Nov. 26, 1963 H. C. FOSTER 3,111,898

BLASTING CARTRIDGES

Filed July 28, 1961 4 Sheets-Sheet 1

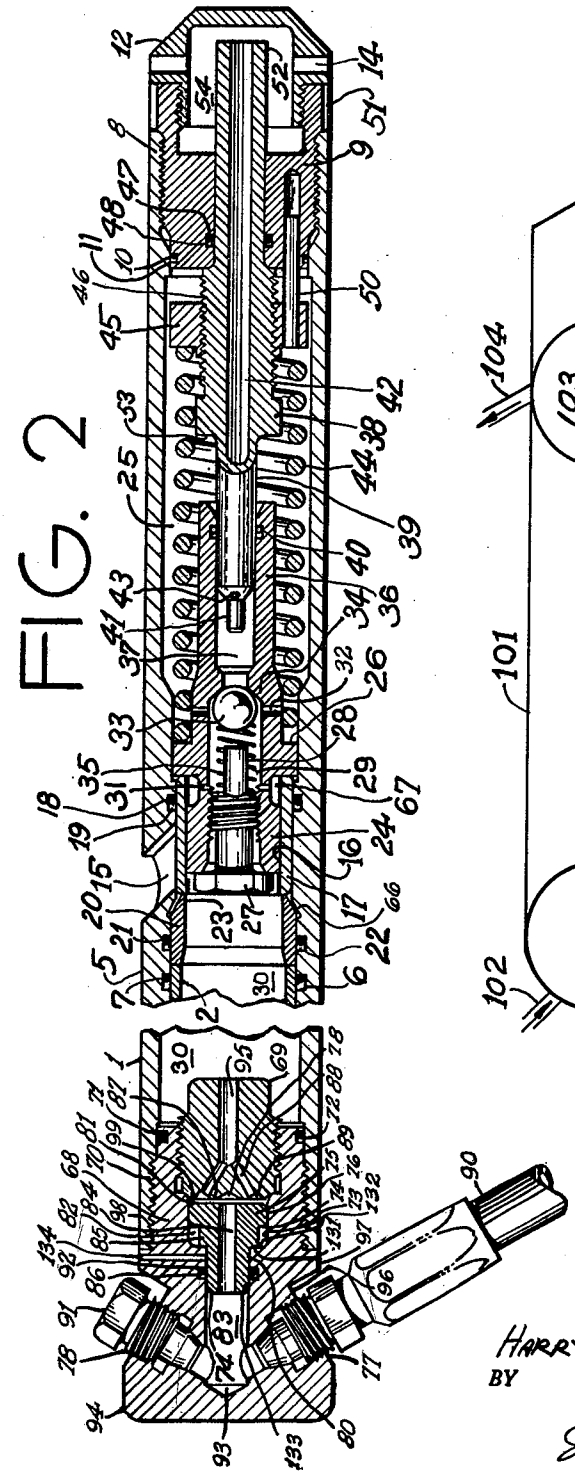


FIG. 2

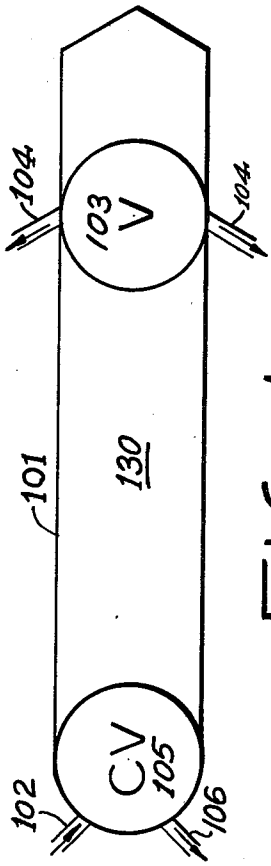


FIG. 1

