

Sept. 22, 1953

C. E. DEARDORFF ET AL

2,652,781

EXPLOSION-ENERGIZED SOURCE OF HYDRAULIC PRESSURE FLUID

Filed March 3, 1950

2 Sheets-Sheet 1

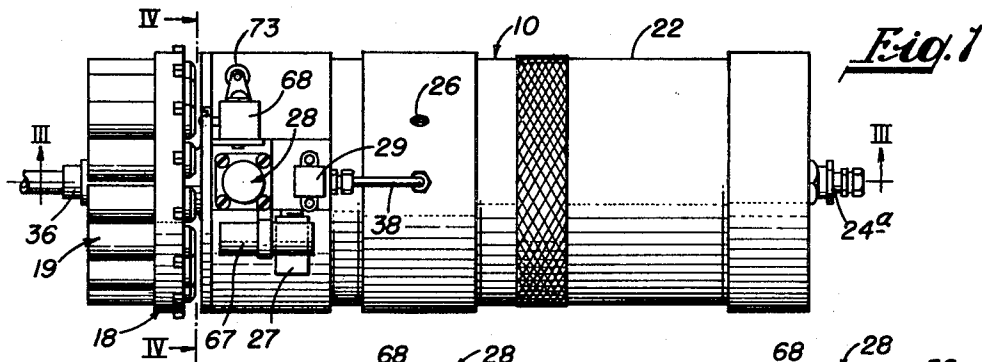


Fig. 4

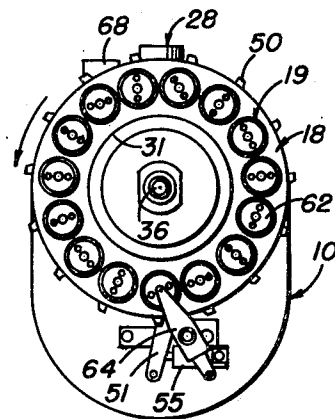
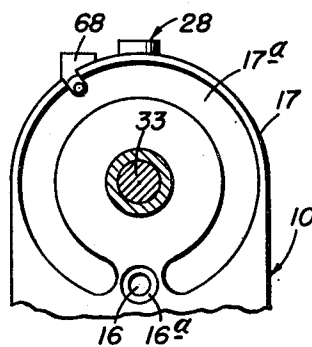


