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MATERIAL BREAKING CARTRIDGE CONSTRUCTION

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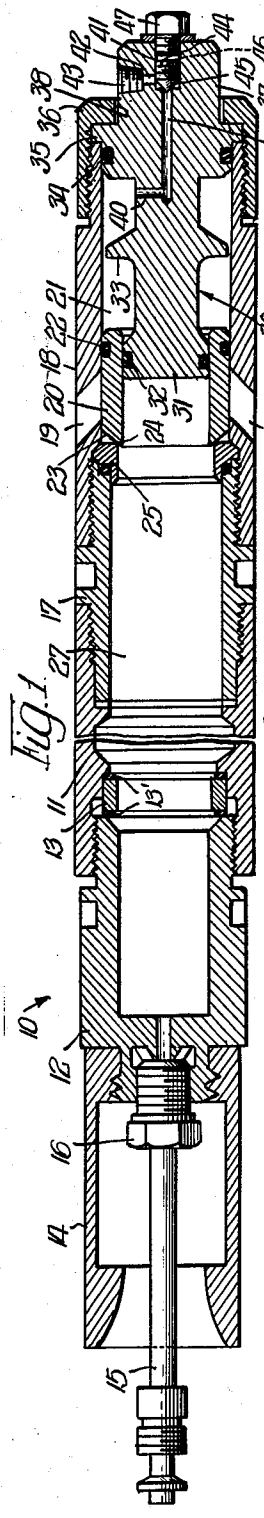


