Oct. 21, 1969 A. E. HAEFNER ET AL 3,473,543

CHIP-FREE EXPLOSIVELY ACTUATED VALVE

Filed July 13, 1964 2 Sheets-Sheet 1

Fig. 1.

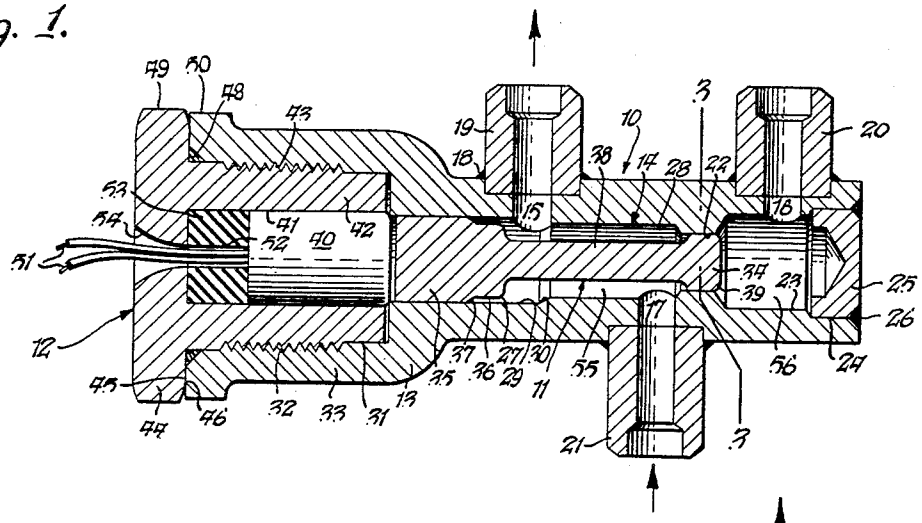
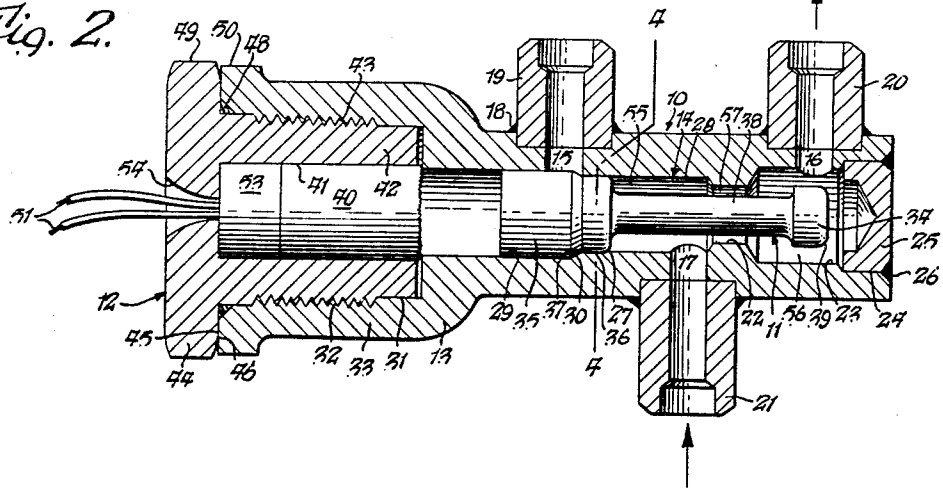


Fig. 2.



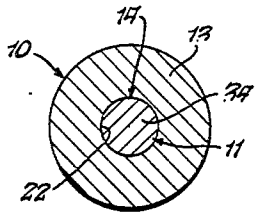


Fig. 3.

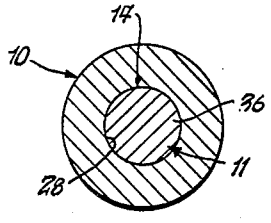


Fig. 4.

INVENTORS
ARTHUR E. HAEFNER
EDWARD G. PIERSON
ROMAN JANKOWIAK

BY Popp and Sommer
ATTORNEYS

Oct. 21, 1969 A. E. HAEFNER ET AL 3,473,543

CHIP-FREE EXPLOSIVELY ACTUATED VALVE

Filed July 13, 1964 2 Sheets-Sheet 2

Fig. 5.