INVENTOR:
HARRY CLARK FOSTER
BY

John D. Williams
ATTORNEY

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FIG. 4

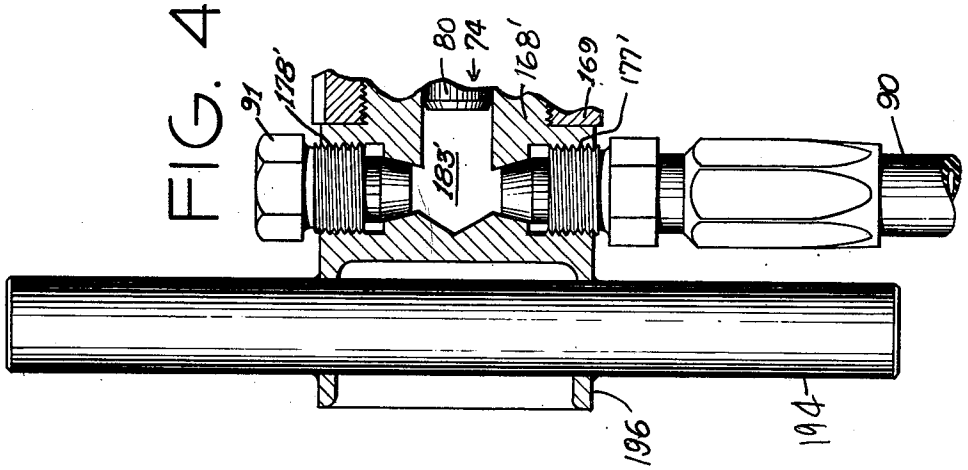
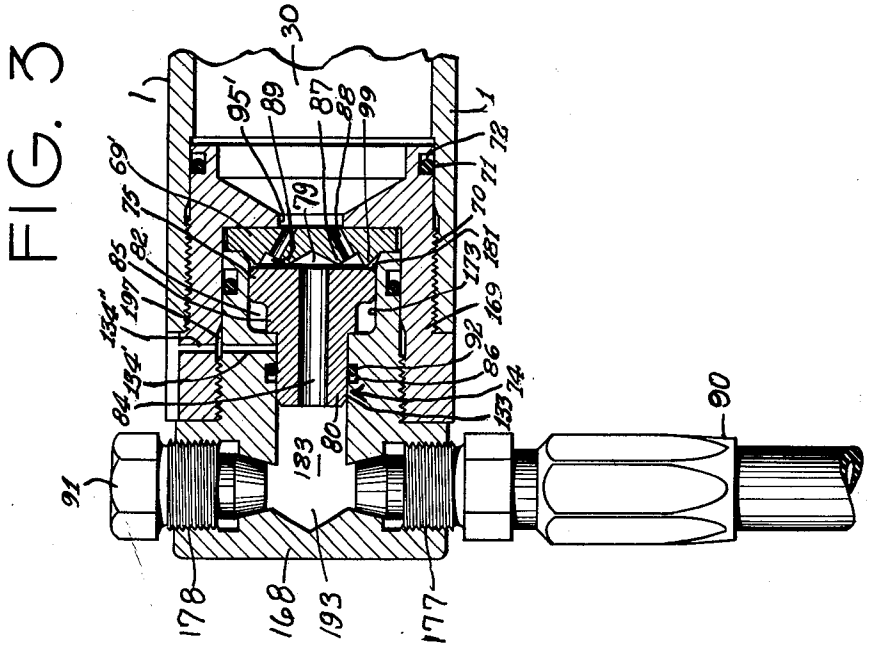


