April 18, 1950 S. M. ZANDMER 2,504,611

PRESSURE REDUCTION CHAMBER AND UNLOADING VALVE FOR EXPLOSIVES

Filed Feb. 25, 1946 2 Sheets-Sheet 1

Fig. 1

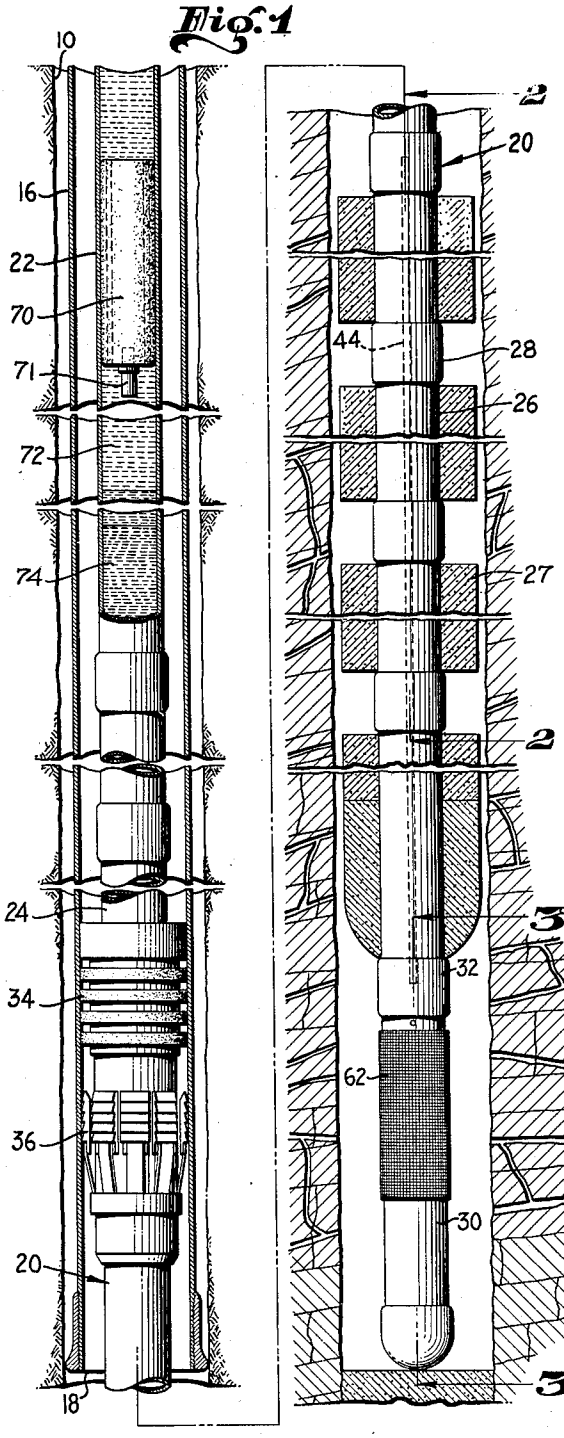
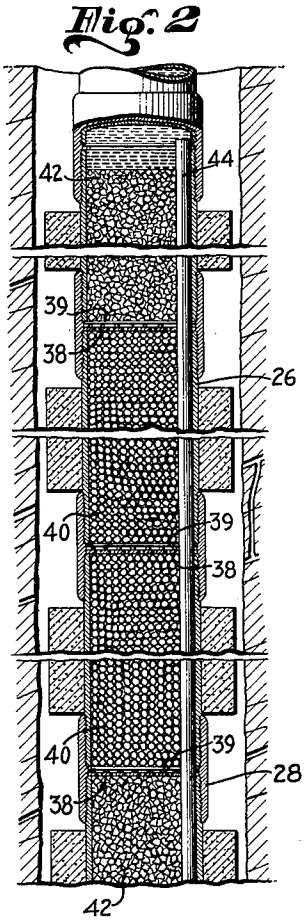
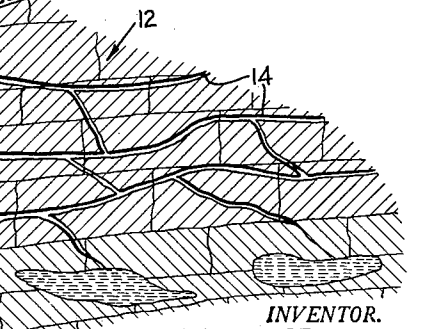