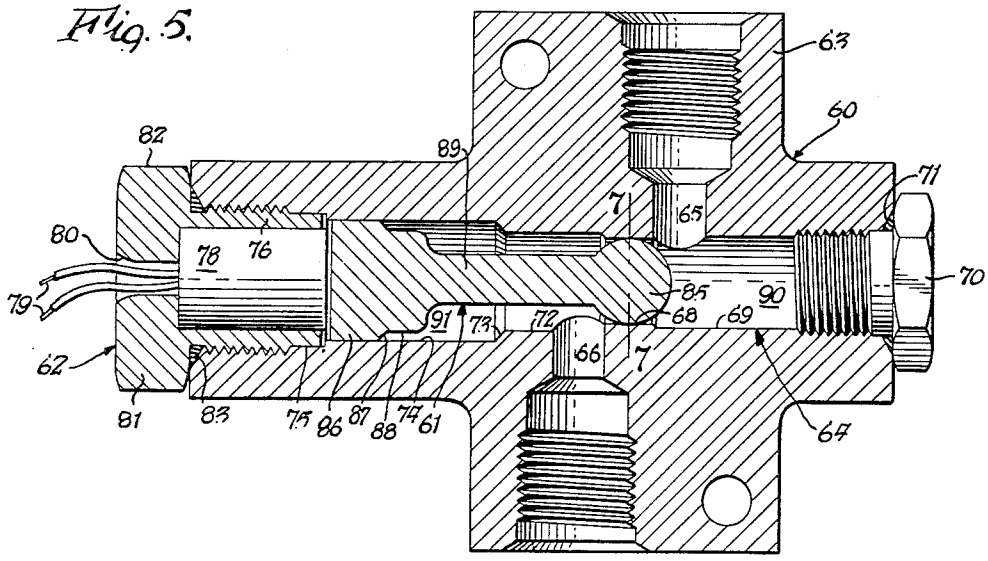


Fig. 6.

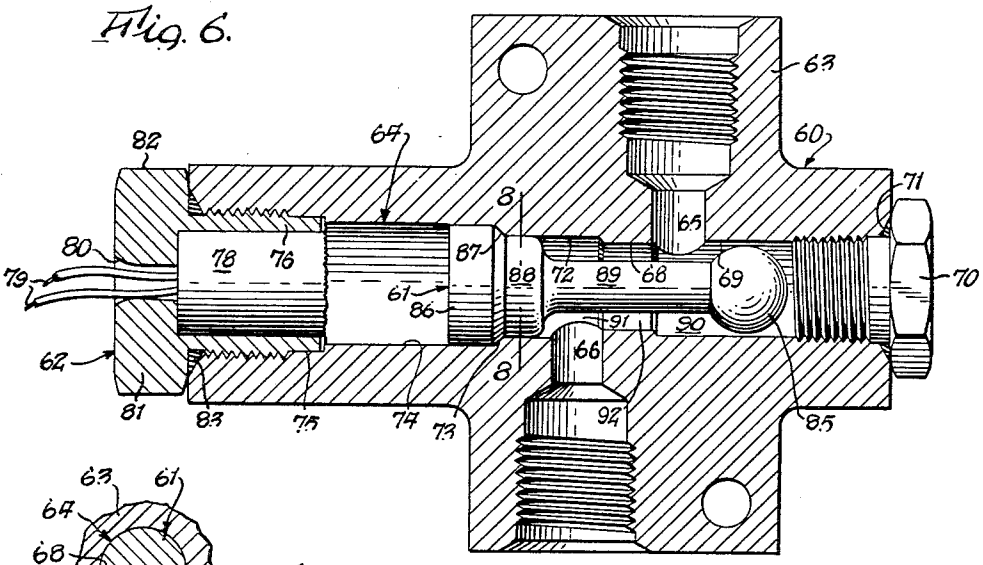


Fig. 7.

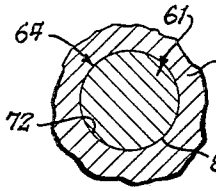


Fig. 8.

