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Hanson et al.

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[54] **PISTON-ACTUATED FLUID DISCHARGE DEVICE**

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[52] **U.S. Cl.** **137/68**

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

[58] **Field of Search** .... 222/5, 3; 280/150 AB; 9/315–320, 324, 325; 137/68; 220/89 A

[56] **References Cited**

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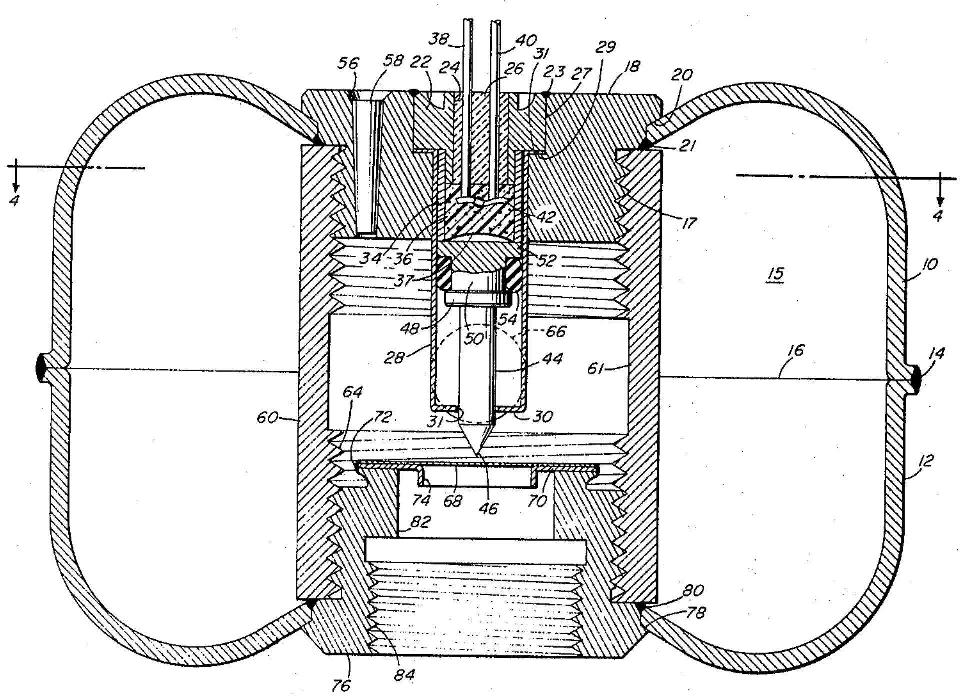
Primary Examiner—Stanley H. Tollberg

[57] **ABSTRACT**

A device for storing and discharging fluid under high pressure includes a toroidal storage chamber and a coaxial spool, in which is mounted two plugs. One plug is formed with a bored gas discharge passage into which a nozzle insert providing a square orifice extends; this passage is normally sealed by a prestressed diaphragm. The second plug provides a cylinder slidably supporting a piston, and mounts a header plug containing gas-generating means for driving the piston to puncture the diaphragm for releasing the gas charge. The spool is threaded in both plugs; and the storage chamber, plugs, and header plug, are connected by circumferential welds which completely seal the device. The fluid storage chamber is sealed from the gas-generating means by spaced flanges and an O-ring so arranged on the piston as to avoid pinching and thus cracking the O-ring.