Fig. 2





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Fig. 3

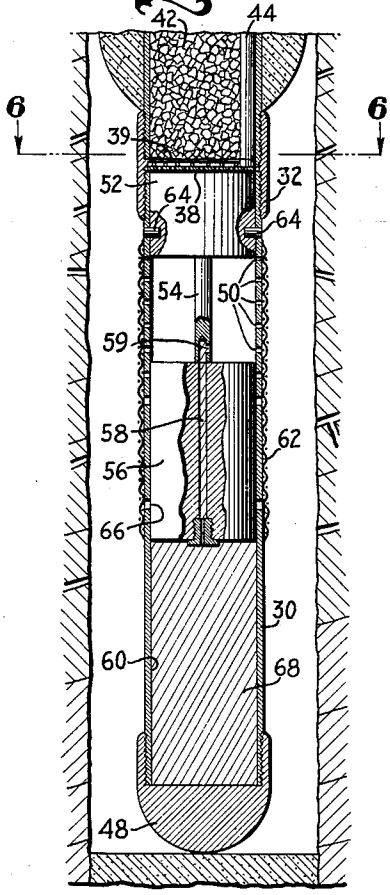


Fig. 4

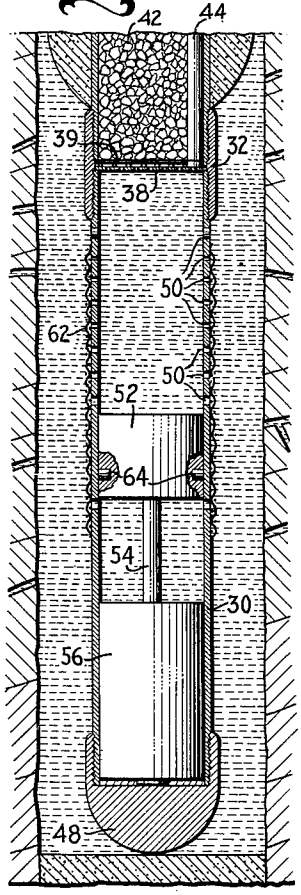
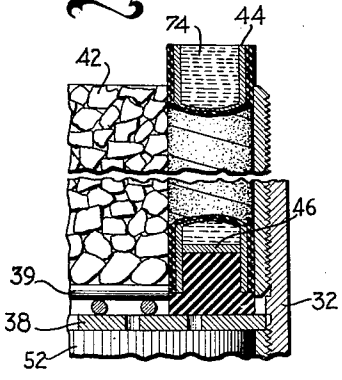


Fig. 5



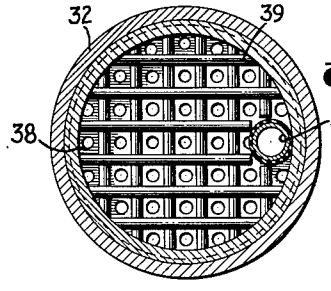


Fig. 6

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PRESSURE REDUCTION CHAMBER AND UNLOADING VALVE FOR EXPLOSIVES

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9 Claims. (Cl. 102—22)

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This invention relates to the art of regulating the displacement and detonation of liquid explosive in wells, and more especially to a pressure reduction chamber and unloading valve for liquid explosives in oil and gas wells which have been prepared for the same.

The present invention is for improved apparatus in connection with means and a method of treating oil and gas wells by the introduction of a liquid explosive and the detonating of the explosive in the oil or gas bearing fissure system of producing strata and covers apparatus which is an improvement over that shown in my co-pending applications, Serial No. 557,100, filed October 4, 1944, and Serial No. 560,565, filed October 27, 1944, now abandoned.

In my prior applications referred to, I disclosed methods and means for introducing a quantity of a liquid explosive, such as nitroglycerine, into a prepared well by displacing a column of a non-explosive fluid, such as water, mud or the like, by a quantity of liquid explosive, and, upon the liquid explosive being placed in with the well tubing or well casing, as the case may be, opening a bottom hole valve and causing the liquid explosive to be moved into the fissure system of the strata and thereafter detonating the explosive to enlarge the fissure system.