Fig. 2

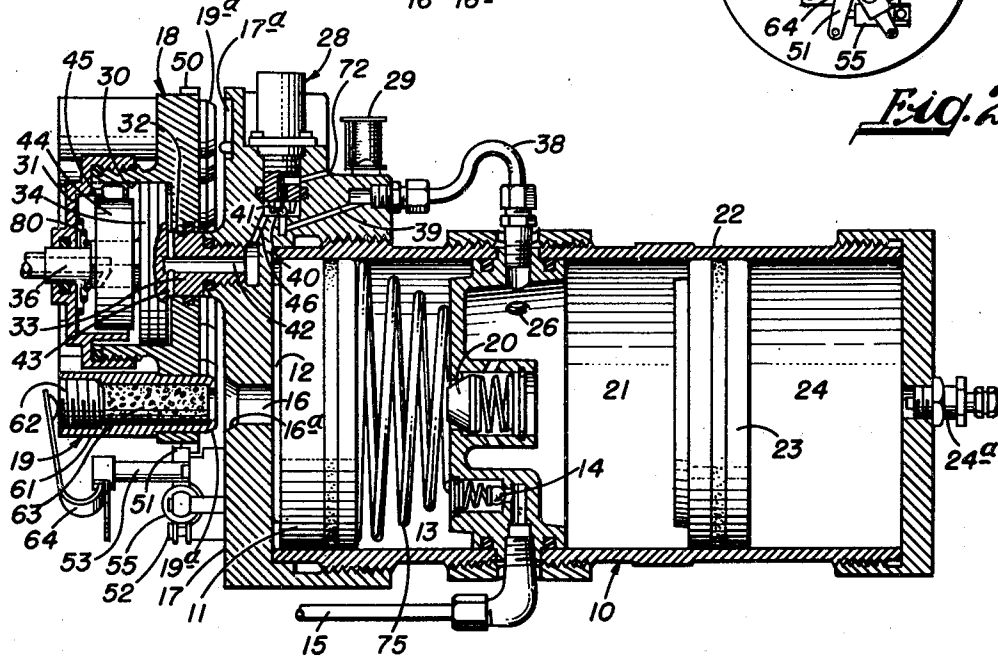


Fig. 3

INVENTORS
C. E. DEARDORFF
AND J. B. GUNN
BY *Edwoodbury*
ATTORNEY

Sept. 22, 1953

C. E. DEARDORFF ET AL

2,652,781

EXPLOSION-ENERGIZED SOURCE OF HYDRAULIC PRESSURE FLUID

Filed March 3, 1950

2 Sheets-Sheet 2

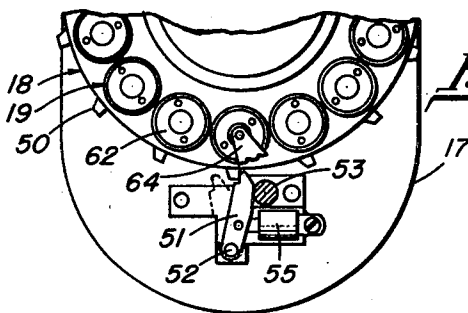


Fig. 5

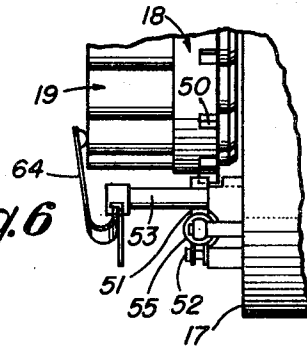


Fig. 6

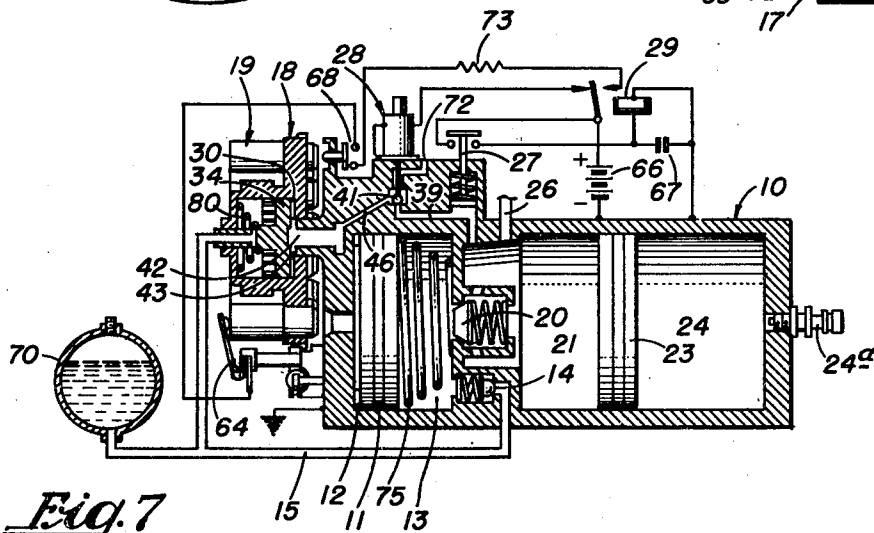


Fig. 7

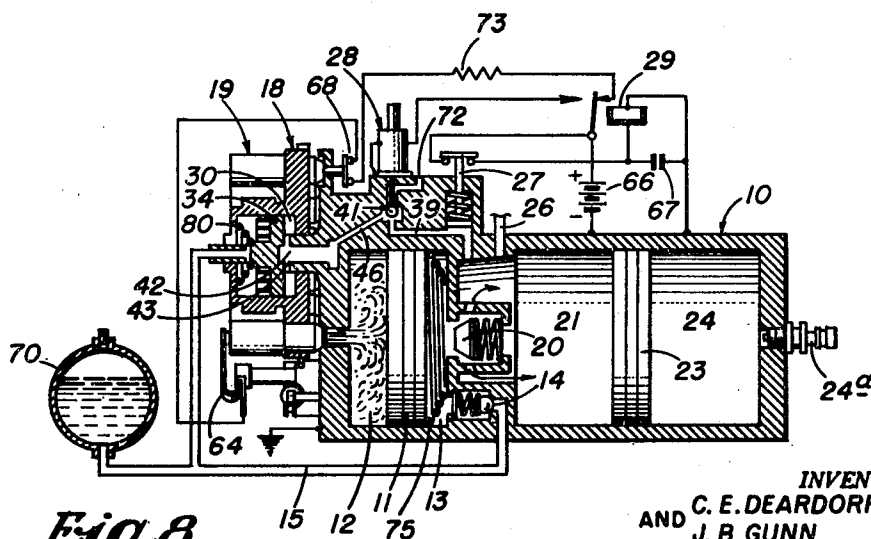


Fig. 8

INVENTORS
C. E. DEARDORFF
AND J. B. GUNN

BY *Edward*
ATTORNEY

UNITED STATES PATENT OFFICE

2,652,781

EXPLOSION-ENERGIZED SOURCE OF
HYDRAULIC PRESSURE FLUID

Clinton E. Deardorff, San Fernando, and Joseph
B. Gunn, North Hollywood, Calif., assignors to
Bendix Aviation Corporation, South Bend, Ind.,
a corporation of Delaware

Application March 3, 1950, Serial No. 147,426

6 Claims. (Cl. 103—54)

1

This invention relates to sources of pressure fluid for the operation of hydraulic systems, and more particularly to a hydraulic pump energized by controlled explosions.

An object is to provide a light, compact and portable source of pressure fluid for actuation of hydraulic devices.

Another object is to provide a suitable and practicable apparatus for storing the energy of an explosion for subsequent utilization.

Another object is to utilize the pressure of an explosion and safeguard the apparatus in which the pressure is utilized from the heat of the explosion.

Other more specific objects and features of the invention will appear from the description to follow.