FIG. 3



INVENTOR:
HARRY CLARK FOSTER
BY

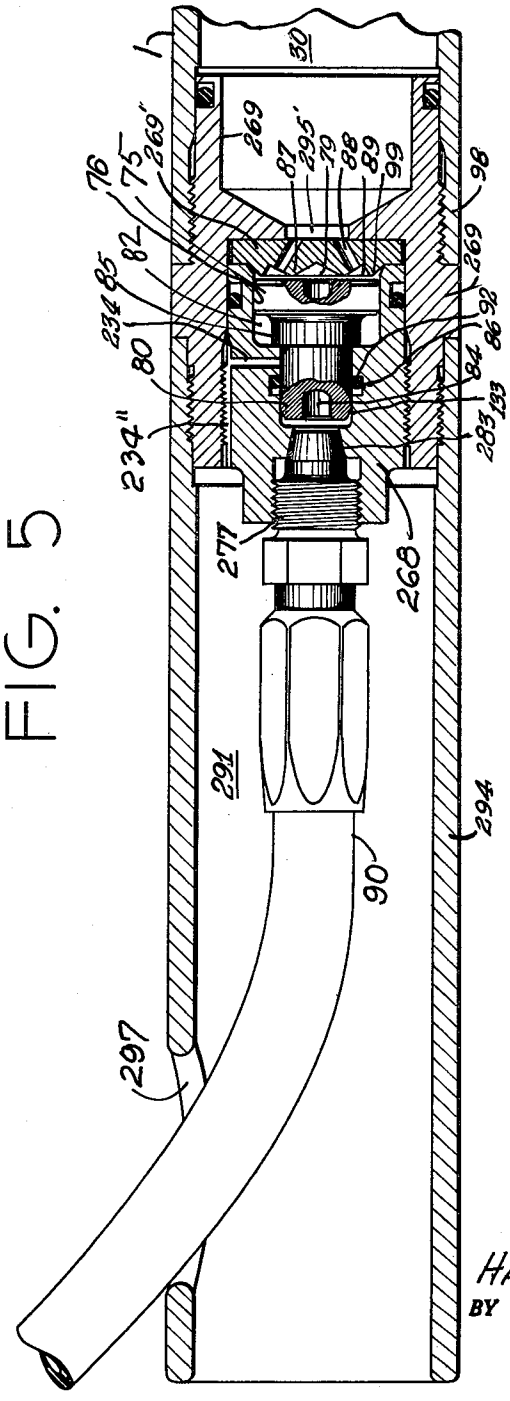
ATTORNEY

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BLASTING CARTRIDGES

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FIG. 5



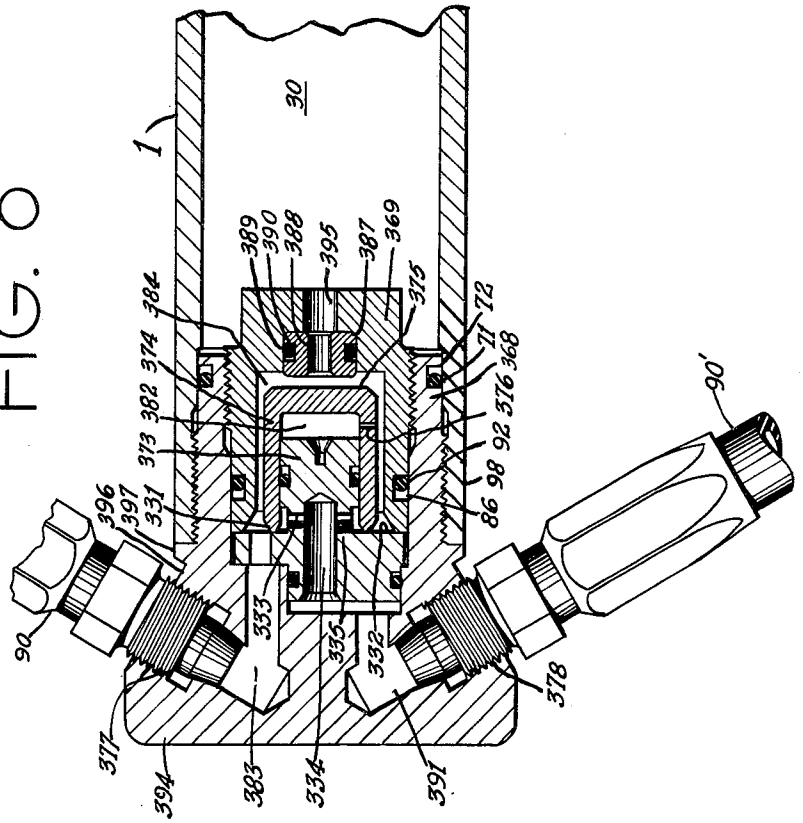
INVENTOR:
HARRY CLARK FOSTER
BY
John D. Wilkins
ATTORNEY.

Nov. 26, 1963 H. C. FOSTER 3,111,898

BLASTING CARTRIDGES

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FIG. 6



INVENTOR:
HARRY CLARK FOSTER
BY
John D. Wilkins
ATTORNEY

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3,111,898

BLASTING CARTRIDGES

Harry Clark Foster, East Alton, Ill., assignor, by mesne assignments, to Commercial Solvents Corporation, a corporation of Maryland

Filed July 28, 1961, Ser. No. 127,680
4 Claims. (Cl. 102—25)

This invention relates to blasting cartridges and particularly to automatic compressed gas cartridges and systems utilizing them for the purpose of blasting coal and the like.

A wide variety of compressed gas blasting cartridges, preferably of the automatic valve type, have been employed particularly in the mining industry to replace explosive charges. Generally each such cartridge is connected by a high pressure line to a remote gas compressor or other source of compressed gas and the cartridges are fired individually when a predetermined gas discharge pressure is attained within the cartridge. Also, cartridge-conduit systems have been proposed for connecting a number of such compressed gas blasting cartridges to one source of supply and discharging the cartridges consecutively. Systems of this type are exemplified by the subject matter of the co-pending application, Serial No. 4,348, of Ralph Vincent Wakefield and Harry Clark Foster filed July 22, 1960.