Fig. 1

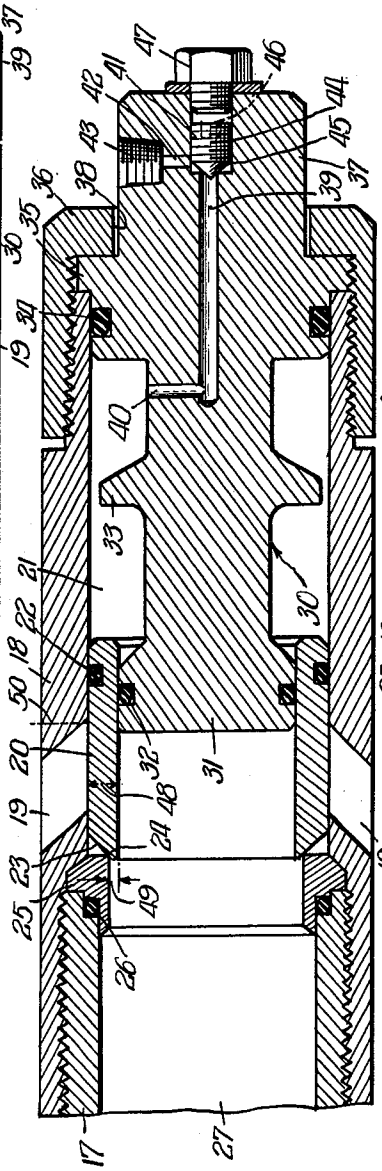


Fig. 2

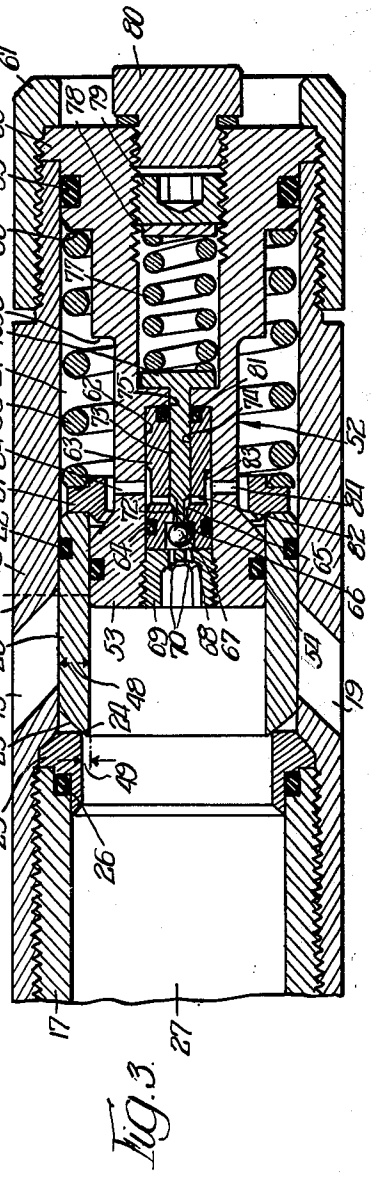


Fig. 3

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MATERIAL BREAKING CARTRIDGE CONSTRUCTION

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This invention relates, generally, to cartridges for breaking down solid material, such as coal, slag and the like, and it has particular relation to compressed gas devices for this purpose.

Among the objects of this invention are: To provide for releasing from a cartridge a charge of compressed gas, such as air, carbon dioxide or the like, at relatively high pressure of the order of 10,000 pounds per square inch and above in a new and improved manner; to employ a discharge valve for this purpose that is held closed entirely or in part by gas pressure in a control chamber into which the discharge valve moves from a material breaking compressed gas release chamber, the area of the discharge valve subject to the gas pressure in the control chamber being several times the area of the discharge valve subject to the pressure of the charge of compressed gas in the release chamber and the control chamber having a volume that is substantially greater than the amount that its volume is reduced by the movement of the discharge valve into it to the end that the pressure of the gas in the control chamber can be substantially lower than the pressure of the gas of the material breaking charge in the release chamber and is not substantially increased by such movement of the discharge valve; to limit the movement of the discharge valve into the control chamber; to provide in the control chamber a permanent filling of compressed gas that is usable without renewal for repeated operation of the discharge valve; to provide for charging the control chamber to the required pressure each time that the material breaking charge of compressed gas is developed in the release chamber of the cartridge; and to discharge the gas in the control chamber following the discharge of the material breaking charge from the release chamber.

In the drawings:

FIG. 1 is a longitudinal sectional view of a material breaking cartridge in which one embodiment of this invention is incorporated.

FIG. 2 is an enlarged vertical sectional view of the discharge end of the cartridge shown in FIG. 1.

FIG. 3 is a view, similar to FIG. 2, showing a modified construction.

Referring now particularly to FIG. 1 of the drawing, it will be observed that the reference character 10 designates, generally, a material breaking cartridge which includes a cartridge tube 11, preferably formed of high strength steel, and having a length depending upon the desired capacity of the material breaking cartridge 10. At the left end of the cartridge tube 11 there is a tube top 12 on the right end of which there is a tube top spacer 13 between it and the cartridge tube 11. Suitable gaskets 13' are interposed between the ends of the tube top spacer 13 and juxtaposed portions of the cartridge tube 11 and the tube top 12. At the left end of the tube top

12 there is a tube top nose 14. As shown, these parts, except for the tube top spacer 13, are threaded together. Extending through the tube top nose 14 and protected thereby is an air supply tube 15 which is connected by a fitting 16 to the left end of the tube top 12. It will be understood that the air supply tube 15 is connected to a suitable source of high pressure air which can be supplied by a suitable high pressure compressor.

At the end of the cartridge tube 11 there is provided an extension adapter 17. As shown, it is threaded into an interior thread at this end of the cartridge tube 11. A discharge head body 18 is threaded onto the extension adapter 17 and it is provided with lateral ports 19 through which the compressed gas is discharged for material breaking purposes. Slidably mounted within the discharge head body 18 is an annular discharge valve 20 that is movable in a manner described hereinafter from sealing relation with respect to the lateral ports 19 into a control chamber 21 that is formed within the discharge head body 18. An O ring seal 22 is provided in a suitable annular groove around the annular discharge valve 20 to provide a seal with the inner cylindrical surface of the discharge head body 18 which forms the outer side of the control chamber 21. At its left end the annular discharge valve 20 has an annular outwardly inclined contact surface 23 that is arranged to have sealing engagement with an annular seat portion 24 of limited area that is provided by a replaceable valve seat 25 which is held in position on the right end of the extension or adapter 17 when the discharge head body 18 is threaded into position. The replaceable valve seat 25 has an O ring seal 26 between it and the juxtaposed portion of the extension or adapter 17.