INVENTORS
ARTHUR E. HAEFNER
EDWARD G. PIERSON
ROMAN JANKOWIAK
BY Popp and Sommer
ATTORNEYS

United States Patent Office 3,473,543 Patented Oct. 21, 1969

3,473,543

CHIP-FREE EXPLOSIVELY ACTUATED VALVE

Arthur E. Haefner, Williamsville, Edward G. Pierson, Grand Island, and Roman Jankowiak, Buffalo, N.Y., assignors to Conax Corporation, Buffalo, N.Y., a corporation of New York

Filed July 13, 1964, Ser. No. 382,058
Int. Cl. F16k 13/04, 17/14, 17/40
U.S. Cl. 137—67 3 Claims

This invention relates to improvements in explosively actuated valves.

Explosively actuated valves are known. For example, United States Patents Nos. 2,815,882 and 2,947,315, owned by the assignee of the present application, show normally closed electrically triggered explosively actuated valves having a metal body divided into two chambers by an integral transverse closure wall adapted to be punched out by a ram. While it is intended that a portion of such closure wall be punched out as a single piece by the ram, it is difficult sometimes to prevent the formation of metal chips in such prior art valves. These chips may be carried downstream by the fluid being handled by the valve with the result that the operation of other equipment downstream may be adversely affected or be caused to malfunction, which is undesirable.

Accordingly, the primary object of the present invention is to provide an explosively actuated valve in which a closure wall member may be displaced in an intact and unfragmented condition by a ram, that is, without such member being ruptured or fragmented which would result in the formation of chips or fragments.

More specifically, another object is to provide an explosively actuated valve in which a closure wall separating two chambers and blocking communication therebetween may be displaced by a ram so as to establish communication between the chambers without the formation of chips.

Another object is to provide such a chip-free explosively actuated valve in which the movable wall is a separate or non-integral member which when in an operative position acts as a closure between the chambers and effectively seals against leakage from one chamber to the other.

Still another object is to provide such a chip-free explosively actuated valve in which the ram for displacing the closure member is itself in a position within the valve body in which it effectively seals against the flow of fluid past it in either direction, when in a ready condition before being fired, while moving during firing or when coming to rest thereafter.

Another aim is to provide such a chip-free explosively actuated valve which is relatively simple in construction and easy to manufacture and hence relatively inexpensive.

Still other objects and advantages of the invention will be apparent from the following detailed description of two embodiments thereof illustrated in the accompanying drawings in which:

FIG. 1 is a vertical central longitudinal sectional view of an electrically triggered explosively actuated three-way valve embodying one form of the present invention, and illustrating the valve in an unfired condition.

FIG. 2 is a sectional view similar to FIG. 1 but illustrating the three-way valve after being fired.

FIG. 3 is a vertical transverse sectional view thereof and taken on line 3—3 of FIG. 1.

FIG. 4 is another vertical transverse sectional view thereof and taken on line 4—4 of FIG. 2.

FIG. 5 is a vertical central longitudinal sectional view of an electrically triggered explosively actuated two-way valve embodying another form of the present invention, and illustrating the valve in an unfired condition.

FIG. 6 is a sectional view similar to FIG. 5 but illustrating the two-way valve after being fired.

FIG. 7 is a fragmentary vertical transverse sectional view thereof and taken on line 7—7 of FIG. 5.

FIG. 8 is another vertical transverse sectional view thereof and taken on line 8—8 of FIG. 6.

FIGS. 1–4

The invention is illustrated in FIGS. 1–4 as being embodied in an electrically triggered explosively actuated three-way valve shown as comprising body means indicated generally at **10**, ram means indicated generally at **11**, and detonator means indicated generally at **12**.

The body means are shown as including an elongated tubular body member **13** having a passage indicated generally by the numeral **14** extending longitudinally therethrough which communicates with axially spaced ports **15**, **16** and **17**. The body member **13** adjacent the port **15** is shown as being externally recessed slightly to receive the inner end of a nipple **19** which is suitably fastened to this body member as by the annular weldment **18**. Similar nipples **20** and **21** are severally mounted similarly on the body member **13** and operatively associated with the ports **16** and **17**, respectively. These nipples **19–21** are adapted to be connected to conduits (not shown) whereby a liquid or gaseous fluid is conducted to and from the valve.