Such systems, although they represent a definite advance over the conventional manner of gas shooting, present a number of inherent problems. In the prior art systems, which provide some economy in the aggregate length of supply line required, all the cartridges must be operatively connected in a relatively complex manner; this necessarily requires the utilization of a separate safety or control valve close to the cartridge somewhere in the line leading to each of the cartridges. Since the safety or check valves as well as their corresponding separate cartridges, are exposed to severe shock, they and their connections must be particularly ruggedly constructed to withstand the abusive treatment which is inherent to their usage. To further minimize breaking, a short length of flexible line has also been tried between each valve and cartridge. All of these schemes make the construction expensive; nevertheless all too-frequent breakage and sometimes malfunctioning occurs. Also, the valves heretofore used with these assemblies were relatively slow and quite unreliable in their functioning.

It is therefore an object of this invention to provide novel and improved automatic compressed gas blasting cartridges. Another object is to provide a new combination of elements in compressed gas blasting systems. A more specific object is to provide a safe, novel, economical valve and cartridge arrangement particularly well adapted for series shooting.

The manner in which these and other objects are accomplished will be apparent from the following specification and the drawing in which:

FIGURE 1 is a schematic representation of a cartridge embodying the features of the present invention;

FIGURE 2 is a longitudinal sectional view of a cartridge illustrating a specific embodiment of the present invention, with a large part of the body broken away;

FIGURE 3 is a fragmentary view taken in longitudinal section at one end of the cartridge illustrating another aspect of the invention;

FIGURE 4 is another fragmentary longitudinal sectional view of the valve in another embodiment of the invention;

FIGURE 5 is a fragmentary longitudinal sectional view of an additional modification; and

FIGURE 6 is a fragmentary longitudinal sectional view

of a valve assembly illustrating another feature of the invention.

Referring to FIGURE 1 of the drawing, an elongated tubular body **101** formed of metal or equivalent material of a strength to contain gas under high pressure, for example, at from about 6,000 to 20,000 p.s.i., is provided generally with suitable means **102** at one end for introducing compressed gas into the tubular body, the outer diameter of which is such that it can be freely set within a bore drilled in the face of the material such as coal to be mined. Adjacent the other end this body is provided with a pressure responsive valve structure **103** which is normally closed by laterally directed outlet ports **104**. Compressed gas entering the tubular body passes through check valve **105** which is made an integral part of the cartridge and mounted protectively within one end of the body **101** in proximity with main chamber **130**. Valve **105** has a bypass **106** for the gas supplied for filling and discharging the cartridges sequentially when in series connection; for filling them simultaneously and then discharging each sequentially, bypass **106** is plugged shut.

In operation, compressed gas is delivered into tubular body **101** through a line at inlet **102** and through check valve **105** from a compressor or other suitable source not shown. Gas delivery continues until the discharge pressure predetermined by structure **103** is built up within the body. At that time, the gas causes pressure responsive valve **103** to open lateral exhaust ports **104**; whereupon the gas within the cartridge chamber is liberated substantially instantaneously and its sudden release results in the breaking or working of the material adjacent to it. Responsive to this substantial reduction of pressure within the tubular body, check valve **105** closes, preventing the introduction of any additional compressed gas to the tubular body, and simultaneously also functions to shunt the supply of gas from inlet **102** to bypass **106**. When cartridges of this type are employed in series firing operations, bypass **106** serves to provide compressed gas from the next cartridge in the series, but, if the cartridge is to be used in a one-shot operation, bypass **106** may be replaced by a sealing plug. This has the advantage of allowing adjustment of the discharge setting of valve **103** of each cartridge independently so that the discharges may occur more rapidly, where desired for better coal breaking for example, than where each cartridge must be both filled and discharged before a succeeding one.

During operation and before and after operation, the cartridge is normally subjected to substantial physical abuse without impairment of its operation.

After the charge of compressed gas in tubular body **101** has been liberated as a work-performing medium, valve **103** is returned to its original position closing discharge ports **104**. These ports are closed quite rapidly after discharge and before the pressure within the tubular body is returned to atmospheric. Thus, some residual pressure normally in the neighborhood of about 500 to 2,000 p.s.i. remains after discharge. This residual pressure serves to initiate return of integral check valve **105** to its original open position when the supply line connected to inlet **102** is ultimately cut-off and the intervening portion vented. The cartridge is thus in condition for recharging without impairment of it and without either a dangerously repeated discharge or undue dissipation of gas from the source.

