United States Patent [19]

Evans et al.

[11] **3,858,392**

[45] **Jan. 7, 1975**

[54] **CONTROLLED BURNING SQUIB ARRANGEMENT**

[75] Inventors: **John H. Evans; Frederick R. McEwen,** both of Lansdale, Pa.

[73] Assignee: **ICI United States Inc.,** Wilmington, Del.

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[21] Appl. No.: **409,756**

[52] **U.S. Cl.** ..... **60/637,** 60/632, 89/1 B, 149/2, 149/24, 102/28, 102/39

[51] **Int. Cl.** **F01b 29/08,** F02n 13/00

[58] **Field of Search** ..... 60/632, 637, 635, 638, 60/633, 634, 636; 102/39, 28; 149/2, 24; 89/1 B

[56] **References Cited**

UNITED STATES PATENTS

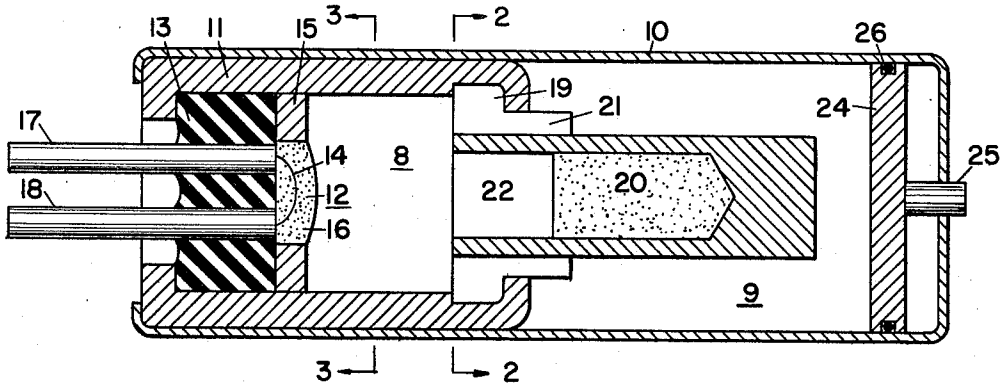
2,589,703	3/1952	Kenney	149/24 X
2,912,902	11/1959	Nessler	60/632 X
3,092,525	6/1963	Cook	149/2
3,102,833	9/1963	Schulz	149/2
3,106,131	10/1963	Barr et al.	60/632
3,199,289	8/1965	Ramsay et al.	60/633
3,299,812	1/1967	Sult et al.	60/632
3,754,060	8/1973	Gawlick et al.	149/2

Primary Examiner—Wendell E. Burns

[57] **ABSTRACT**

A controlled burning squib arrangement is presented wherein a first-stage ignition is used to heat an adjacent second-stage deflagrator such that the explosive components are substantially converted to gas in a first chamber prior to entering an expandable second chamber. Such arrangements are particularly useful in thrusters designed to drive pistons, bellows, or flexible membranes in lateral displacement mechanisms.