17 Claims, 4 Drawing Figures



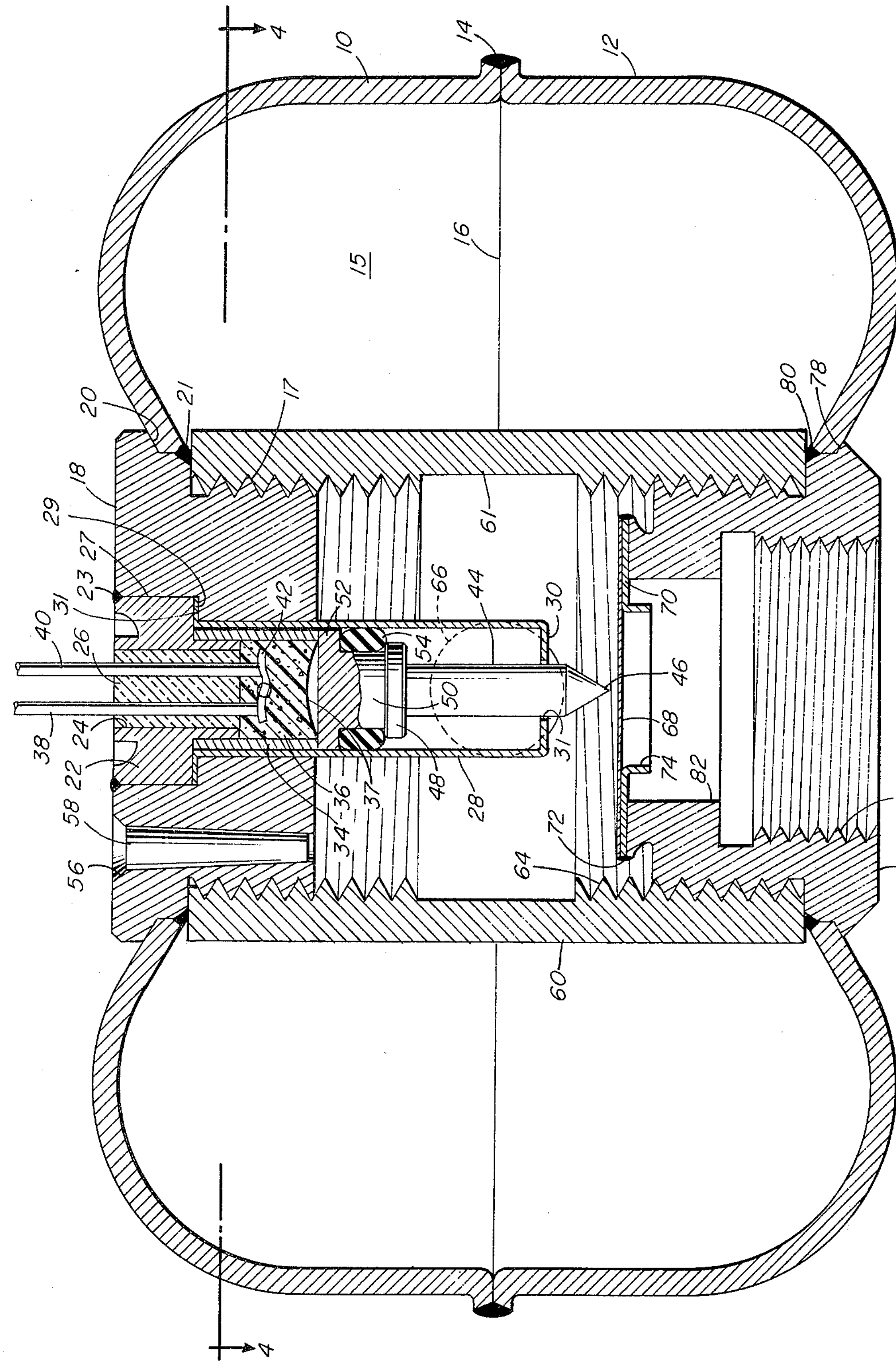

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FIG. I

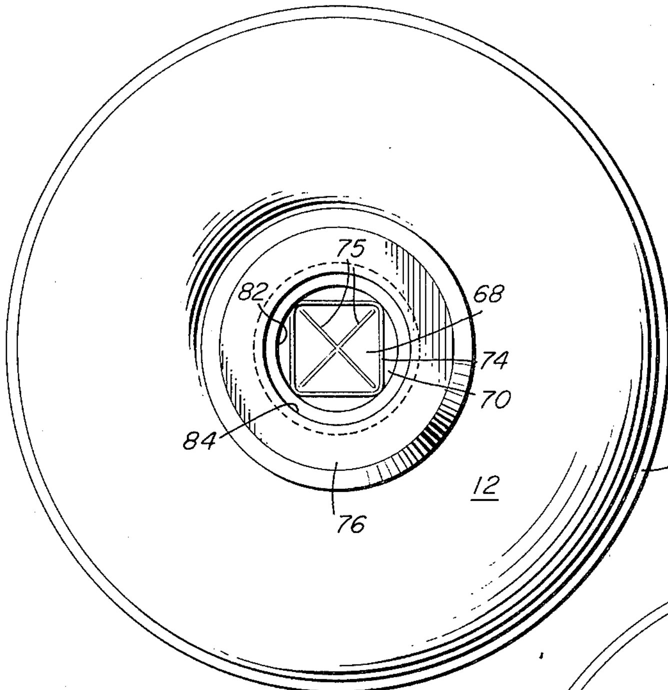

FIG. 2

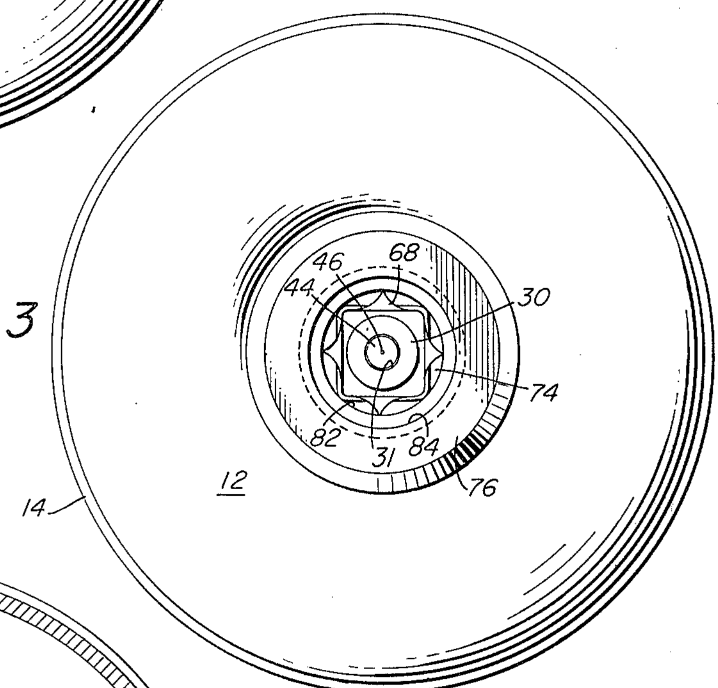

FIG. 3

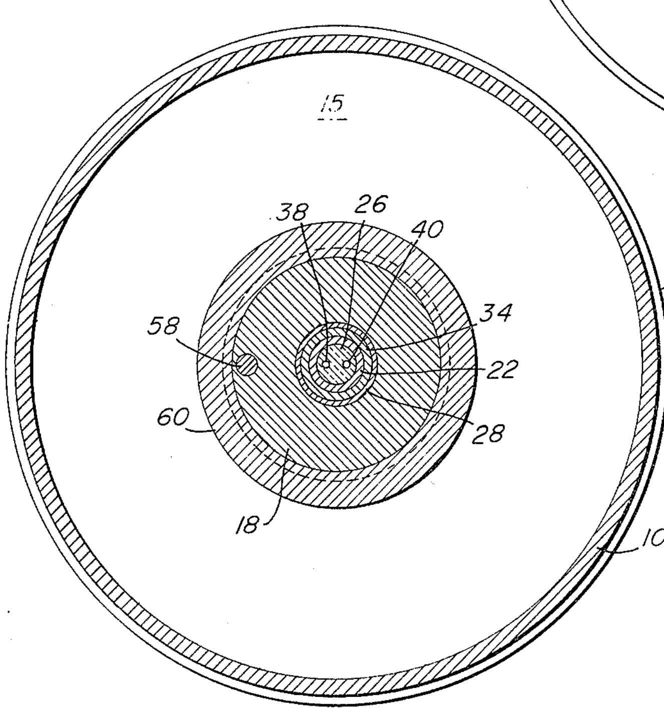

FIG. 4

PISTON-ACTUATED FLUID DISCHARGE DEVICE

BACKGROUND AND BRIEF DESCRIPTION OF THE INVENTION

Compact devices for discharging fluid stored under high pressure are employed in large quantity for such purposes as inflating marker bouys, life rafts, aeronautic and astronautic equipment, and the like. Because of the requirement to store fluid (liquid, gas, or a combination) at very high pressures, many known devices of this nature are subject to fluid leakage through imperfectly sealed joints. More reliable constructions tend to be excessively expensive to manufacture. Another common requirement of such devices is that the discharged fluid must be pure, and must contain no foreign matter or other fluid. It is therefore necessary to provide a sealing device which will not shatter into fragments when opened, and also to seal off the fluid-discharge path from the pyrotechnic gas-generating devices which are used for operating pistons or cutters for puncturing the sealing devices.

It is the general object of the present invention to provide an improved fluid discharge device which is reliable in operation, seals the fluid charge effectively against leakage, and is economical to manufacture. It is another object to provide a fluid discharge device with an improved discharge nozzle and seal arrangement. It is another object to provide a fluid discharge device with an improved actuator arrangement which affords effective sealing against mixing of actuating gas with the stored fluid. It is another object to provide an improved actuator arrangement which is unitarily constructed with the chamber body and which affords greater reliability of operation and improved economy of assembly. It is another object to improve the sealing of a fluid discharge device against loss of fluid pressure. Further objects and advantages will appear as the following description proceeds.