In FIGURE 2 of the drawing the elongated cylindrical body **1** forms the main chamber **30**. At one end of this body, there is an adapter **2** one end of which (not shown) may be screw threadedly attached to body **1** while the other end extends into and is similarly attached to a discharge head **5** provided with a suitable number of lateral exhaust ports **15** inclined as shown to develop a force resisting ejection of the cartridge upon discharge. These

ports are normally closed by a sleeve valve 17 adapted to axially abut the ridge or knife edge 23 formed on slidable and replaceable valve seat ring 20 retained in the head by its constriction 66. Complete sealing is effected by O-rings 7 and 21 and 18 seated in internal grooves 6, 22, and 19, respectively in the head. At this end of the cartridge, the head houses a discharge valve structure.

At the other end of body 1 there is screw threadedly attached a cut-off valve structure as an integral part of the cartridge.

As typically disclosed in application Serial No. 75,033, filed December 9, 1960, one suitable valve structure in the ported head has all of its actuating parts assembled therein as a readily replaceable unit, which also includes the valve control piston 24 slidably mounted within sleeve 17 with sufficient but restricted clearance space 16 between them to allow the gas to flow thereby into secondary chamber 25 to through recess 67 and through passages 31, valve and spring chamber 29 and passages 32. Piston 24 is provided with plug 27 having a reduced portion 28 extending into valve and spring chamber 29 wherein ball valve 33 is normally urged against seat 34 by spring 35, and wherein the ball valve is acted on by end pin 41 when piston 24 carrying the ball valve is urged away from the discharge ports toward the nose cap 12 in opposition to control spring 44 as the pressure increases in chambers 30 and 25.

That portion of the control piston 24 remote from valve 17 is tubular section 36 having a bore 37 for telescopically seating the reduced extension 39 of a control adjusting stem 38 seated on and passing through cylinder end plug 9. The stem in turn has a bore 42 forming a passage throughout its length and has end orifices 43 adjacent the central end pin 41 in communication with bore 37 and bore 42.

Control piston 24, having a differential cross sectional area because the effective area in main chamber 30 is greater than that in secondary chamber 25, is gradually forced toward the end pin 41 with increase in pressure in the chambers; the pressure in main chamber 30 moves piston 24 from the position shown in FIGURE 2 although both ends of the piston as well as both ends of sleeve valve 17 are subjected to substantially the same pressure.

Since the effective cross sectional area of valve 17 facing nose cap 12 is greater than that of the end contacting seat 20, the valve is normally urged shut and as the pressure increases, the sealing force on valve 17 also increases.

Stem 38 is completely sealed with respect to section 36 of control piston 24 by resilient O-ring 40, but orifices 43 make it possible for compressed air or other suitable gas introduced from main chamber 30 into passageway 37 by way of space 16, annular recess 67, holes 31 and 32, and chamber 25, when ball valve 33 is open, to pass into passage 42.

This occurs when the adjustable force of control spring 44, abutting both flange 26 of piston 24 and also spring seat 45, is overcome gradually thereby forcing the piston 24 to the right. Spring seat 45 is screw threadedly attached at 46 to stem 38 for adjustment of the force and therefore the pressure at which the cartridge blows. The other terminal portion 52 of stem 38 passes through plug 9 and ends inside cap 12 in some polygonal or socket wrench shape to facilitate turning stem 38 for adjustment. Spring seat 45 is held against rotation by control seat pin 50 extending from the seat into a well or bore in plug 9. This allows the seat 45 to be adjusted axially to vary the tension of spring 44 as stem 38 is turned.

The seal between cap 9 and stem portion 52 is completed by another resilient O-ring 47 in groove 48.

The plug 9 is screw threadedly attached to head 5 at its internally threaded end 8 and the joint is sealed by resilient ring 10 in groove 11 at one end of the plug which at its other end is closed as by cap 12 at which the stem is vented by the vents 14. This plug and its cap are removable as by a spanner wrench accommodated in indentations or serrations 51.

In operation, gas admitted into main chamber 30 there exerts a moving force on piston 24 tending to unseal secondary chamber 25 in opposition to the force exerted by the gas in chamber 25; this piston motion continues until ball 33 touches end pin 41 whereupon further motion must overcome the force not only of spring 44 but also gas pressure which is seating the ball. At this position portion 36 of piston 24 is only slightly spaced from shoulder 53 of stem 38, and flange 26 of piston 24 has moved away from valve 17 which is held sealed only by gas pressure on its right end. Spring 35 acts to initially seat the ball 33 and exerts only a minor force holding the ball in seated position.

