22A. Since tip 22A was separated from sealed end 100A by axial distance D that is less than axial distance L, movement of tip 22A by axial distance L causes tip 22A to puncture sealed end 100A. Further, because of the configuration of puncture pin 22, shaft 22B extends through and resides in the now-punctured sealed end 100A when annular shoulder 14C and annular flange 18C abut as illustrated in FIG. 3.

As mentioned above, tip 22A and shaft 22B differ in axial cross-section. In general, these differing axial cross-sections provide gaps around shaft 22B so that the pressurized gas content of gas cartridge 100 is released around shaft 22B and into chamber 12A. For example, tip 22A could be triangular in cross-section while shaft 22B could be circular in cross-section and sized to fit within the triangular cross-section of tip 22A. The gas escaping from cartridge 100 can be ported from chamber 12A via a gas relief port 12B as indicated by arrow 40.

While piston 18 and piston cylinder 14 have been described as

being cylindrical, these could have cross-sections of any complementary shape that allows piston 18 to slide within housing 12.

Although the present invention has been explained for use in actuating a single gas cartridge, it is not so limited. That is, multiple gas cartridges could be actuated using a single solenoid actuator. For example, FIG. 4 illustrates a system for simultaneously actuating two gas cartridges 100 where two of the above-described systems 10 are incorporated into a single housing 12. In this example, a single bar or pin 30 is configured to simultaneously engage a portion of corresponding annular notches 26 associated with each gas cartridge 100. When pin 30 is disengaged by a solenoid actuator (identical to actuator 32 but not visible in the FIG. 4 view), pin 30 is simultaneously withdrawn from notches 26 so that springs 24B act on corresponding pistons 18 as previously described.

The advantages of the present invention are numerous. A non-powered, mechanical spring provides the necessary puncturing force for actuating a gas cartridge while only a low-power solenoid is required to release the spring. The solenoid allows the mechanism to be operated remotely for purposes of safety.

It will be understood that many additional changes in the details, materials, steps and arrangement of parts, which have been herein described and illustrated in order to explain the nature of the invention, may be made by those skilled in the art within the principle and scope of the invention as expressed in the appended claims.

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LOW-POWER GAS CARTRIDGE ACTUATION SYSTEM

ABSTRACT OF THE DISCLOSURE

A low-power gas cartridge actuation system uses a mechanical spring assembly to drive a piston disposed in a piston cylinder. A puncture pin is coupled to one end of the piston opposing the sealed end of a gas cartridge. A spring assembly, coupled to the other end of the piston, supplies an axial spring force to the piston such that it is biased to move towards the sealed end of the gas cartridge. A low-power solenoid assembly including a retractable pin has (i) a non-actuated state defined as the retractable pin being in engagement with the spring assembly to keep the puncture pin spaced apart from the sealed end of the gas cartridge, and (ii) an actuated state defined as the retractable pin being withdrawn from engagement with the spring assembly so that the piston experiences a sliding movement in the cylinder as driven by the axial spring force.