DESCRIPTION OF THE DRAWINGS

While the specification concludes with claims specifically pointing out the subject matter which we regard as our invention, it is believed that a clearer understanding may be gained from the following detailed description of a preferred embodiment thereof, referring to the accompanying drawings, in which:

FIG. 1 is a cross-sectional view in elevation of a preferred form of the fluid discharge device;

FIG. 2 is a bottom plan view prior to release of a fluid charge from the device;

FIG. 3 is a bottom plan view showing the device after the fluid charge has been released; and

FIG. 4 is a sectional plan view taken along line 4—4 in FIG. 1, looking in the direction of the arrows.

In the drawings, a piston-actuated fluid discharge device includes a pair of annular chamber shells **10** and **12**, which mate along lips **16** and are joined by a circumferential weld **14**. A toroidal fluid chamber **15** is defined by the shells **10** and **12** and by an annular cylindrical spool **60** received coaxially therein. A first plug member **76** and a second member **18** are threadedly engaged with the spool at **64** and **17**, respectively. The strength of the fluid chamber is increased by seating the shells **10** and **12** under circumferential flanges **20** and **78** formed in the respective plugs.

The spool **60** is so dimensioned that it engages the plugs **18** and **76** and the shells **10** and **12**. This insures

that the threads **17** and **64** are fully engaged when the device is assembled, thereby achieving maximum bursting strength.