The body passage **14** is shown as including an intermediate restricted portion or hole **22** formed by an internal cylindrical wall surface. On one side of this hole **22**, the passage **14** is shown as including an adjacent diametrically enlarged inner cylindrical portion **23** and a remote still further diametrically enlarged cylindrical outer portion **24**. This latter portion **24** is shown as occupied by a sealed plug **25** which is secured in any suitable manner to the body member **13** as by welding indicated at **26**.

On the other side of the hole **22**, the passage **14** is shown as including an adjacent cylindrical portion **28** having a diameter somewhat larger than that of the hole **22** but not as large as that for the passage **23**. Arranged remotely from the hole **22** is a cylindrical portion **29** of larger diameter than the portion **28**, and connecting these portions **28** and **29** is an intermediate frusto-conical portion **30**. Outwardly of the remote portion **29**, the passage **14** is shown as greatly enlarged in diameter as indicated at **31** and formed with internal threads **32**, the surrounding portion **33** of the body member being enlarged to accommodate the passage enlargement.

The ram means **11** are shown as being in the form of an elongated one-piece element having at one end a cylindrical closure part **34**, a cylindrical piston part **35** at the other end, a cylindrical deceleration part **36** adjacent this piston part and of smaller diameter, a frusto-conical part **37** connecting the piston and deceleration parts, and a rod part **38** intermediate these deceleration and closure parts and serving as a spacer therebetween. This rod part **38** is also preferably cylindrical in external configuration and is shown as having a diameter smaller than those for the closure part **34** and deceleration part **36**. The axially outer annular corner of the closure part **34** is shown at **39** as being rounded.

The closure part **34** is shown in FIG. 1 as being arranged in the restricted passage portion or hole **22** with its cylindrical periphery engaging the cylindrical hole wall surface and, being imperforate, transversely fills this hole as shown in FIG. 3. A feature of the present invention is that this closure part **34** has an interference fit with the wall surface defining the hole **22**. Such interference fit is achieved by forming the hole **22** with an inside diameter which is several thousandths of an inch smaller than the outside diameter of the closure part **34** and axially forcing this closure part into this hole from the left as viewed in FIG. 1. The rounded leading edge **39** on the closure part **34** facilitates such entrance into the hole portion **22**.

The piston part 35 of the ram means is press fitted within the passage portion 29, effected when the closure part 34 is positioned in the hole 22 as just described. The adjacent deceleration part 36 is axially spaced from the passage portion 28 when the valve is in its unfired condition as shown in FIG. 1. Another feature of the present invention is that this passage portion 28 has an inside diameter several thousandths of an inch less than the outside diameter of the deceleration ram part 36 so that when the ram is moved axially toward the passage portion 28 this deceleration part will be forced into an interference fit with the wall surface of this passage portion and completely transversely fill this passage portion as shown in FIG. 4. The leading annular edge of the deceleration part 36 is preferably rounded as indicated at 27.

The detonator means 12 are shown as comprising a squib or detonator 40 arranged within a cylindrical recess 41 formed in a plug member 42. This plug member is shown as having an externally threaded portion 43 adapted to be screwed into the internal threads 32 provided in the body member 13, and a radially enlarged annular head part 44 formed to provide an axially facing annular flat radial shoulder 45 adapted to abuttingly engage an outwardly facing annular flat radial surface 46 formed on the outer end of the enlarged body portion 33 of the body member 13. The inner corner of this end surface 46 is shown as being chamfered to accommodate a seal ring 48 such as a rubber O-ring in the space formed between this chamfered edge and the corner between the outer surface of the tubular part 42 and head part 44.

The periphery 49 of the head part 44 is formed with an out-of-round configuration. A similar out-of-round peripheral configuration 50 is preferably formed on the enlarged part 33 of the body member 13 adjacent the head part 44. These out-of-round configurations 49 and 50 severally may be of any suitable shape but preferably are hexagonal when viewed from the end so as to permit the application of a wrench (not shown) or other suitable tool. By applying such tools to the out-of-round surfaces 49 and 50, it will be seen that the plug member 42 can be firmly tightened down against the enlarged part 33 of the body member 13 so as to compress the seal ring 48 and prevent the escape of fluid outwardly past the threaded connection between these members.