The successful method which has been achieved by my present invention of depositing the liquid explosive into the fissure system has required the development of certain techniques wherein the liquid explosive is carried to the bottom of the well and then transferred to the fissure system.

This transition step requires the displacement of the water or mud column in the interstitial spaces of the column of turbulence by the liquid explosive and thereafter accelerating and displacing the liquid explosive by movement into the strata. This starting movement or acceleration must be accomplished without any shock, jolting or vibration, which would cause a detonation of the explosive at the time its motion is started or before it has been substantially transferred to the formation, and is accomplished by my present invention by the herein disclosed pressure reduction chamber and unloading valve, whereby the pressure on the liquid explosive, due to its own column and the column of inert liquid thereabove, is reduced to a pressure which is above the reservoir fluid pressure to permit the liquid explosive to flow into the formation, and this change in pressure is effected gradually and without shock.

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The pressure reduction chamber and unloading valve of this invention comprise essentially a cylinder secured to the loading pipe or tubing, if the tubing method is employed, or positioned in the well casing itself substantially at or slightly above the level of the producing strata, and having an upper inlet and a lower outlet, the outlet being controlled by a suitable valve which may be a piston valve. If the latter, the piston valve may include a hydraulic jack or dash-pot feature which is moved slowly to a position to open the outlet to release the liquid explosive held above the piston, the movement of the piston being initiated by the application of fluid pressure higher than that of the hydrostatic pressure of the column of fluid, which could be sustained by the shear pins without this additional fluid.

Immediately above the piston I provide a turbulence chamber or chambers which may include spaced plates or similar elements which provide small orifices, pipes or other openings, or may comprise straight or curved tubes of any type or shape, in the nature of a filter to resist the movement of the liquid explosive therein and thereabove so that the fluid movement is restricted and the fluid pressure is reduced before reaching the outlet port or ports. The turbulence chamber or pressure reduction chamber may include a plurality of pellets, such as spheres, agates, marbles or the equivalent, forming interstitial spaces which restrict the fluid flow to the desired and necessary rate.

With the foregoing general purpose and objective contemplated, the invention can be best understood by the more specific description thereof considered with reference to the accompanying drawings, wherein:

Figure 1 is an elevation view of a pressure reduction chamber and unloading valve embodying a form of my invention.

Figure 2 is an enlarged partial sectional view of the same, the section being taken along the line 2—2 of Figure 1.

Figure 3 is a sectional view taken along the line 3—3 of Figure 1, showing the plunger valve prior to movement to outlet opening position.

Figure 4 is a view similar to Figure 3, showing the valve after movement to outlet opening position.

Figure 5 is a fragmentary enlarged view showing the lower end of the pilot tube shown in the other figures.

Figure 6 is an enlarged sectional view taken along the line 6—6 of Figure 3.

Referring more particularly to the drawings, I show a well bore 10 extending vertically into an oil or gas bearing stratum 12 having a fissure system 14 in communication with bore 10. The well is shown as having a casing 16 terminating at 18 immediately above the stratum 12.

I show and indicate by numeral 20 a pressure reduction chamber and unloading valve connected to a pipe or tube string 22 running to the top of the well and lowered or manipulated by the conventional derrick, not shown. Unit 20 comprises essentially a pipe section 24, a plurality of pipe sections 26 connected by collars 28 and a pipe section 30 connected by a collar 32 to the adjacent section 26. Suitable packers 34 may be provided on pipe section 24, and slips 36 may be similarly provided.

A plurality of plates 38 are provided and secured between pipe sections 26, as shown. A screen 39 may be provided on each plate 38 to prevent the pellets from covering the holes in the plate. The plates may be formed with small apertures to support pellets 40 to form a turbulence chamber provided by the interstitial spaces between the pellets, constituting restricted flow passages therethrough.

Upper and lower chambers or other chambers may be filled with gravel 42 or other material which will pack to a degree, and the interstitial spaces therebetween may be initially filled with water, aquajell or similar material which will not permit the liquid explosive to enter this chamber until the bottom hole valve has been opened, but which will then permit a flow thereof through the chamber. A pilot tube 44 extends through reduction chamber 20, as shown, and has a plug 46 at the bottom thereof, as shown in Figure 5. Pipe sections 26 may be encased in cement sleeve 27 or other outside tamping, if desired.