The shell **10** is secured and sealed to the plug **18** by a circumferential weld **21**, while the shell **12** is similarly secured to the plug **76** by a circumferential weld **80**. In assembling the device, the internal parts are first assembled with the plugs **18** and **76**, the welds **21** and **80** are formed, the plugs **18** and **76** are threaded onto the spool **60** until the lips **16** meet firmly, and the weld **14** is made last.

The plug **76** is formed with a fluid discharge passage including a circular bore **82** and a threaded port **84** adapted for attachment to a discharge conduit. The interior **61** of the spool **60** communicates with the fluid storage chamber **15** through one or more openings **66** formed in the spool wall, and the fluid escapes through the bore **82** after the device is actuated. A sealing diaphragm **68** normally seals the bore **82**, and is secured to the plug **76** by a circumferential weld **72**.

It is necessary that the diaphragm open without shattering when it is punctured, so that no fragments will be discharged with the pure fluid charge. It has previously been discovered that a square nozzle form backing up the sealing diaphragm will promote a clean puncture and avoid fragmentation, when the diaphragm is prestressed with crossed linear indentations extending along the diagonals of the squared nozzle, such as shown at **75** in FIG. **2**. According to previous practice, a squared nozzle was formed by broaching a plug such as **76**; this is an expensive machining procedure. We employ a circular bore **82**, which is relatively inexpensive to form, and provide a separate nozzle insert **70** which has a squared-off orifice portion **74** extending into the bore **82**. The insert **70** is formed of thin sheet metal and can be stamped or otherwise formed by low-cost high-production methods. The orifice portion **74** is not truly square, as will be seen in FIG. **2**, but has corners which are rounded to a radius less than half the width of the squared orifice. This aids in preventing shattering fragmentation of the diaphragm.