The squib or detonator 40 may be of any suitable and known construction. It is shown as having lead wires 51 leading therefrom by which an electrical current may be supplied to the powder charge of this detonator to fire the same. These wires 51 are shown as passing through a central axial hole 52 in a cylindrical body 53 of compressible material. The wires 51 also extend through a central axial hole 54 provided in the head part 44 of the plug 42. The compressible body 53 is useful to absorb some of the recoil of the squib or detonator 40 when fired and the axial compression of this body so produced effects a radially inward contraction thereof about the wires 51 to produce a sealing effect.

With the various components of the valve arranged in the unfired condition illustrated in FIG. 1, it will be seen that the passage portions 28–30, closed at one end by the closure part 34 and at the other end by the piston part 35, provide a chamber 55 on one side of the closure part 34. On the other side thereof, the passage portion 23, closed at one end by the closure part 34 and at its other end by the plug 25, provides another chamber 56. The port 16 is shown as communicating at all times with this chamber 56. The port 17 is shown as communicating at all times with the chamber 55 immediately adjacent the hole 22. The port 15 is shown as communicating with the chamber 55 adjacent the juncture between the passage portions 29 and 30. Thus in the ready-to-fire condition of the mechanism shown in FIG. 1, the ports 15 and 16 are in fluid conducting communication with each other through the intermediary of the chamber 55. This chamber 55 is blocked from communication with the chamber 56 by the closure part 34.

When an electrical current passes through the lead wires 51, the squib or detonator 40 is triggered and fires, generating gas under pressure which will serve as a propellant to drive the ram means 11 in a rightward direction as viewed in FIG. 1. When being so driven, the closure part 34 is displaced from sealing engagement with the wall surface of the restricted hole 22 and is displaced into the chamber 56, as illustrated in FIG. 2. This removal of the closure part 34 from the hole 22 establishes communication between the chambers 55 and 56 through the annular space 57 provided between the ram rod part 38 and the surrounding and radially spaced wall surface of the hole 22, also as illustrated in FIG. 2. The rightward movement of the ram means 11 from its unfired position shown in FIG. 1 is restrained yieldably by the drag produced not only by the press fit between the piston part 35 and wall of passage portion 29 but as well by the interference fit between the closure part 34 and wall of hole 22. While the drag of the piston part 35 continues, that associated with engagement of the closure part 34 with the surface of hole 22 will terminate when this closure part is removed completely from this hole, and about this time the deceleration part 36 enters the passage portion 28. It is nicely cammed into engagement by its rounded leading edge 27 sliding on the wall surface of the frusto-conical passage portion 30. As previously described, the deceleration part 36 has an interference fit with the wall surface of the passage portion 28. This serves to dissipate the ram drive energy and gradually slow down rightward movement of the ram means 11 which continues until it is stopped by the frusto-conical ram part 37 engaging the wall surface of thee frusto-conical passage portion 30. At this time the deceleration part 36 has been inserted to its full axial extent into the passage portion 28. Since it has an interference fit therewith, fluid conducting communication between the ports 15 and 17 is sealingly blocked and a leakproof joint is provided.

Thus with the three-way valve in the unfired condition shown in FIG. 1, the port 17 communicates in fluid conducting relation with the port 15 but is blocked from communication with port 16. When the valve is fired by electrically triggering the squib or detonator 40 and the ram means 14 moves to the fully fired condition illustrated in FIG. 2, it will be seen that port 17 has been blocked from communication with port 15 but has had fluid conducting communication established with port 16 through annular space 57. If port 17 is an inlet and ports 15 and 16 are outlets, fluid flow will occur from inlet port 17 to outlet port 15 but not to outlet port 16 when the valve is unfired, and when fired fluid flow will occur from inlet port 17 to outlet port 16 but not to outlet port 15.

FIGS. 5–8

The invention is illustrated in FIGS. 5–8 as being embodied in a normally closed two-way valve shown as comprising body means indicated generally at 60, ram means indicated generally at 61 and detonator means indicated generally at 62. The body means 60 is shown as comprising a body member 63 cruciform in shape in longitudinal section and formed internally with a through passage indicated generally at 64 which communicates with a pair of longitudinally spaced ports 65 and 66. The outer end portions of these ports 65 and 66 are shown as enlarged and internally threaded so as to receive means (not shown) for attaching fluid conduits (not shown).