Briefly, the invention consists of a hydraulic cylinder having a floating piston therein dividing it into an explosion chamber and a hydraulic fluid chamber, with inlet and outlet valves in the fluid chamber for the intake and discharge of fluid in response to reciprocation of the piston, and means for developing a high pressure in the explosion chamber by the explosion of a powder charge, to move the piston in fluid-discharging direction. The high pressure fluid discharged by the power of the explosion may be stored in a hydraulic accumulator for gradual use by hydraulic equipment, and the explosion means may be actuated in response to a predetermined drop of pressure in the accumulator for recharging the latter automatically as necessary. The explosion means comprises a magazine breech mounted adjacent the explosion chamber and carrying a plurality of powder charges adapted to be successively brought into communicating relation with the explosion chamber. The details of one form of apparatus that may be employed will be explained with reference to the drawing in which:

Fig. 1 is a plan view of an explosion-energized source of hydraulic pressure fluid in accordance with the invention.

Fig. 2 is a left end elevation view of the unit.

Fig. 3 is a longitudinal vertical section in the plane III—III of Fig. 1.

Fig. 4 is a cross section taken in the plane IV—IV of Fig. 1.

Fig. 5 is a detail elevational view of a portion of the left end of the unit illustrating the operation of the indexing mechanism.

Fig. 6 is a side elevational view of the portion of the apparatus shown in end elevation in Fig. 5; and

2

Figs. 7 and 8 are schematic diagrams illustrating the operation of the unit.