A piston or cutter **44**, having a pointed tip **46**, is slidably received in a cylinder **28**, and is adapted to be driven downwardly as viewed in FIG. **1** to puncture the diaphragm **68** at the intersection of the linear indentations **75**. When the piston is actuated, the pressure of the fluid charge in the chamber **15** and the spool **60** instantaneously rips the diaphragm along the indentations **75**, and the quarters of the diaghragm fold against the walls of the orifice portion **74**, as shown in FIG. **3**, to release the fluid charge.

The cylinder **28** is formed with a locating flange **29** which rests in a stepped bore **27** formed in the plug **18**, and abuts a circumferential seat **31**. The use of the flange **29** rather than the commonly used weld bead at the top of the cylinder **28** provides greater reliability by virtue of the greater mechanical strength of the flange. Also, the possibility of weld defects adversely affecting the reliability of actuator firing is eliminated. The drop-in cylinder **28** is locked in place by the weld bead **23**, which affords a more economical actuator construction. The weld bead **23** unitizes the chamber and actuator construction, and increases the reliability of the entire assembly by virtue of the leak-proof welded construction. The bottom portion **30** is formed with a central opening **31** through which the piston protrudes. According to one aspect of the invention, the piston is formed with a first circumferential flange **48** which is of smaller diameter than the cylinder **28**, and a second spaced-apart circumferential flange **52** which has substantially the same diameter as the cylinder and is slidably and conformably received therein. An O-ring seal **54** of rubber or other elastomeric material is received about a reduced portion **50** between the flanges **48** and **52**, and seals the cylinder against fluid flow around the piston. If a pair of flanges each of the same diameter as the spool are used to locate the seal **54** therebetween, there is a tendency for the seal to become pinched when assembled, and therefore to fail when the piston is actuated. We have discovered that the provision of a reduced-diameter flange **48** for locating the seal with respect to the full-size flange **52** overcomes this problem.

To actuate the piston **44**, a charge of gas-generating pyrotechnic mix **36** of any suitable composition is placed within a tubular ferrule **34** received in the cylinder **28** behind the piston. A suitable pyrotechnic mixture has been developed for use in this application. Only a small amount of gas-generating material is needed, as the volume of the mix is required to multiply only a few-fold to drive the piston forwardly to engage the flange **48** against the bottom **30** of the cylinder, terminating the piston stroke.

The ferrule **34** serves not only to locate the piston in its normal retracted position shown in FIG. **1**, but also serves as a measure for the proper quantity of pyrotechnic mix **36**. A header plug **22** is received in the bore **27** to enclose the charge **36**. This plug receives electric leads **38** and **40**; these are interconnected by a fuse or bridge wire **42** which is immersed in the charge **36**, and serves to ignite it when an electric potential is applied to the leads by suitable external means (not shown) of a conventional nature. The charge **36** of pyrotechnic mix is placed within the ferrule **34** prior to assembly of the ferrule and plug **22** with the cylinder **28**. It is preferred to form the charge with a concave surface **37** adjacent to the flange **52**.

To seal the device against leakage of the gas generated by the charge **36**, the leads **38** and **40** are sealed by a glass bead received in a bore **24** through the header plug **22**. The header plug **22** is preferably formed of an alloy having substantially the same coefficient of thermal expansion as the glass bead **26**, so that the glass-to-metal seal will not be damaged by changing temperatures encountered before the device is used.

The header plug **22** is permanently attached to the plug **18** by a circumferential weld **23** at the entrance to the bore **27**. This insures against pressure leakage either from the fluid charged in the chamber **15**, or from the gas generated by the charge **36**. Equally important, this measure strengthens the device at what might otherwise be a weak point, and overcomes a tendency in prior devices for the piston-actuating header plug to be blown out when the device is operated, thus releasing the fluid charge and rendering the device ineffective.