The passage 64 is shown as including an intermediate restricted cylindrical portion 68 which on one side has a slightly enlarged cylindrical portion 69. The outer end portion of this passage portion 69 is shown as being slightly enlarged and internally threaded to receive a plug 70 which may be screwed into place, the threaded engagement being sealed by a suitable seal ring 71 such as a

rubber O-ring. On the other side of the restricted passage portion **68**, the passage **64** is shown as including an adjacent cylindrical portion **72**, a frusto-conical portion **73** which enlarges into a cylindrical portion **74**. This cylindrical portion **74** has a larger diameter than the portion **72** which in turn has a larger diameter than the restricted portion **68**. Outwardly of the passage portion **74** is a further enlarged cylindrical portion **75** having internal threads which receive the external threads of a plug member **76** forming a component of the detonator means **62**.

Other components of this detonator means including a squib or detonator **78** having lead wires **79** which extend through a hole **80** in an enlarged head part **81** of the plug member **76**. This head part has an out-of-round external configuration indicated at **82** to which a suitable tool (not shown) may be attached for tightening the plug member against the end face of the body member **63**. The adjacent part of the body member **63** is preferably provided with an external out-of-round configuration to permit a tool to be applied to it for this purpose. A suitable seal ring **83** such as a rubber O-ring is shown as clamped between the opposing faces of the head part **81** and the body member **63**.

The ram means **61** is shown as being an elongated one-piece member including at one end an enlarged imperforate spherical closure part **85**, at the other end a cylindrical piston part **86** connected by a frusto-conical part **87** to a cylindrical part **88** of relatively smaller diameter, in turn connected to a rod part **89**. This rod part **89** is preferably cylindrical and of smaller diameter than both the spherical closure part **85** and deceleration part **88** and serves as a spacer therebetween. The piston part **86** has a press fit in the passage portion **74**. The hole **68** is dimensioned with respect to the spherical closure part **85** so as to have a slightly smaller diameter thereby to provide an interference fit. Likewise, the passage portion **72** is dimensioned somewhat smaller than the deceleration part **88** so that when they engage an interference fit therebetween will be provided.

With the two-way valve in the unfired condition illustrated in FIG. 5, the passage portion **69**, closed at one end by the spherical closure part **85** and at its other end by the plug **70**, provides a chamber **90**. On the other side of the closure part **85**, the connected passage portions **72–74**, closed at one end by the spherical closure part **85** and at its other end by the piston part **86**, provide a chamber **91**. The port **65** communicates with chamber **90** adjacent hole **68** and port **66** is shown as communicating with chamber **91** adjacent hole **68**. In this unfired condition of the valve, the ports **65** and **66** are blocked from fluid conducting communication with each other by the spherical closure part **85** of the ram means **61**. This spherical closure part **85** has a circular periphery when viewed from the end of the ram which has an interference fit with the wall surface of the hole **68**, as previously explained, and further it will be seen that this closure part **85** transversely fills the hole **68** as shown in FIG. 7.

When the two-way valve is fired by passing a current through the wires **79** leading to the squib or detonator **62**, the various elements ultimately assume the fully fired condition illustrated in FIG. 6. In moving from the unfired condition shown in FIG. 5 to the fully fired condition shown in FIG. 6, it will be seen that the spherical closure part **85** has been displaced axially from the restricted hole **68** into a position within the chamber **90** to provide an annular space **92** representing the now unoccupied portion of hole **68**, thereby placing this chamber in communication through this space with chamber **91** and port **66**. At the same time, the frusto-conical ram part **87** has been moved into abutting engagement with the frusto-conical passage portion **73** and the deceleration part **88** has been forced into an interference fit with the wall surface of passage portion **72** to provide a leakproof joint therebetween as shown in FIG. 8.

Thus fluid conducting communication is established betwen the ports **65** and **66**, one of which can serve as a fluid inlet and the other of which can serve as a fluid outlet. In either case, the interference fit between the spherical closure part **85** and the wall surface of hole **68** seals the chambers **90** and **91** from each other. If the port **66** is considered an inlet port and fluid, whether a gas or liquid, is confined under pressure in the chamber **91**, it will be seen that engagement between the spherical closure part **85** and the wall surface of the hole **68** seals one end of this chamber, and the press fit of the piston head part **86** in passage portions **74** seals the other end of this chamber, when the valve is in an unfired condition as shown in FIG. 5. When the valve is in a fired condition as shown in FIG. 6, the deceleration part **88** by reason of its interference fit with the passage portion **72** provides an additional seal to prevent leakage of fluid either from chamber **91** past piston head part **86**, or propellant gases generated by firing of the squib or detonator **78** past the piston head part **86** into chamber **91**.