Pipe section 30 is capped or plugged at the bottom at 48 and has one or more openings 50 in a side wall portion thereof forming the discharge outlet for the unit. A piston valve 52 is positioned in section 30 and has a stem 54 connected thereto and to a plunger 56. Plunger 56 has a tubular passage 58 terminating with an opening 59 which communicates from the chamber 60, formed below the plunger, and the space thereabove which is in communication with the openings 50 and thence to the fissure system 14 of stratum 12. A screen 62 may be provided to protect openings 50 if desired or found necessary. Piston valve 52 is initially secured in the position shown in Figure 3 by one or more shear pins 64 secured to pipe section 30, which pins may be sheared at a predetermined pressure which is ultimately built up by increasing the liquid column pressure above the piston valve to shear these pins when desired. One or more openings 66 may be provided in pipe section 30, which openings are covered by plunger 56, as shown in Figure 3, until the plunger is moved to uncover the openings to permit the dashpot fluid 68 below the plunger to escape after passing through passage 58 after piston 56 has passed below the lowermost of the outlet apertures 50.

In the operation of the invention, unit 20 is lowered on tubing 22 to the bottom of the well bore 10, as shown in Figure 1, and the tubing 22 either left in the well or removed from above the packer, according to whether the tubing or casing method described in my co-pending applications is used. The unit extends substantially opposite the oil or gas bearing strata 12, the

fissures 14 of which have been opened or enlarged by acidizing, such as by the method described in my co-pending applications referred to above. Tubing 22 is then filled with an inert fluid, such as water, mud or the like, after which the liquid explosive is poured in the tubing and displaces the inert fluid above the unit 20, or liquid explosive may be poured direct into the tubing 22 without previously filling the tubing 22 with inert fluid or liquid. The pilot tube 44 had been filled with explosive when it was first placed in the tubing and the interstitial spaces formed by pellets 40 and the gravel or equivalent material 42 was filled with inert fluid when these pellets or gravel were placed in each section of this chamber. When all of the explosive desired to be ultimately displaced into the formation has been added to the tubing, or to the casing, if the tubing has been removed, a detonating device or "go-devil" 70 is pushed down to the top of the explosive. This "go-devil" has a ball and seat float which allows the "go-devil" to be pushed down to the top of the explosion allowing the air to escape from under it, until the "go-devil" reaches the explosive, at which time the ball float rises and closes so that the "go-devil" cannot be pushed through the liquid explosive.

There is another ball above this first ball which closes or seats down and does not let fluid, which is to ultimately drive the "go-devil" and the liquid explosive, flow or pass through the "go-devil" so that the "go-devil" now forms a solid piston between the top of the explosive and the driving fluid above it. If the casing method is used, the "go-devil" will have the same construction but will naturally be made to fit the casing rather than the tubing. In either case, it can be so arranged that a given volume of inert fluid, as water, can be placed on top of the liquid explosive so that the "go-devil" rests on top of this fluid, the purpose in these cases being to have the upper portion of the column of turbulence filled not with explosive but with inert fluid at the time the "go-devil" reaches the top of the column.

When ready, that is when the "go-devil" which carries the contact exploder or "war-head" 71 is in position as above described, the fluid head of the column is then increased, as by pumping, at the top of the well, which increase of pressure will cause pins 64 to shear off and permit the unloading valve, comprising piston 52 and plunger 56, to move downward, uncovering outlet openings 50, and permit the liquid explosive to flow into the fissure system 12, the movement of the piston being maintained at a slow rate while the dash-pot fluid 68 escapes through passage 58 and thence out through outlet openings 50 or through openings 66, when the piston unit has moved to lowermost position, as shown in Figure 4.

The liquid explosive thus starts to move slowly downwardly through the turbulence chamber without shock, jolting or vibration, which would otherwise occur if upon the shearing of pins 64, the piston 52 could move suddenly, or if there were liquid explosive in the column of turbulence at that time. The inert fluid in the bottom of the column of turbulence is under the full pressure of the column when the piston 52 is caused to move, and therefore, when this fluid rushes out of the holes 50, it is shocked by the release of pressure, but this fluid is inert, that is non-explosive. However, by the time that the liquid explosive reaches these portholes, it has had to transverse the entire column of turbu-

lence and its pressure is gradually broken in this chamber or column so that when it reaches the portholes there has been a gradual pressure reduction and no shock takes place. The damping piston 56 below pins 64 causes piston 52 to move so slowly as it gradually passes more and more apertures 50 so as to practically eliminate vibration, shock and hydraulic hammer of even the inert fluid.