9 Claims, 5 Drawing Figures



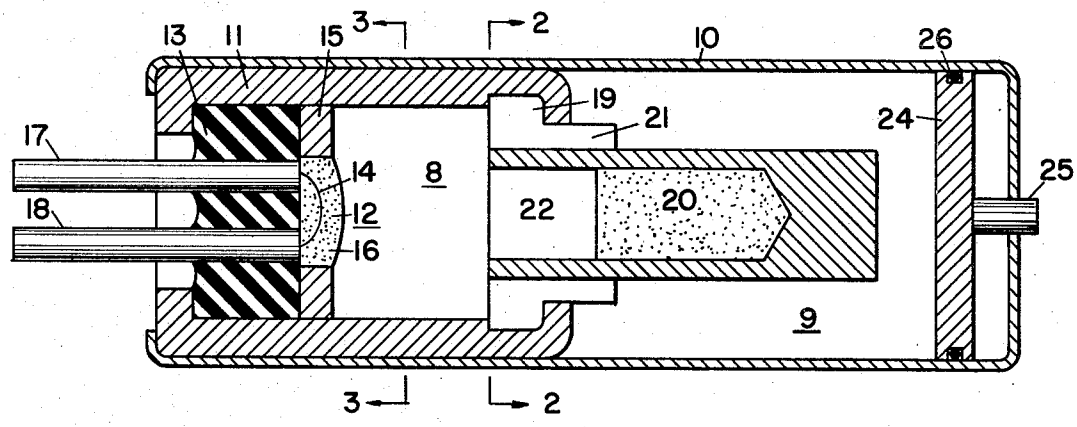


FIG. 1

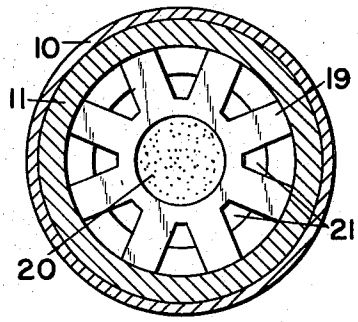


FIG. 2

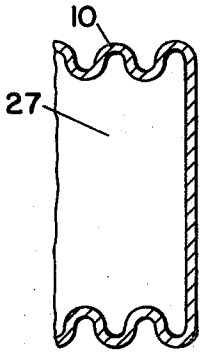


FIG. 4

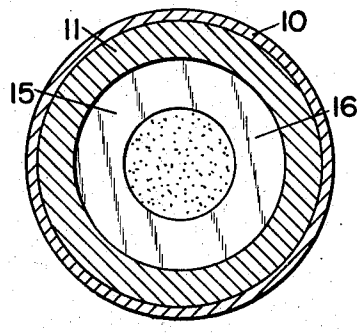


FIG. 3

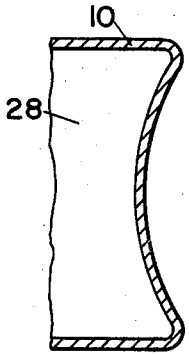


FIG. 5

CONTROLLED BURNING SQUIB ARRANGEMENT

The invention relates to an explosively activated thruster or squib arrangement wherein an electrically activated first-stage squib component is used to ignite an adjacent second-stage deflagrating material held in a cavity near the first-stage component. The second-stage burns completely in a chamber common to the first-stage and which intercommunicates with a second expandable chamber through openings having sufficient cross-sectional area to permit the gases forming in the first chamber to exhaust or vent into a second expandable chamber such that a very low pressure differential is maintained between the first and second chambers.

Gas pressure developed by the squib arrangement can be used to force the lateral displacement of a piston, bellows, or flexible component to act as a motor displacement mechanism. Such devices are particularly useful in highly reliable, single-shot, electrically activated control devices especially required in aerospace controls and components. Furthermore, such devices can be sufficiently shielded such that stray currents developed by surrounding radiation will not preignite the squib.

It is an object of the present invention to provide a controlled burning squib arrangement for use in lateral displacement devices.

Another object of the present invention is to provide an arrangement which permits relatively accurate control of gas pressure generated by a burning squib within an expandable chamber for use as a lateral displacement motor device.

Prior art devices are characterized in that the squib component vents directly into the expandable chamber to be pressurized. Typical examples of such arrangements are better described in U.S. Pat. Nos. 3,133,408; 3,119,302; 3,111,808; 3,336,452; 3,354,634; 3,482,484; and 3,149,457. Such devices which generate very high intital pressure are less easily controlled and the amount of gas generated from one device to the next can vary over wider ranges than that which occurs with the present invention. This variation can be fatal to applications in which an expandable bellows is driven a distance which is directly proportional to the developed pressure. Under-pressurization results in insufficient driving force while overpressurization results in rupture or destruction of the device.

The present invention will become more apparent from the following detailed description taken with regard to the accompanying drawings in which like numerals represent the same elements throughout several views.

FIG. 1 is a longitudinal midsectional view of one embodiment of the present invention taken through section 1—1 of FIGS. 2 and 3.

FIG. 2 is a transverse sectional view taken through section 2—2 of FIG. 1.

FIG. 3 is a transverse sectional view of FIG. 1 taken through section 3—3.

FIG. 4 is an alternate configuration for the expandable chamber wherein the expandable part is a bellows.

FIG. 5 is an alternate arrangement for an expandable chamber shown in FIG. 1 and shown as a flexible diaphragm.