What is claimed is:

1. In an explosively actuated valve, the combination comprising a body formed to provide an elongated compartment having a relatively restricted cylindrical intermediate portion, a first ported chamber on one side of said restricted portion and a second ported chamber on the other side of said restricted portion, said second chamber including a cylindrical section adjacent said restricted portion and a remote section, said adjacent section having a diameter larger than said restricted portion but less than said remote section, elongated ram means arranged in said compartment and including a closure part at one end arranged in said restricted portion and transverely filling the same and having an interference fit with the surrounding wall surface of said restricted portion, a piston part at the other end and transversely filling said remote section and having a press fit with the surrounding wall thereof and a cylindrical deceleration part arranged in said remote section between said closure and piston parts and having a slightly larger diameter than said adjacent section and out of engagement therewith, and detonator means arranged when fired to drive said closure part out of said restricted portion into said first chamber and thereby establish communication between said chambers and also to drive said deceleration part toward said adjacent section and into an interference fit therewith and thereby sealingly close one end of said adjacent section.

2. In an explosively actuated valve, the combination comprising a body formed to provide an elongated compartment having a relatively restricted cylindrical intermediate portion, a first ported chamber on one side of said restricted portion and a second ported chamber on the other side of said restricted portion, said second chamber including a cylindrical section adjacent said restricted portion, a remote cylindrical section of larger diameter and a frusto-conical section interconnecting said adjacent and remote sections, said adjacent section having a diameter larger than said restricted portion, elongated ram means arranged in said compartment and including a circular closure part at one end, a cylindrical piston part at the other end, a cylindrical deceleration part adjacent said piston part and of smaller diameter, a frusto-conical part interconnecting said piston and deceleration parts and a rod part intermediate said deceleration and closure parts, said closure part being arranged in said restricted portions and transversely filling the same and having an interference fit with the surrounding wall surface of said restricted portion, said piston part transversely filling said remote section and having a press fit with the surrounding wall thereof, said deceleration part being arranged in said remote section and having a slightly larger diameter than said adjacent section and out of engagement therewith, said rod part having a transverse di-

mension less than both said closure and deceleration parts, and detonator means arranged when fired to drive said closure part out of said restricted portion into said first chamber and thereby establish communication between said chambers and also to drive said deceleration part toward and into said adjacent section with an interference fit until said frusto-conical section and part engage and thereby sealingly close one end of said adjacent section.

3. In an explosively actuated three-way valve, the combination comprising a body having first and second chambers and a wall surface portion defining a passage which connects said chambers, said second chamber including a portion adjacent said passage having a transverse dimension larger than that of said passage, a first port communicating with said first chamber, a second port communicating with said second chamber, a third port communicating with said adjacent portion, a first movable imperforate closure member arranged in said passage and transversely filling the same and having an interference fit with the surrounding wall surface and being arranged between said first and third ports thereby to block communication between said first port and said second and third ports, said second and third ports communicating with each other, a second movable imperforate closure and deceleration member arranged in said second chamber and spaced from said adjacent portion and larger in transverse dimension

than said adjacent portion and adapted to be moved into said adjacent portion with an interference fit so as to block communication between said second and third ports, spacer means separating said members and smaller in transverse dimension than both said adjacent portion and passage, and explosively actuated means for displacing said members and spacer means to drive said first member into said first chamber thereby to establish communication between said first and third ports and to drive said second member into said adjacent portion and thereby block communication between said second and third ports.

References Cited

UNITED STATES PATENTS

2,517,061	8/1950	Stackelberg	137—625.11
2,937,654	5/1960	Wilner	137—68
2,997,051	8/1961	Williams	137—68
3,122,154	2/1964	Siebel	137—68
3,260,272	7/1966	Eckardt	137—68

WILLIAM F. O'DEA, Primary Examiner

RICHARD GERARD, Assistant Examiner

U.S. Cl. X.R.

137—625.11; 251—11, 63