The interior of the cartridge tube 11, tube top 12 and extension or adapter 17 provides a release chamber that is indicated at 27. It will be understood that the release chamber 27 is formed in the body of the cartridge 10, in particular in the portions thereof just referred to, and that the control chamber 21 located within the confines of the discharge head body 18 also is located within the cartridge body with the lateral ports 19 being located in such position that, on movement of the annular discharge valve 20, to the open position or into the control chamber 21, the material breaking compressed gas charge in the release chamber 27 is permitted to be discharged through the lateral ports 19. When the release chamber 27 is filled with compressed air, the pressure used may be of the order of 10,000 pounds per square inch. It will be understood, however, that the pressure may be above or below this pressure as may be required. Alternatively, the pressure in the release chamber 27 can be generated in known manner using carbon dioxide which fills the release chamber 27 at a relatively low pressure of the order of 4,000 pounds per square inch, for example, and provision is made for rapidly increasing the temperature of the carbon dioxide filling to the end that its pressure increases to a value of the order of from 15,000 pounds per square inch to 30,000 pounds per square inch. Regardless of the manner in which the pressure is generated in the release chamber 27 to provide for knocking down coal or the like, the same annular discharge valve 20 arranged and controlled as herein described, can be employed for releasing the charge.

Referring now particularly to FIG. 2 of the drawing, it will be observed that the right end of the discharge

head body 18 has mounted therein a valve stop and closure member that is indicated, generally, at 30. It has a cylindrical inner end portion 31 over which the annular discharge valve 20 is telescoped with an O ring seal 32 therebetween. The movement of the annular discharge valve 20 into the control chamber 21 is limited by an annular stop shoulder 33. An O ring seal 34 is provided between the right end of the valve stop and closure member 30 and the juxtaposed end portion of the discharge head body 18 and an end flange 35 is provided on the former which is clamped to the latter by a threaded cap 36 through which an extension 37 projects in an opening 38. For a purpose that will be apparent presently provision is made for filling the control chamber 21 with a charge of compressed gas. For this purpose a longitudinal passageway 39 is provided in the right end of the valve stop and closure member 30 and it communicates at its inner end with a transverse passageway 40 that opens into the control chamber 21. The outer end of the longitudinal passageway 39 has a counterbore 41 that is threaded and communicates through a transverse passageway 42 with the bottom of a threaded opening 43 in the extension 37 that is adapted to receive a charging hose connection. A screw 44 having a conical head 45 at one end is provided for closing the outer end of the longitudinal passageway 39 when the control chamber 21 has been filled to the desired pressure. A kerf 46 at the outer end of the screw 44 permits rotation thereof. A closure cap screw 47 is threaded into the outer end of the threaded counterbore 41 as a protection for the screw 44.