Referring to Figs. 1 and 3, the apparatus comprises a container 10 formed as a cylinder and having a floating piston 11 therein which divides the container into an explosion gas chamber 12 and a liquid pumping chamber 13. The pumping chamber has an inlet check valve 14 connecting it to a low pressure line 15 containing hydraulic fluid under pressure of say 75 p. s. i., which is sufficient to cause the fluid to flow past the check valve 14 and fill the chamber 13, moving the piston 11 to reduce the volume of the explosion gas chamber 12 to a very low value. Any gas present in the chamber 12 is exhausted at this time through an open port 16 in the left end wall 17 of the container. There is mounted on the left end wall 17 a rotatable breech member 18 carrying an annular row of cartridges 19 which are moved past the port 16 in response to rotation of the breech member. An indexing mechanism is provided which rotates the breech member 18 by small increments to bring successive ones of the cartridges 19 into registration with the port 16. Means is also provided for shifting the breech member 18 longitudinally to the right, to cause the tapered end 19a of the registered cartridge into sealing relation with the flared end 16a of the port 16, and while the cartridge is thus held it is fired. The gases resulting from the explosion are driven through the port 16 into the explosion chamber 12, expanding the latter and moving the piston 11 to the right. This applies high pressure to the hydraulic fluid in the chamber 13 and forces it past a check valve 20 into the fluid chamber 21 of an accumulator. The accumulator is shown as being of the piston type comprising a cylinder 22 having a floating piston 23 therein dividing the cylinder into the fluid chamber 21 and a gas chamber 24, which is precharged with gas under high pressure through a valve 24a. The liquid in the pumping chamber 13 is raised to a pressure high enough to displace it entirely into the accumulator chamber 21, compressing the gas in the chamber 24 in so doing. The gas in the chamber 24 may be initially precharged to a pressure of 1400 p. s. i., and may be compressed to a pressure of about 2100 p. s. i. when the liquid is all driven from the chamber 13 into the chamber 21.

The fluid chamber 21 of the accumulator may be connected by an outlet connection 25 to a utilization circuit to be actuated by pressure fluid. The unit includes automatic control apparatus for firing one of the cartridges 19 to restore the

pressure in the accumulator chamber 21 whenever that pressure drops below a predetermined desired value. This control apparatus includes a pressure switch 27 (Figs. 1 and 7), an electrically actuated valve 28 (Fig. 3), and a relay 29, in addition to the breech member 18.

The breech member 18 comprises a body having a cylinder 30 formed therein which is closed at its left end by a cap 31 and has at its right end a cylindrical passage 32 in sealing relation with the neck 33 of a stationary breech support which carries on its left end a piston 34 which seals in the cylinder 30. The neck 33 really constitutes a piston rod and is anchored to the left end member 17 of the container 10. The left end of the cylinder 30 is supplied with hydraulic fluid at approximately 75 p. s. i. through a hollow extension 36 that extends from the left end of the stationary piston 34 through the end cap 31 in sealing relation therewith. This pressure of 75 p. s. i. is ordinarily sufficient to maintain the cylinder 30 in leftmost position with respect to the stationary piston 34, in which position the right ends of the cartridges 19 are clear of the left end wall 17 through which the port 16 extends, so that the breech member is capable of rotating. If desired, a spiral, helical spring 80 may be compressed between the stationary stem 36 and the cap 31 to provide the restoring force in place of, or to aid, the pressure fluid from the reservoir 70.

It is necessary, before firing one of the cartridges 19, that is, the cartridge in registration with the port 16, to move the breech member to the right to bring the tapered end 19a of the registered cartridge into sealing relation with the chamfered or flared face 16a of the port 16. This movement is accomplished by admitting high pressure fluid into the right end of the cylinder 30 to move the cylinder and the breech to the right. The pressure fluid to perform this operation must of course be at higher pressure than that in the left end of the cylinder 30, and its source is the accumulator 21, the minimum pressure of the fluid in which is never permitted to drop below approximately 1400 p. s. i. Thus, pressure fluid is supplied from the chamber 21 through a tube 38, through a passage 39 to a valve seat 40 normally closed by a poppet 41 of the solenoid valve 28, and thence through a passage 46, a passage 42 and passages 43 into the right end of the cylinder 30. The solenoid valve 28 is normally energized, and the poppet 41 is closed on the seat 40 when the valve is energized.

When the breech member is shifted to move the registered cartridge into the flared end 16a of the port 16, the remaining cartridges are prevented from abutting against the end wall 17 by providing a groove 17a in the outer face of the wall 17 to receive the ends 19a of the remaining cartridges.