In this position of the parts, the predetermined discharge pressure is nearly attained; when attained, further movement of 24 unseats ball 33, 36 abuts shoulder 53 and secondary chamber 25 is vented through vents 32 in 24, through passage 37, vents 43, passage 42 in 38 and out to the atmosphere by way of 14.

Because of the annular restriction at 16, pressure in chamber 25 and also in valve and spring chamber 29 and in annular recess 67 by connection at 31 drops suddenly thereby reducing the pressure on the right side of sleeve valve 17 whereupon the higher pressure on the left side of it causes the valve to fly open swiftly and liberate the whole gas charge in main chamber 30 through discharge ports 15.

This valve action is automatic; after the high pressure charge is expelled, control spring 44 tends to reset the head parts to the position shown in FIGURE 2 in readiness for recharging.

At the inlet end 98 of cartridge body 1 of FIGURE 2, there is provided another chamber, a cut-off chamber 93 having an enlarged outlet end part 73 and a reduced inlet end 83 together with parts forming an integral cut-off valve at this chamber for stopping the flow of gas from feed line 90 immediately upon discharge of the cartridge. Various designs of this end of the cartridge are contemplated to provide a rugged construction capable of functioning despite forcible ejection of the cartridge, if such occurs.

The inlet structure shown in FIGURE 2 has inlet body 68 having a massive enlarged head 94 projecting axially beyond the body inlet end 98 and intervening undercuts 96 converging conically toward the cartridge end 98 which abuts abutment flange 97 adapted to be screwed down against the end 98, at which 68 is attached by its external thread 70 to end 98. Undercut 96 contains inlet opening 77 screw threaded for connection with gas feed line 90 and also contains by-pass opening 78 threaded for connection either with pipe plug 91 when a single blasting cartridge is to be connected to line 90 or for connection with a bypass line when a series of such cartridges are to be fired in sequence without connection to long individual feeders from a main trunk line. This directs the connected lines reversely away from the head 94 for protection of them because the head overhangs them and is adapted to take the brunt of any blow. Long, unprotected main branch lines are avoided with bypassing and secondary lines so that the total length of line needed and drop of pressure are reduced.

The seal between inlet body 68 and main body 1 is completed by resilient O-ring 71 in groove 72 of 68.

The structure also includes a perforated open-ended valve piston 74 in chamber 93 the outlet end of which is closed by gas feed and valve seat body 69 in the form of a female member screwed into body 68 and having gas delivery bore 95.

In the enlarged cylinder part 73 of check valve chamber 93 there is slidably mounted enlarged end 75 of the piston having valve passage 84 for passing gas from the inlet port 83 of 93 to an outlet clearance space 81 of the chamber formed when the inlet valve is open initially and

normally as shown whereat piston enlargement 75 divides cylinder part 73 into outlet spaces 81 and obturating chamber 82. Reduced valve stem 80 is formed opposite end 75 and is slidably mounted in reduced chamber part 83 leaving thereat an annular restricted vent passage 133 one end of which is sealed by resilient O-ring 92 in groove 86 while the opposite end communicates with obturating chamber 82 for bleeding gas from the latter off into 133, but only when piston 74 is moved to the right in closed position thereby eliminating space 81 and taking face 131 out of abutment with shoulder 132 between chamber ends 73 and 83. Gas thus admitted into passage 133 in turn leaks off into radial vent or vents 134 until chamber 82 is cut off as 131 and 132 abut when the valve piston 74 is moved to the left.

Chamber 82 is formed annularly between piston 74 and body 68 for effecting automated obturation and occurs in enlarged end 73 between shoulder 132 and enlarged piston end 75 which in turn is slidably mounted in enlarged cylinder part 73 of the chamber inside body 68. The mounting is with small clearance forming a restricted passage 76 between 68 and 75 allowing very slow gas communication between obturating chamber 82 and outlet space 81 adjacent the rim like valve seat 87 surrounding the depression 79 in the end of body 69 and surrounded in turn by annular groove 89 about ridge 87. Orifices 88 extend from this outer groove to delivery bore 95. Chamber 82 always includes the toroidal volume formed by the differences in diameter between piston enlargement 75 and median piston part 85.

When piston 74 is in closed position annular ridge 87 of the feed and seat body 69 forms a seat for the piston to cut off piston bore 84 from annular groove 89 adapted for collecting gas for passage through restricted orifices 88 angling in from groove 89 to central bore 95.