There is an important relationship between the areas of the ends of the annular discharge valve 20 that are exposed, respectively, to the pressure in the control chamber 21 and the pressure in the release chamber 27. The area of the end of the annular discharge valve 20 that is exposed to the pressure of the filling of compressed gas in the control chamber 21 in a closing direction is the area of the annulus whose radial thickness is indicated at 48 and is the radial thickness of the annular discharge valve 20. Since the annular outwardly inclined contact surface 23 at the other end of the annular discharge valve 20 engages the annular seat portion 24 on the replaceable valve seat 25, only the inner portion of the end surface of the annular discharge valve 20 is subject to the pressure of the gas charge in the release chamber 27 in an opening direction. This area is the area of the annulus whose radial dimension is indicated at 49 and preferably it is substantially less than the radial dimension 48 or the area of the right end of the annular discharge valve 20 that is exposed to the pressure in the control chamber 21. For example the area of the discharge valve 20 acted on by the pressure in the release chamber in an opening direction may be one-fifth the area of the discharge valve 20 acted on by the pressure in the control chamber 21 in a closing direction. Using this relationship of areas, when the control chamber 21 is filled to a pressure of the order of 2,000 pounds per square inch, the annular discharge valve 20 is held in the closed and sealing position with respect to the lateral ports 19 and against the annular seat portion 24 until the pressure in the release chamber 27 reaches a value of the order of 10,000 pounds per square inch. When this pressure is reached and exceeded slightly, the annular discharge valve 20 begins to move away from the sealed position and thereupon exposes the entire area of the left end of the annular discharge valve 20 to the relatively high pressure in the release chamber 27 with the result that the force acting on the annular discharge valve 20 to move it to the open position exceeds by many times the force acting on the annular discharge valve 20 due to the pressure of the filling of gas in the control chamber 21 tending to hold the annular discharge valve 20 in the closed position. The annular discharge valve 20 then moves at optimum speed to the open position until the right end engages the annular stop shoulder 33 and the left end occupies a position indicated by broken line 50.

While the movement of the annular discharge valve 20 into the control chamber 21 effects a corresponding reduction in its volume, it will be observed that the volume of the control chamber 21 is substantially greater than the amount that it is reduced as the result of the movement of the annular discharge valve 20 into it. Accordingly, the pressure increase in the control chamber 21 due to this reduction in volume is relatively slight.

Because a relatively low pressure is employed in the control chamber 21 and its volume is relatively great as compared to the reduction thereof resulting from the movement of the annular discharge valve 20 into it, the annular discharge valve 20 moves to the open position at relatively high speed which permits a correspondingly increased discharge of the compressed gas from the release chamber 27 through the lateral ports 19.

As soon as the force acting on the left end of the annular discharge valve 20 due to the charge of compressed gas in the release chamber 27 is reduced by discharge through the lateral ports 19 to a value where the force exerted by the charge of compressed gas in the control chamber 21 is sufficient to initiate movement of the annular discharge valve 20 to the closed and sealed position, this action occurs. In this embodiment of the invention the filing of gas in the control chamber 21 is substantially permanent and thus can be reused many times for controlling the opening of the annular discharge valve 20. Since it is not possible to make a perfect seal using the O ring seals 22, 32, and 34 and the screw 44, there may be some slight leakage over a long period of time. However, for practical purposes the filling of gas in the control chamber 21 can be considered to be permanent.

When it is desired to change the pressure at which the annular discharge valve 20 begins to move from the closed and sealed position to the open position, provision can be made for changing the volume of the control chamber 21 or for bleeding off some of the charge of compressed gas therein. Preferably the volume of the control chamber 21 is at least twice the amount that its volume is reduced by movement of the annular discharge valve 20 into it.

In the embodiment of the material breaking cartridge 10 shown in FIGS. 1 and 2 of the drawing it will be noted that there is only a single moving part, i.e., the annular discharge valve 20 together with its O ring seal 22. Thus the initial cost of the material breaking cartridge 10 is reduced to a minimum and the expense involved in maintaining it in operation is also a minimum. Since the only opening to the interior of the material breaking cartridge 10 from the atmosphere is through the lateral ports 19, and since they are opened only for a brief period on movement of the annular discharge valve 20 to the open position at which time the charge of compressed gas in the release chamber 27 is flowing outwardly, there is a minimum of likelihood of the entry of coal dust, dirt and corrosive fluids into the interior of the material breaking cartridge 10.

The control chamber 21 can be provided with its charge of compressed gas at any suitable time. For example, it can be charged at the plant of the manufacturer of the material breaking cartridge 10 and shipped to the place, such as a mine, where it is to be used with this gas pressure holding the annular discharge valve 20 in the closed position. The release chamber 27 can be filled with compressed air at the coal face in a conventional manner, if the charge of compressed gas is air. As pointed out hereinbefore, carbon dioxide also can be employed in a conventional manner to provide the charge of compressed gas in the release chamber 27.