Some additional advantages of the design are as follows. The design of the actuator permits the pyrotechnic device **36, 34**, etc., to be inspected during the fabrication of the fluid discharge device. The cutter or piston **44** and the cylinder **28** are captured in position when the header plug **22** is located and welded in place. This simplifies manufacture and secures the cylinder so that it cannot fly off when the actuator is fired. Thus the actuator is assembled as the device is fabricated. These features improve reliability, reduce the cost of manufacture, permit inspection of the pyrotechnic device, and render testing less dangerous.

The fluid charge is supplied to the device, after assembly is completed, through a port **56** in the plug **18**. A taper pin **58** is then driven into the port to seal the device. Although high fluid pressures are normally employed, on the order of 3000 p.s.i., the small area of the tip of the taper pin results in a very moderate force acting to displace it, and we have found this method of sealing highly secure.

Within the broader aspects of the invention, we contemplate its application to fluid discharge devices which are actuated mechanically rather than electrochemically, e.g., by driving the piston directly rather than through the medium of gas generated by an electrically initiated pyrotechnic mix.

We claim:

1. A piston-actuated fluid-discharge device comprising, in combination:

means forming a storage chamber for pressurized fluid comprising an annular shell having central openings at opposite axial ends thereof, a pair of plug members received conformably in said openings and welded circumferentially to said shell, and an annular cylindrical spool received coaxially within said shell and threaded at opposite ends thereof in said plug members, said spool being formed with an opening communicating the interior thereof with the interior of said shell;

a first one of said plug members being formed with a fluid discharge passage of circular cross-section;

a nozzle insert overlying an inlet end of said discharge passage and formed with a squared orifice portion extending into said passage;

diaphragm means overlying said nozzle insert and normally sealing said storage chamber from said discharge passage;

a second of said plug members being provided with means for puncturing said diaphragm means including cylinder-forming means extending axially within said spool, a piston slidably received in said cylinder-forming means and having a tip adapted for puncturing said diaphragm means, and gas-generating means received in said cylinder-forming means at an end of said piston opposite said tip for driving said piston forwardly in said cylinder-forming means for puncturing said diaphragm means;

said piston being formed with a first circumferential flange portion conformably and slidably received in said cylinder-forming means, and with a second circumferential flange portion spaced apart along said piston from said first flange portion, said second flange portion being circumferentially spaced apart from said cylinder-forming means;

and sealing ring means received about said piston between said flange portions and sealingly engaging said cylinder-forming means.

2. A piston-actuated fluid-discharge device comprising, in combination:

means forming a storage chamber for pressurized fluid including an outlet plug member formed with a fluid discharge passage of circular cross-section;

a nozzle insert overlying an inlet end of said discharge passage and formed with a generally squared orifice portion having rounded corners, said orifice portion extending into said passage;

diaphragm means overlying said nozzle insert and normally sealing said storage chamber from said discharge passage;

means for puncturing said diaphragm means including cylinder-forming means, a piston slidably received in said cylinder-forming means and having a tip adapted for puncturing said diaphragm means, and means for driving said piston forwardly in said cylinder-forming means for puncturing said diaphragm means.

3. A device as recited in claim **2,** in which said generally squared orifice portion is formed with corners rounded to a radius less than half the width of said orifice portion.

4. A device as recited in claim **2,** said diaphragm being pre-stressed by means of crossed linear indentations extending substantially along each diagonal of said squared orifice portion.

5. A device as recited in claim **2,** in which said chamber-forming means includes an annular shell having central openings at opposite axial ends thereof, a further plug member, said outlet plug member and said further plug member being received conformably in said openings and welded circumferentially to said shell, and an annular cylindrical spool received coaxially within said shell and threaded at opposite ends thereof in said plug members; said spool being formed with an opening communicating the interior thereof with the interior of said shell, and receiving said piston and cylinder-forming means therein in alignment with said diaphragm means.

6. A device as recited in claim **5,** in which said means for driving said piston comprises gas-generating means received in said cylinder-forming means at an end of said piston opposite said tip, said further plug member being formed with an axial bore receiving said cylinder-forming means, and a header plug including means for actuating said gas-generating means from an external location, said header plug being received conformably in said axial bore in said further plug member and being circumferentially welded thereto.