FIG. 1

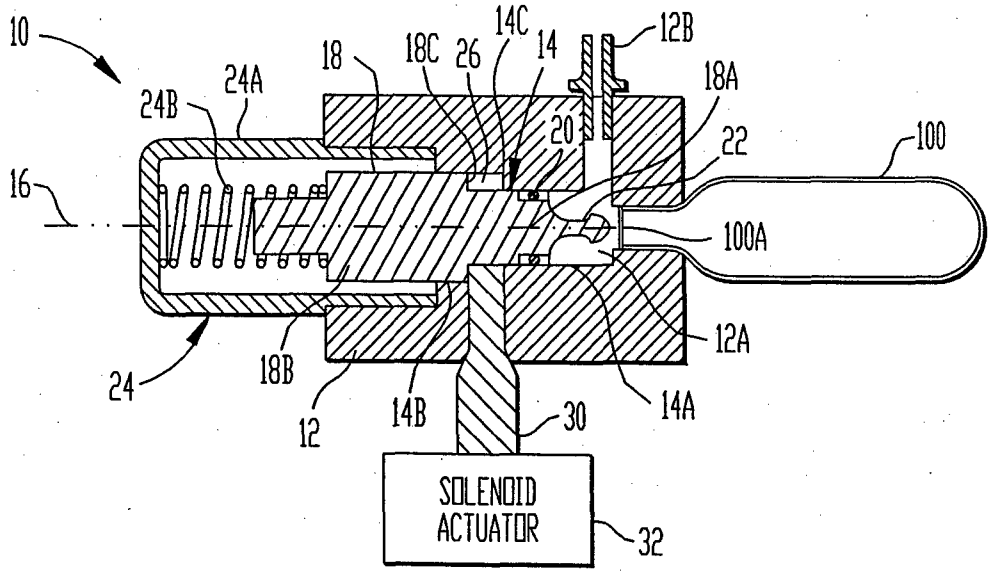

10
24A
24B
18
18C
26
14C
14
12B
18A
20
22
100
16
100A
12A
24
18B
12
14B
30
14A
SOLENOID
ACTUATOR
32

FIG. 2

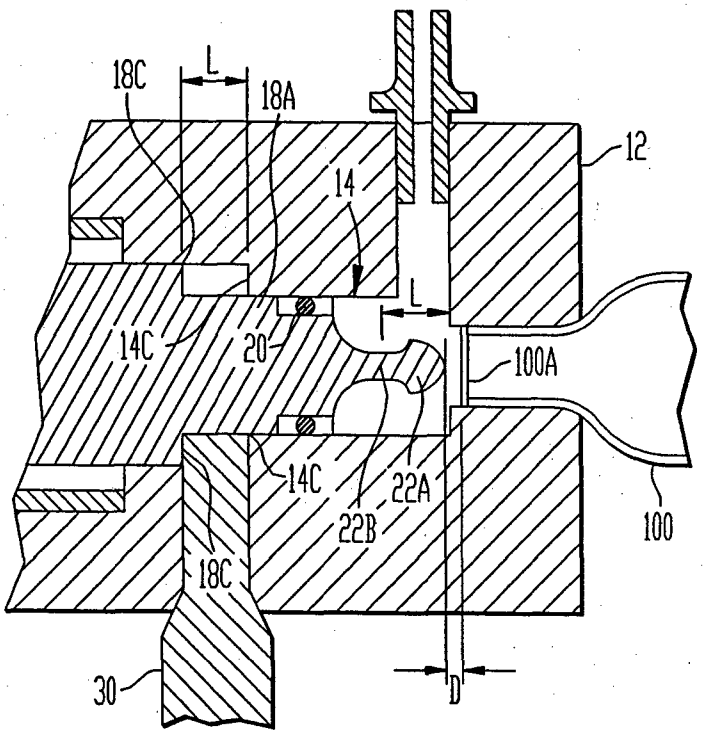

18C
L
18A
12
14
L
14C
20
100A
14C
22A
22B
100
18C
30
D

FIG. 3

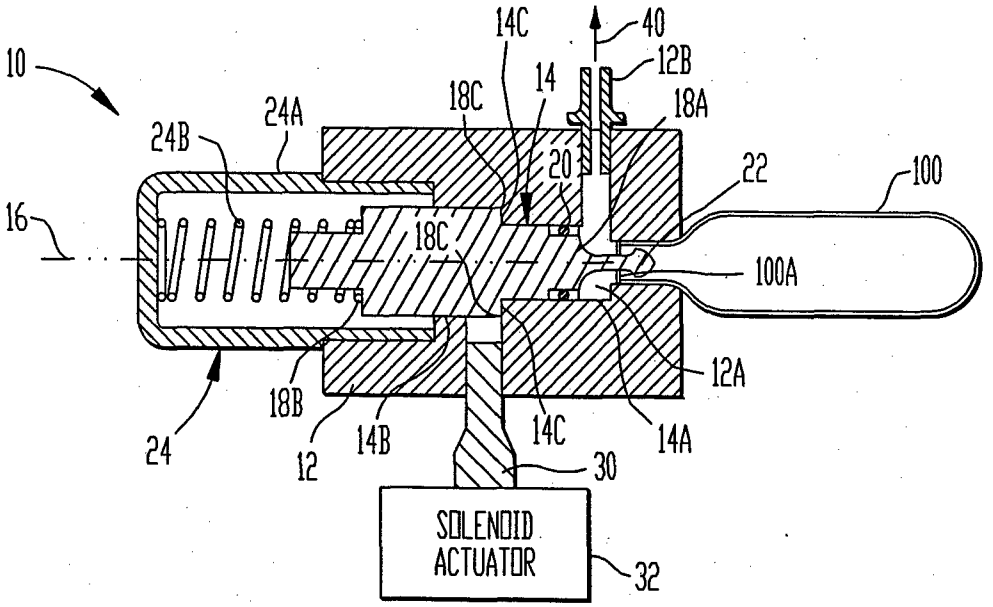
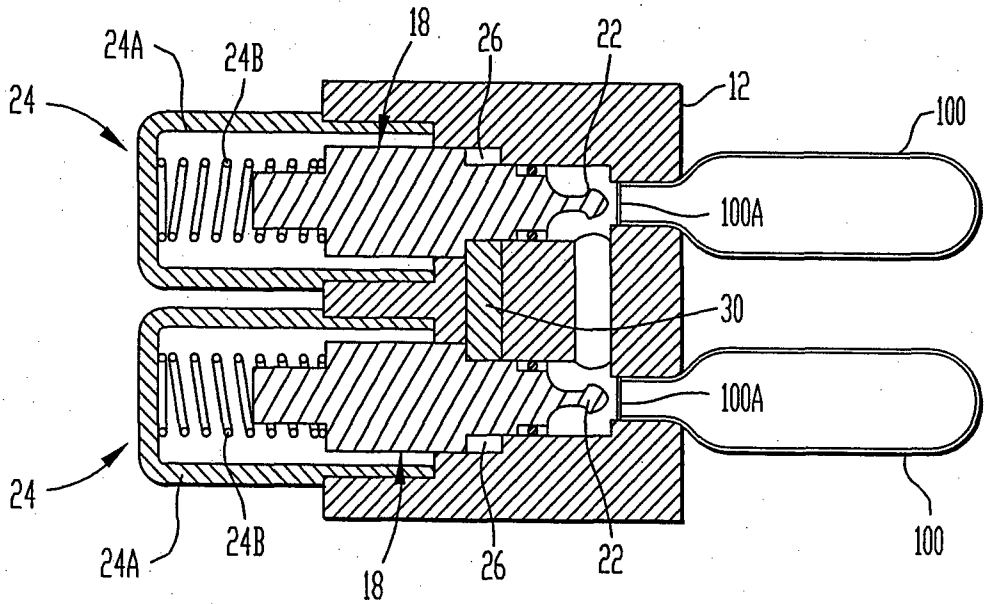

10
16
24
24A
24B
18C
14C
14
40
12B
18A
20
22
100
100A
18C
12A
18B
12
14B
14C
14A
30
SOLENOID ACTUATOR
32

FIG. 4


24
24A
24B
18
26
22
12
100
100A
30
100A
100
24
24A
24B
18
26
22