Indexing of the breech member 18 to bring a fresh cartridge 19 into registration with the port 16 is produced by a clock spring 44, which is positioned within the left end of the cylinder 30 and is anchored at its outer end by a pin 45 to the breech member 18, and is anchored at its inner end to the stationary stem 36 extending from the piston 34. The spring 44 is wound by rotating the breech member 18 in clockwise direction when looking at the left end of the unit and thereafter tends to urge the breech member in counterclockwise direction. However, movement in counterclockwise direction is controlled

by a detent mechanism so arranged that movement can only occur during leftward movement of the breech member away from the end member 17 of the container.

Referring to Fig. 5, this detent mechanism comprises a plurality of projections or fingers 50 projecting from the periphery of the breech member 18, and a stop arm 51 pivoted at its lower end by a pivot 52 to the stationary end wall 17. The upper end of the arm 51 projects into the path of the fingers 50 in all axial positions of the breech member except when it is moved to carry the end 19a of one of the cartridges 19 past the face of the end wall 17 and into the flared end 16a of the port 16.

Clockwise rotation of the arm 51 (with respect to Fig. 5) is limited by contact with a stationary pin 53, in which position, the arm 51 holds the rotating breech member in position such that a cartridge 19 is registered with the port 16. When the breech member is shifted to move the end 19a of the registered cartridge into the flared end 16a of the port 16, the finger 50 that was engaged by the arm 51 moves beyond the arm, so that the latter no longer restrains the breech member from rotation. However, such rotation is prevented at this time by engagement of the end 19a of the registered cartridge with the flared end 16a of the port. As soon as the finger 50 moves out of engagement with the arm 51, the latter is snapped to the left by a spring link 55 into the dotted line position shown in Fig. 5, in which position it is clear of the previously engaged finger 50 as the breech member is moved to the left (with reference to Fig. 3) following firing of the registered cartridge 19. The breech member is therefore free to be rotated by the clock spring 44 until the next finger 50 engages the arm 51, moves the latter against the stop pin 53, and is itself stopped to bring the next cartridge into registration with the port 16.

The cartridges 19 are electrically fired, thus each cartridge comprises a tubular casing 61 open at the right end, and closed at the left end by an electrical priming cap 62 which may be of known form. Thus it may have a fine resistance wire therein in contact with a solid explosive 63 in the cartridge, which wire is raised to a high temperature by the passage of an electric current therethrough. Connection for the flow of the electric current may be through a spring connector 64 which is so positioned as to successively engage the outer ends of the priming caps 62 as successive cartridges 19 are moved into firing position.

The electrical circuit of the apparatus is shown in Figs. 7 and 8. It includes, in addition to the pressure switch 27, electrically actuated valve 28, a relay 29, a battery 66, a condenser 67 shunted across the winding of relay 29, a resistor 73, and a switch 68 which is normally open, but is closed in response to movement of the rotary breech member 18 to the right into firing position.

The operation of the system may be traced as follows: So long as the pressure within the accumulator chamber 21 is above a predetermined minimum value of, say 1550 p. s. i., the pressure switch 27 is maintained in open position, under which condition the relay 29 is de-energized and connects the battery 66 over its back contact to the solenoid 28, so that the latter is normally energized, under which condition it closes the valve poppet 41 against its seat, as shown in Fig. 7, to block application of the pressure in the chamber 21 to the breech cylinder 30. Hence,

5

the fluid pressure supplied by the low pressure reservoir 70, which is constantly applied to the left end of the cylinder 30 maintains the breech in non-firing position, as shown in Fig. 7.

The pressure switch 27 is constantly responsive to the pressure in the accumulator chamber 21, and when it drops below the predetermined desired value of 1550 p. s. i., the switch 27 closes, thereby completing a circuit from the battery 66 to the winding of the relay 29, energizing the latter to open the energizing circuit for the electrically actuated valve 28 and complete a circuit from the battery 66, through the resistor 73, to the switch 68, which is still open.