Referring now to the drawings of FIGS. 1 through 5, the rigid tubular longitudinal casing 11 of metal or rigid plastic has mounted therein in gas-tight relationship a first-stage squib comprising an explosive material 16 held in place by spacer ring 15 at the closed end of the casing through a glass metal seal 13 through which pass electrical lead wires 17 and 18 which abut with metal bridge wire 14. Held in alignment through a central axis with the first-stage squib 12 is a second-stage squib cavity 22 containing a non-detonatable, pyrogenic, deflagratable material 20 such as lead styphnate under uniform compressions of 30,000 – 60,000 psi and having burning rates of 0.5 – 20 inches per second. The cylindrical second-stage squib component 20 is held in place by a foraminous retainer ring or end-closure 19 having a multiplicity of intercommunicating conduits 21 which have a total cross-sectional opening area at least equivalent to the cross-sectional area of cavity 22. An exterior shell component 10 in gas-tight sealed arrangement with casing 11 forms a second expandable chamber 9 which intercommunicates with burning chamber 8 through conduits 21. Expandable chamber 9 can expand through increased gas pressure by forcing piston 24 having O-ring seal 26 and a push rod 25 such as shown in FIG. 1 or an expandable bellows section 27 as shown in FIG. 4 or a flexible diaphragm 28 as shown in FIG. 5.

In operation, electric current is passed through lead wires 17 and 18 to ignite explosive 16 or the first-stage squib 12. The heat generated by the first-stage ignition ignites the pyrogenic material 20 which fills chamber 8 with gas and which indirectly passes through conduits 21 into chamber 9 forcing chamber 9 to expand through the increased pressure generated therein.

By way of example it can be shown that the prior art squib arrangements employing a single expandable chamber having an initial volume of 0.01 cubic inches, a diameter of 0.25 inches, a piston weight of 0.386 pounds, and a mass of 0.001 pound-sec.2/inch require 93.11 milligrams of lead styphnate to accelerate the piston to a velosity of 1,000 inches per second in a distance of one inch to attain a kinetic energy value of 500 inch - pounds. The initial pressure developed in the firing of such a device is 27,932 pounds per square inch. Because of this high initial pressure the system must be housed in a thick metal casing so that it will not be destroyed or ruptured.

By comparison, a controlled burning squib arrangement such as that for driving a piston as shown in FIG. 1 of like dimensions under similar conditions of 500 inch - pounds of kinetic energy and velocities of 1,000 inches/sec. can be made from a less substantial light weight casing in that the controlled burning squib avoids the very high initial peak pressure by supplying gas over a relatively longer period of time at pressures of no greater than 10,186 psi thus operating at relatively uniform pressures which are about one third that of the peak pressure developed by a conventional one chamber squib arrangement. Such savings in weight are important when the arrangements are combined with aerospace and missile components.

What is claimed is:

1. A controlled burning squib arrangement comprising:

a. a first-stage squib component having an electrically activated pyrogenic explosive;

b. a second stage squib component having a pyrogenic, non-detonatable explosive in a separate cavity adjacent to and ignited by said first-stage squib;

c. a rigid chamber spacing and communicating with said first-stage and said second-stage squib components; and

d. means for venting said rigid chamber between said squibs into an expandable second chamber.

2. A controlled burning squib arrangement comprising:

a. a tubular rigid longitudinal casing;

b. an electrically activated first-stage squib sealed at one end of said casing;

c. a second-stage, non-detonatable squib component at the other end of said casing mounted in a foraminous end-closure in facing alignment with said first-stage; and

d. an expandable shell encompassing said rigid casing in gas tight relationship therewith and communicating with the longidutinal casing between said first and second squibs such that gas formed by the ignition of said second-stage can pass into said encompassing expandable shell.

3. A controlled burning squib arangement of claim **2**

wherein said second-stage is a non-detonatable pyrogenic material contained in a cavity having a cross-sectional opening area no greater than the total opening area in said foraminous end-closure.

4. A squib arrangement of claim **2** wherein said expandable shell is a metal bellows.

5. A squib arrangement of claim **2** wherein said expandable shell is a flexible membrane.

6. A squib arrangement of claim **2** wherein said expandable shell component comprises a movable piston.

7. A controlled burning squib arrangement of claim **1** wherein said non-detonatable explosive is a deflagratable material having burning rates of 0.5 – 20 inches per second.

8. A squib arrangement of claim **7** wherein said non-detonatable explosive material is a deflagratable material under uniform compression of 30,000 – 60,000 pounds per square inch.

9. A squib arrangement of claim **8** wherein said deflagratable material is lead styphnate.

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