There are some applications of the material breaking cartridge where it is desirable that the control chamber 21 be filled with its charge of compressed gas at the same

time that the release chamber 27 is filled with the material breaking charge of compressed gas. Also it is desirable to provide for adjusting the pressure to which the control chamber 21 is charged at the coal face, for example, in a simple manner. For these purposes the modified construction shown in FIG. 3 can be employed in lieu of the construction shown in FIG. 2 for mounting on the extension or adapter 17 of FIG. 1. Here it will be observed that the annular discharge valve 20 is essentially the same as previously described and is employed for closing off the lateral ports 19 and is arranged to have the annular outwardly inclined contact surface 23 in sealing engagement with the annular seat portion 24 of the limited area on the replaceable valve seat 25. However, in this embodiment of the invention there is provided a valve stop and closure member indicated generally at 52, which corresponds to the valve stop and closure member 30 previously described for the embodiment shown in FIGS. 1 and 2 of the drawing. The valve stop and closure member 52 has a cylindrical end 53 with which the annular discharge valve 20 cooperates in the manner previously described. An O ring seal 54 is provided between the inner side of the annular discharge valve 20 and the cylindrical inner end 53.

Normally the annular discharge valve 20 is biased toward the closed position shown in FIG. 3 by a coil compression spring 55 that is located in the control chamber 21. One end of the spring 55 reacts against a shoulder 56 on the valve stop and closure member 52 and its other end reacts against a contact ring 57 which, in turn, bears against the right end of the annular discharge valve 20. An annular stop shoulder 58 on the valve stop and closure member 52 limits the inward movement of the contact ring 57 and thereby the opening movement of the annular discharge valve 20. An O ring seal 59 is interposed between the right end of the valve stop and closure member 52 and the adjacent surface of the right end of the discharge head body 18 to provide a seal while a shoulder 60 is held in position on the right end of the discharge head body 18 by a threaded cap 61.

It will be noted that the cylindrical inner end 53 of the valve stop and closure member 52 has a central aperture 62 within which a valve body 63 is positioned. An O ring seal 64 is interposed between the left end of the valve body 63 and the juxtaposed surface of the central aperture 62. At its left end the valve body 63 is provided with an opening 65 that forms a valve seat 66 with which a ball valve 67 cooperates, the ball valve 67 being located in a counterbore 68 in the left end of the valve body 63. The valve body 63 is held in place in the central aperture 62 by a hollow retainer screw 69 that is provided with aperatures 70 at the bottom which communicate between the release chamber 27 and the counterbore 68 and thence to the opening 65.

The ball valve 67 normally is held in the open position shown in FIG. 3 by a tip 72 at one end of a valve stem 73 that is slidable in a central opening 74 in the valve body 63. The valve stem 73 is slidable in an opening 75 in the valve stop and closure member 52 and it has a head 76 that is engaged by a coil compression spring 77 at one end. The other end of the spring 77 bears against a washer 78 that is variably positionable by an adjusting screw 79 that is threaded into the right end of the valve stop and closure member 52. A closure cap screw 80 serves to protect the adjusting screw 79. An O ring seal 81 surrounds the valve stem 73 and provides a seal between it and the valve body 63.

It will be recalled that the opening 65 is in communication with the release chamber 27 through the counterbore 68 and apertures 70. They form a part of a passageway between the release chamber 27 and the control chamber 21 which can be interrupted by the ball valve 67. The passageway continues from the opening 65 through radial openings 82 and an annular recess 83 in the valve body 63 and thence through radial ports 84 in the valve stop and closure member 52 to the control chamber 21.

When the release chamber 27 does not contain a material breaking charge of compressed gas, the coil compression spring 55 acts to hold the annular discharge valve 20 in the closed position. Under these conditions the coil compression spring 77 biases the head 76 and valve stem 73 to the position shown in FIG. 3 where the tip 72 engages the ball valve 67 and holds it in the open position away from the valve seat 66. The passageway between the release chamber 27 and control chamber 21 then is open and they are at the same pressure which may be atmospheric pressure or a higher pressure but a relatively low one as compared to the pressure to be created in the control chamber 21 for operating purposes.