When all of the liquid explosive is caused to pass out through outlet openings 50 into the fissures 14 and has thus been unloaded from the well, the detonating device or "go-devil" 70 strikes the gravel 42, which detonates the liquid explosive in the unit 20 and the fissure system, the explosion being conducted through pilot tube 44 to insure a rapid propagation of the explosion through the cylinders comprising the turbulence chambers.

This process has actually been gone through in a test well wherein 5,200 quarts of liquid explosive were displaced and exploded outside the bore in the exact manner described and the explosive was successfully handled without shock to cause a premature explosion. The pressure when shearing the pins 64 was reduced, in this case, from 3,700 pounds per square inch to the reservoir fluid pressure below the column of turbulence, which, in this case, was 678 pounds per square inch and the entire volume of liquid explosive was displaced through the column and into the formation. The detonating device or "go-devil" 70, upon reaching the top of the column of turbulence, contacted the first material or substance in the chamber, which, in this case, was gravel 42 and the contact exploder fired, by contact, and detonated the liquid explosive in the pilot tube 44 and the explosion conducted through the pilot tube insured a rapid propagation of the explosive through the remaining explosive in the lower portion of the column of turbulence and thence to the connected explosive flowing therefrom in the formation.

In this case, as long as there was a substantial column of explosion in the pilot tube to be detonated, it could detonate the explosive which had been displaced from the bore, even though said displaced explosive became separated from the bore by an inert fluid, which fluid could, by detonation of the explosive in the pilot tube, transmit the explosive shock to the displaced explosive and cause that explosive to be detonated as well.

This principle of displacing explosive from the bore may well result in putting very large quantities out in similar manner and exploding these large volumes of explosive farther and farther from the bore as it is learned just how far away from the bore the inert driving fluid can set off that explosive by transmitted shock.

Although I have herein shown and described my invention in what I have conceived to be the most practical and preferred embodiment, it is recognized that departures may be made therefrom within the scope of my invention, which is not to be limited to the details disclosed herein but is to be accorded the full scope of the claims so as to embrace any and all equivalent devices and systems.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:

1. Apparatus of the character described comprising a cylinder having an upper inlet and a lower outlet, means adapted to sustain a fluid column of unstable explosive above said outlet and adapted to be actuated by an increase in the fluid column pressure to open said outlet, and flow restricting means in said cylinder above said first means and a passage by-passing said flow restricting means for a portion of the column of explosive, said last means including a plurality of spaced plates, each having a plurality of openings of relatively small cross-section, said plates forming turbulence chambers.

2. Apparatus of the character described comprising a cylinder having an upper inlet and a lower outlet, means adapted to sustain a fluid column of unstable explosive above said outlet and adapted to be actuated by an increase in the fluid column pressure to open said outlet, and flow restricting means in said cylinder above said first means and a passage by-passing said flow restricting means for a portion of the column of explosive, said last means including a plurality of spaced plates, each having a plurality of openings of relatively small cross-section, said plates forming turbulence chambers, and loose flow restricting material in said chambers.

3. Apparatus of the character described comprising a cylinder having an upper inlet and a lower outlet, impermeable means adapted to sustain a fluid column of unstable explosive above said outlet and adapted to be actuated by an increase in the fluid column pressure to open said outlet, and flow restricting means in said cylinder above said first means and a passage by-passing said flow restricting means for a portion of the column of explosive, said last means including a plurality of spaced plates, each having a plurality of openings of relatively small cross-section, said plates forming turbulence chambers, and flow retarding material in said chambers, said material comprising pellets disposed to provide interstitial spaces therebetween.

4. Apparatus of the character described comprising a cylinder having an inlet and an outlet, means adapted to sustain a fluid column of unstable explosive above said outlet and adapted to be actuated by an increase in the fluid column pressure to open said outlet, and flow restricting means in said cylinder above said first means and a passage by-passing said flow restricting means for a portion of the column of explosive, and having a lower end closure releasable upon said increase in fluid column pressure, said first means including a piston having dash-pot means adapted to regulate the rate of movement thereof when actuated by said fluid column pressure.