The annular ridge 87 may be in piston 74 opposite the same end of the feed and seat body 69 having the central depression 79.

The effective cross wise areas of the small end of stem 80, of the enlarged end at 75 opposite ridge 87 and of the groove 89 in the body 69 provides a differential area effecting a normally open condition of the valve, a rapid obturation cutting off the gas flow to the cartridge when the gas pressure falls suddenly in main chamber 30, and finally a valve reset to open position after a suitable time delay determined by the differential areas and the bleeding action at the restricted clearance at 133.

In operation gas passes successively through 83, 84, 81, 89, 88 and 95 of the open cut-off valve. Because of the area difference, gas at 81 exerts a force to the left exceeding that exerted to the right in 83 on the end of stem 80 of piston 74. Restriction at orifices 88 is enough to prevent the valve from acting as a surge closure device until the cartridge reaches the desired predetermined pressure of the discharge valve and is suddenly discharged through ports 15. Thereupon the higher pressure on the stem 80 in 83 and in chamber 82 exerts a closing force. Before discharge, gas bleeding through 76 and trapped at 131 and 132 charges chamber 82 to substantially the same pressure as that in the rest of the valve. When piston 74 moves to the right, closing the valve, the seal between 131 and 132 is broken permitting residual pressure in chamber 82 to be vented to atmosphere through clearance 133 and vent 134. Residual pressure, from chamber 30, in groove 89 between inner ridge 87 and outer ridge 99 and acting therein to the left upon enlarged piston end 75, reopens the valve as the pressure in chamber 83 is bled off to a sufficiently low value.

In FIGURE 3, inlet body 168 has both inlet opening 177 and by-pass opening 178 straight out to the side for line 90 and plug 91 respectively. Separate valve seat 69' has the central depression 79, ridge rims 87 and 99 for valve seating and has annular groove 89 and orifices 88 for feeding into delivery opening 95' of the intermediate body 169 which with 168 forms the enclosure having the

cut-off valve chamber 193 with reduced end 183 and large end 173 which carry the same type of piston 74 as in the previous embodiment sealed in 168 by O-ring 92 in groove 86. Body 169 is fastened at thread 70 to body 1 and sealed therewith by O-ring 71 carried in groove 72.

The obturating chamber vent consists of three parts, namely radial passage 134' of inlet body 168, radial outlet extension 134", and intermediate annular connector 197. The action is much the same as in the previous embodiment having the same obturating chamber 82, but the added sealing O-ring between 169 and the body 1 is new. The gas fed goes through 177 to 183, 84, space 181, groove 89, orifices 88 and then to delivery port 95' when the cartridge needs to be charged.

FIGURE 4 illustrates how the cut-off valve end of FIGURE 3 is modified by addition of an attached heavy protective cross bar 194 held in extension 196 of modified body 168' to guard and prevent breakage of the line connections at 177' and 178' to the integrated cut-off valve and cartridge cylinder of this invention. Otherwise the parts and functions are quite similar to what is shown in FIGURE 3 where gas from line 90 enters small end 183' by inlet 177' and from thence passes through the bore of stem 80 of valve 74.

In FIGURE 5 cut-off valve inlet body 268 is modified to have axial end inlet 277 into the reduced part 283 of the chamber and radial vent 234 is in series connection with longitudinal vent outlet 234" discharging obturating chamber 82 at median piston part 85 into bore 291 of sleeve extension 294 threaded on the body 269 modified for the purpose as compared to body 169 of FIGURE 3. Sleeve 294 has a side opening 297 for receiving line 90 which is first connected at 277 after which sleeve 294 is screwed on body 269 which serves to lock separate valve seat 269' in the valve. Sleeve 294 protects line 90 at the connection.

FIGURE 6 shows still another form of drop-of-pressure gas feed cut-off valve arrangement the inlet body 368 of which is attached at end 98 of cartridge cylinder body 1 and sealed thereto by resilient ring 71 in groove 72. Body 368 is closed at one end by massive head 394 having reversed feed line 90 at inlet 377 and by-pass line 90' attached at 378 at the tapers 396 converging toward flange 397 at which 368 abuts body 1 sealed by ring 71 in groove 72. Body 368 is closed and lined by body 369 threaded therein and having a large bore containing a differential pressure cup valve 374 normally and initially open with respect to valve seat 387, a self-aligning ring floating in 369 on resilient ring 389 in groove 390. Seat 387 has central delivery orifice 388 for passing the gas from the passage space 384 between 374 coaxially spaced from 369 into delivery opening 395 in 369 for admission axially to chamber 30. Cup valve 374 is mounted slidably on hub 373 to form reset chamber 382 having a smaller inner effective area than outer end area 375 of valve 374 in passage 384 connected to chamber 382 by a restricted bleeder port 376.