7. A device as recited in claim **2,** said piston being formed with a first circumferential flange portion conformably and slidably received in said cylinder-forming means, and with a second circumferential flange portion spaced apart along with piston from said first flange portion toward said tip, said second flange portion being circumferentially spaced apart from said cylinder-forming means; together with sealing ring means received about said piston between said flange portions and sealingly engaging said cylinder-forming means.

8. A piston-actuated fluid-discharge device comprising, in combination:

means forming a storage chamber for pressurized fluid comprising an annular shell having central openings at opposite axial ends thereof, a pair of plug members received conformably in said openings and welded circumferentially to said shell, and an annular cylindrical spool received coaxially within said shell and threaded at opposite ends thereof in said plug members, said spool being formed with an opening communicating the interior thereof with the interior of said shell;

a first one of said plug members being formed with a fluid discharge passage;

diaphragm means normally sealing said discharge passage,

a second of said plug members being provided with means for puncturing said diaphragm means including cylinder-forming means extending axially within said spool, a piston slidably received in said cylinder-forming means and having a tip adapted for puncturing said diaphragm means, and gas-generating means received in said cylinder-forming means at an end of said piston opposite said tip for driving said piston forwardly in said cylinder-forming means for puncturing said diaphragm means.

9. A device as recited in claim **8,** said second plug member being formed with a stepped axial bore providing a circumferential seat therein, said cylinder-forming means extending within said bore and being formed with an annular flange abutting said seat, together with a header plug received in said axial bore and overlying said flange to capture said cylinder-forming means in said second plug member, said header plug being circumferentially welded to said second plug member to securely retain said cylinder-forming means and said gas-generating means received therein in assembly with said second plug member.

10. A device as recited in claim **8,** said second plug member being formed with an axial bore, together with a header plug including means for actuating said gas-generating means from an external location, said header plug being received conformably in said axial bore in said second plug member and being circumferentially welded thereto.

11. A device as recited in claim **10,** said cylinder-forming means being received in said axial bore in said second plug member, said header plug overlying and positioning said cylinder-forming means with respect to said second plug member.

12. A device as recited in claim **11,** together with a ferrule received in said cylinder-forming means between said header plug and said piston to locate said piston in a retracted position spaced apart from said header plug.

13. A device as recited in claim **12,** said gas-generating means being received in said ferrule.

14. A device as recited in claim **8,** said piston being formed with a first circumferential flange portion conformably and slidably received in said cylinder-forming means, and with a second circumferential flange portion spaced apart along said piston from said first flange portion, said second flange portion being circumferentially spaced apart from said cylinder-forming means;

and sealing ring means received about said piston between said flange portions and sealingly engaging said cylinder-forming means.

15. A device as recited in claim **8,** said storage chamber-forming means being formed with a tapered orifice for filling said chamber with a charge of fluid, together with a taper pin sealingly engaged in said orifice with a force fit.

16. A device as recited in claim **8,** said spool being of a length to abut said shell at each of said central openings at said opposite axial ends thereof.

17. A piston-actuated fluid discharge device comprising in combination:

means forming a storage chamber for pressurized fluid, said chamber being provided with a fluid discharge passage;

diaphragm means normally sealing said discharge passage;

means for puncturing said diaphragm means including cylinder-forming means, a piston slidably received in said cylinder-forming means and having a tip adapted for puncturing said diaphragm means, and gas-generating means received in said cylinder-forming means at an end of said piston opposite said tip for driving said piston forwardly in said cylinder-forming means for puncturing said diaphragm means;

said chamber-forming means being formed with a stepped axial bore providing a circumferential seat therein, said cylinder-forming means extending within said bore and being formed with an annular flange engaging said seat, together with a header plug received in said axial bore and overlying said flange to capture said cylinder-forming means in said bore, said header plug being circumferentially welded to said chamber-forming means to securely retain said cylinder forming means and said gas-generating means received therein in assembly with said chamber-forming means.

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