Immediately upon deenergization of the electrically operated valve 28, the valve poppet 41 opens, permitting pressure fluid to flow from the chamber 21 into the right end of the breech cylinder 30, moving the breech to the right to seal the cartridge that is in registration with the port 16 with the port, and final movement of the breech member to the right closes the switch 68 to connect the battery through the spring 64 to the firing cap of the registered cartridge. The registered cartridge is thereupon fired, and gases of the explosion are driven into the chamber 12, as shown in Fig. 8, driving the piston 11 therein to the right and forcing fluid from the pumping chamber 13 past the check valve 20 into the accumulator chamber 21. Since the pressure increase created by the explosion is very rapid, the pressure switch 27 is promptly opened to again energize the electrically operated valve 28 and close the poppet 41 on its seat. This cuts the pressure fluid off of the breech cylinder 30 and connects the latter to an exhaust passage 72 so that the low pressure of 75 p. s. i. in the left end of the breech cylinder 30 can restore the breech into its normal leftmost position. As the breech moves outward it is indexed to bring the next adjacent cartridge into firing position, as previously described with reference to Fig. 5. The movement of the fired cartridge away from the port 16 permits the escape of any residual pressure in the explosion gas chamber 12, whereupon the fluid from the reservoir 70 at 75 p. s. i. flows past the check valve 14 into the pumping chamber 13 to move the piston 11 back into its normal leftmost position. This movement of the piston may be aided by a spring 75. In some instances the pressure supplied to the check valve 14 may be insufficient to move the piston 11, in which case the spring 75 may be made stiff enough to perform this function alone. In other instances the pressure of the source 70 may be always sufficient to move the piston 11, and the spring 75 can be dispensed with.

The operations described complete a cycle of operation which will be successively repeated in response to usage of fluid from the accumulator chamber 21, until all of the cartridges in the breech member have been fired.

Although the powder charge in the cartridges burns quite rapidly and little time is required for the pistons 11 and 23 to complete their rightward movement in response to the high pressure developed by the explosion, in some instances the pressure applied to the pressure valve 27 may cause the latter to open before movement of the piston 11 has been completed. To prevent such a condition, the condenser 67 may be shunted across the relay 29. The action of the condenser 67 is to permit flow of current to continue in the winding of relay 29, due to its inductance, for a short interval following the

6

opening of the pressure switch 27, thereby holding the electrically operated valve open a slightly longer time, and maintaining the fired cartridge in sealing relation with the port 16 for a slightly longer period. This result may be achieved in other ways than by employing the condenser 67. For example, relays are available that are inherently slow in releasing.

The resistor 73 is provided to prevent excessive flow of current from the battery 66 in case a short circuit should occur in the firing cap of the cartridge as a result of the firing.

Although for the purpose of explaining the invention, a particular embodiment thereof has been shown and described, obvious modifications will occur to a person skilled in the art, and we do not desire to be limited to the exact details shown and described.

We claim:

1. Apparatus of the type described comprising: a container having end walls and a fixed partition wall dividing said container into two cylinders, a freely movable barrier in each cylinder dividing them into inner and outer chambers, the outer chamber of one cylinder constituting an explosion chamber and the inner chamber constituting a pumping chamber, and the other cylinder constituting a hydraulic accumulator in which the inner chamber is a fluid chamber and the outer chamber is a pressure gas chamber; valve means for introducing gas into said pressure gas chamber; an outlet check valve connecting said pumping chamber to said fluid chamber for passing working fluid from said pumping chamber to said fluid chamber; a source of working fluid at a predetermined pressure; inlet check valve means connecting said source to said pumping chamber for supplying working fluid to said pumping chamber in response to a predetermined decrease in pressure therein below said predetermined pressure; a cartridge containing an explosive; said container having a gas-entry and exhaust port communicating with said explosion chamber; means for placing said cartridge into covering, sealing relation with said explosion chamber port; means for firing said cartridge to deliver explosion gas through said port into said explosion chamber at a pressure substantially higher than said predetermined pressure; and means for moving said cartridge out of sealing relation with said port for venting said explosion chamber.