5. Apparatus of the character described comprising a cylinder having an inlet and an outlet, means adapted to sustain a fluid column of unstable explosive above said outlet and adapted to be actuated by an increase in the fluid column pressure to open said outlet, and flow restricting means in said cylinder above said first named means and a passage by-passing said flow restricting means for a portion of the column of explosive, and having a lower end closure releasable upon said increase in fluid column pressure, said first means including a piston having dash-pot means adapted to regulate the movement thereof throughout the full extent thereof when actuated by said fluid column pressure, said dash-pot means comprising a cylinder, a fluid in said cylinder and a plunger in said cylinder having a restricted fluid escape passage.

6. An apparatus for loading an oil well with explosive fluid comprising a cylinder having an

upper inlet and a lower outlet, a flow control valve means initially closing said lower outlet comprising a member substantially filling the cylinder adjacent the lower end thereof and so positioned with respect to the bottom of the cylinder as to provide a space therebetween, said member including a recessed portion above said space and a passage communicating between said space and the recessed portion, a mass of substantially solid material in the space adapted to flow under pressure through said passage, temporary retaining means between said member and the cylinder releasable under pressure, flow restricting means in said cylinder above said member forming interstitial space, an inert fluid in the lower portion of said space, and an unstable explosive fluid in said cylinder located above and separate from said inert fluid, said explosive fluid having access to said lower opening following the passage thereto of the inert fluid after release of said temporary retaining means.

7. An apparatus for loading an oil well with explosive fluid comprising a cylinder having an upper inlet and a lower outlet, a flow control valve means initially closing said lower outlet comprising a piston element in the cylinder forming a space between itself and the bottom of said cylinder, a second piston element above and spaced from the first piston element forming a recess therebetween having access to said lower outlet, means forming a restricted passage between said space and said recess and a substantially solid material in said space adapted to flow under pressure, temporary retaining means securing one of said piston elements to the cylinder, finely divided flow restricting means in said cylinder above the second piston element forming interstitial space, an inert fluid in the lower portion of said space having access to said lower opening on release of said temporary retaining means, and an unstable explosive fluid in said cylinder above and separate from said inert fluid.

8. An apparatus for loading an oil well with explosive fluid comprising a cylinder having an upper inlet and a lower outlet, a flow control valve means initially closing said lower outlet comprising a piston element in the cylinder forming a space between itself and the bottom of said cylinder, a second piston element above and spaced from the first piston element forming a recess therebetween having access to said lower outlet, means forming a restricted passage between said space and said recess and a substantially solid material in said space adapted to flow under pressure, temporary retaining means securing one of said piston elements to the cylinder, finely divided flow restricted means in said cylinder above the second piston element forming interstitial space, an inert fluid in the lower portion of said space having access to said lower opening on release of said temporary retaining means, and an unstable explosive fluid in said cylinder above and separate from said inert fluid, and a pilot tube for explosive fluid bypassing the flow restricting means, said temporary retaining means being releasable under fluid pressure in the upper portion of said cylinder whereby said pressure is transferred to said solid material for gradually pressing said piston elements to a position opening said lower outlet.

9. An apparatus for loading an oil well with explosive fluid comprising a cylinder having an upper inlet and a lower outlet of progressively increasing flow capacity, a flow control valve means initially closing said lower outlet comprising a piston element in the cylinder above the bottom of said cylinder forming a space between itself and the bottom, a second piston element above and spaced from the first piston element forming a recess therebetween having access to said lower outlet, a mass of substantially solid flowable material in the space adapted to flow under pressure, means forming a restricted passage between said space and said recess for said material, shear pins securing said second piston element to the cylinder, finely divided flow restricting means in said cylinder above the second piston element forming interstitial space, an inert fluid in the lower portion of said space, an unstable explosive fluid in said cylinder above and separate from said inert fluid, and a pilot tube for explosive fluid bypassing the flow restricting means and communicating at the lower end with said second piston element and at the upper end with the interior of said cylinder above the flow restricting means, said pins being shearable under pressure of fluid above said second piston element whereby said piston elements move downwardly at a rate retarded by flow of said material through the restricted passage means to a position wherein said lower outlet is adapted to successively receive the inert fluid and the explosive fluid at a progressively increasing rate.

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