The edge 331 at the end of valve 374 opposite area 375 seats on by-pass seat 332 having radial vents 333 connecting through axial vent outlet 334 and transverse passage 335 to bypass passage 391 in head 394 of body 368. In operation, gas flows from inlet bore 383 into chamber 384 from inlet line 90 at connection 377 whereby increase of pressure first moves valve 374 to the left to seat edge 331 on seat 332 to cut-off the bypass but allowing gas pressure to build up equally in chamber 30 for discharge at the predetermined pressure and also in chamber 382.

When gas is so released in 30, pressure in 384 falls below that maintained higher in 382 by restricted port 376 and by sealing O-ring in hub 373; end 375 of valve 374 slams shut on seat 387 cutting off the feed to the blasting cartridge shown and simultaneously breaking the seal between edge 331 and seat 332 for exposing vents

333 and by-passing the feed to line 90' to actuate the next cartridge in sequence.

In this stage, compressed gas entering bore 383 flows through vents 333, outlet 334 and transverse passage 335 out at passage 391.

Modifications may be made in any of these embodiments by those skilled in the art without departing from the spirit and scope of the invention as set forth in the appended claims. For example in FIGURE 6, hub 373 may carry an axial stem extension and face 375 may be orificed to pass this extension to extend toward 388 with venturi effect and a clearance passing gas slowly into 382 and out of it at this orifice. During initial charging the venturi reduces pressure in 382 but then later pressure builds up in 382 around the extension so that pressure is built up therein at a delayed time. Another change places in 384 a large ball and compression spring urging the ball to the left, away from seat 387, all in substitution for the sleeve valve 374 and the extended part of the hub 373; this keeps the bypass closed normally except temporarily upon discharge when the surge throws the ball to the right against the other seat, 387.

What is claimed is:

1. A blasting assembly comprising an automatic valve operated cartridge having an elongated substantially cylindrical case forming a chamber adapted to contain a blasting charge of compressed gas, and provided with a lateral outlet discharge port intermediate the ends of said case together with a discharge valve normally closing said outlet discharge port and responsive to attainment of a predetermined pressure in said chamber for operating said port for discharging, spring means in said cartridge operative to automatically return said discharge valve to said normally closed position thereby retaining a residual pressure in said cartridge, manually operated means for preselecting said pressure of discharge, a gas inlet and means for securely mounting said inlet within one end of said case for connection to a line containing gas under pressure for introducing said gas into said casing, and a check valve mounted within said casing between said chamber and said inlet and having a pressure-responsive cutoff element and having a single outlet to said chamber controlled by said element for automatically closing said outlet upon said discharge and maintaining said outlet closed so long as gas pressure remains in said line and for resetting said check valve by said residual pressure in said cartridge when the pressure in said line is reduced relative to said residual pressure, said one casing end including an extension protectively outwardly of said inlet, mounting means and check valve, said valves having opposed differential area surfaces and pressure differential creating means affecting said surface.

2. The assembly of claim 1 wherein the extension includes a reversely directed connection extending from an undercut in the extension.

3. The assembly of claim 1 wherein the case comprises a secondary chamber for retaining compressed gas from the charge containing chamber, wherein the discharge valve is normally held in sealing position by said compressed gas, and including a ball valve comprising an adjustable valve spring, a ball, a fixed ball-unseating abutment, a secondary chamber vent and a movable control piston forming differential areas between said chambers and carrying said ball normally seated by said gas in said piston for sealing said secondary chamber vent, said control piston being operable solely by said gas in said charge containing chamber against said spring and abutment to release gas pressure from said secondary chamber thereby unsealing the discharge port.

4. A blasting system comprising a series of automatic valve operated cartridges, means for charging said cartridges simultaneously with compressed gas, each of said cartridges having a substantially cylindrical elongated cartridge case adapted to contain a charge of compressed gas, inlet means mounted protectively at one end of said case for introducing gas into the case, a lateral discharge port proximate the other end of the case, discharge valve means normally closing the port until a predetermined discharge pressure is attained within the cartridge case, cut-off means within the cartridge case adjacent the inlet means for closing the inlet means upon the discharge of the compressed gas from the cartridge case, and manually operated means for preselecting said discharge pressures of successive cartridges to obtain the desired sequence of firing.

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