2. Apparatus of the type described comprising: a container having a freely movable wall therein defining a variable volume working fluid pumping chamber and a variable volume explosion gas chamber respectively, said gas chamber having an opening; a source of working fluid at a predetermined pressure; and inlet check valve means connecting said source to said pumping chamber for supplying working fluid to said pumping chamber in response to a decrease in pressure therein below said predetermined pressure; means for receiving working fluid, and outlet check valve means for delivering working fluid thereto from said pumping chamber; a plurality of cartridges containing explosive and adapted to be electrically fired; means for successively moving said cartridges into connecting relation with said opening comprising hydraulically actuated loading means responsive to firing of each cartridge for removing the fired cartridge from connecting relation with said opening and subsequently, after a time interval, placing a new cartridge in connecting relation therewith, said opening be-

7

ing unobstructed whereby it vents pressure gas from said explosion gas chamber during said time interval between said removal of a fired cartridge and said placing of a new cartridge; an electrically controlled valve for applying working fluid from said working fluid receiving means to said loading means to actuate it; an energizing circuit for said valve; a pressure switch responsive to the pressure in said working fluid receiving means for controlling said energizing circuit; means responsive to the operation of said switch by decreasing pressure for opening said electrically controlled valve to hydraulically actuate said loading device and responsive to operation of said switch by increasing pressure for closing said electrically controlled valve; and a firing switch responsive to said hydraulic actuation of said loading means for completing a firing circuit to the loaded cartridge.

3. Apparatus according to claim 2 in which said energizing circuit comprises a relay having a winding connected in series with said pressure switch and a current source, said relay having contact means connecting said source to said electrically controlled valve for opening said valve when the relay is energized, and means for delaying release of said relay following opening of said pressure switch.

4. Apparatus of the type described comprising: a container having a freely movable wall therein defining a pair of inversely variable chambers, one a fluid pumping chamber and the other an explosion gas chamber; inlet valve means and a fluid source connected thereto for supplying fluid to said pumping chamber in response to expansion thereof; outlet valve means for discharging pressure fluid from said pumping chamber in response to contraction thereof; a rotatable and reciprocable breech member having a plurality of explosive cartridges mounted in an annular row, said container having a gas-entry and exhaust port communicating with said explosion chamber and juxtaposed to said row in registration with one cartridge therein; means yieldably urging said breech member in one direction into a normal position in which said cartridges are in spaced relation to and uncovering said port for exhaust of gas from said gas chamber; shifting means energizable to shift said breech member in the other direction to move the cartridge in registration with said port into covering sealing relation therewith; means for energizing said shifting means to shift said breech member in said other direction; means responsive to movement of said breech member in said other direc-

8

tion for firing the cartridge in registration with said port to deliver explosion gas to said explosion chamber at a first pressure and apply the pressure thereof to said movable wall to move it in one direction expanding said explosion chamber and contracting said fluid chamber and thereby discharge fluid under pressure from said fluid chamber through said valve outlet means; means responsive to a predetermined pressure rise in said pumping chamber to a pressure less than said first pressure for deenergizing said shifting means to permit return of said breech member to normal position; indexing means responsive to said return movement of said breech member for rotating said breech into position to bring the next adjacent cartridge into registration with said port; means including said inlet valve and fluid source for applying to the pumping chamber side of said movable wall a restoring force in direction to expand said pumping chamber and urge fluid therein from said source, said restoring force being of magnitude less than the opposing force on said wall of said first pressure in said gas chamber; whereby dissipation of explosion gas through said port in response to said return of said breech member to normal position enables said restoring force to move said wall to contract said gas chamber and expand said pumping chamber and transfer fluid therein from said source.

5. Apparatus according to claim 4 in which said shifting means comprises hydraulic motor means responsive to said pressure fluid to shift said breech member in said other direction, and said means for energizing and deenergizing said shifting means comprises a control valve connecting said motor to the discharge side of said outlet valve.

6. Apparatus according to claim 5 in which said control valve is electrically actuated, a source of electric current, and means including a pressure switch responsive to pressure in said fluid pumping chamber container for actuating said control valve.

CLINTON E. DEARDORFF.
JOSEPH B. GUNN.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
79,938	Babbitt	July 14, 1868
1,129,362	Ryder	Feb. 23, 1915
1,280,519	Miller	Oct. 1, 1918
1,838,228	Kershaw	Dec. 29, 1931