Now when the pressure of the material breaking charge in the release chamber is increased, the pressure within the control chamber 21 is correspondingly increased. This relationship is maintained until the pressure in the release chamber 27 as applied to the ball valve 67 is sufficient to overcome the biasing action of the coil compression spring 77 whereupon the ball valve 67 engages the valve seat 66. As a result, continued application of increased pressure to the release chamber 27 does not effect a corresponding increase in the pressure of the charge of gas in the control chamber 21. Under these conditions the annular discharge valve 20 is acted on not only by the coil compression spring 55 but also by the pressure of the charge of gas in the control chamber 21. This charge of gas acts on the right end of the annular discharge valve 20 and against an annular area the radial dimension of which is indicated at 48, the same as previously described. At the same time the pressure in the release chamber 27 is acting on the annular area at the left end of the annular discharge valve 20 whose radial dimension is indicated at 49. These areas are so chosen, as previously described, that the area of the annular discharge valve 20 at the right end against which the gas pressure in the control chamber 21 reacts is substantially greater, for example five times greater, than the area at the left end of the annular discharge valve 20 against which the pressure in the release chamber 27 reacts. It will be understood that this relationship can be varied so that a four to one ratio or a six to one ratio or like values are used depending upon the operation that is desired.

The pressure in the release chamber 27 continues to increase and to react against the left end of the annular discharge valve 20 exposed thereto, as described, while holding the ball valve 67 closed. When the pressure in the release chamber 27 reaches such a value that the force exerted on the annular discharge valve 20 in an opening direction exceeds the force exerted thereon by the spring 55 and the gas pressure in the control chamber 21 acting to close, the annular discharge valve 20 starts to open and immediately the entire area at its left end is exposed to the high pressure in the release chamber 27. As a result the annular discharge valve 20 moves with maximum speed to uncover the lateral ports 19 and permit the charge of compressed gas in the release chamber 27 to be discharged through the lateral ports 19. This action reduces the pressure applied to the ball valve 67 and when the reduction has been sufficient, the spring 77 acts to move it to the open position thereby reestablishing communication between the control chamber 21 and the release chamber 27. Accordingly, the compressed gas in the control chamber 21 begins to discharge into the release chamber 27 and a corresponding reduction on the force tending to close the annular discharge 20 is effected. When the force exerted by the charge of compressed gas in the release chamber 27 on the discharge valve 20 acting in an opening direction has been reduced to the point where the spring 55 and the remaining gas pressure in the control chamber 21 are effective to move the annular discharge valve 20 back to the closed position, this action takes place.

The annular discharge valve 20 is stopped in its opening movement when the contact ring 57 engages the shoulder 58. The left end of the annular discharge valve 20 then occupies a position indicated by the broken line 85. Here the volume of the control chamber 21 has been reduced by the amount that the annular discharge valve 20 has moved into it but, because this volume reduction is relatively small as compared to the total volume of the control chamber 21, the increased compression of the gas in the control chamber 21 is slight.

It will be understood that the pressure to which the control chamber 21 is charged and thus the pressure in the release chamber 27 at which the annular discharge valve 20 begins to move to the open position can be adjusted by changing the position of the adjusting screw 79. This changes the tension of the spring 77 and effects a corresponding change in the pressure required to move the ball valve 67 to the closed position.

What is claimed as new is:

1. In combination; a cartridge body having arranged therein successively longitudinally thereof in the order named a cylindrical release chamber in which a material breaking charge of compressed gas is to be developed and from which the charge is to be released, lateral gas charge release ports, and a cylindrical control chamber; means for connecting said cartridge body to a source of compressed gas to supply the same directly to said release chamber, a valve closure member secured to said cartridge body in said control chamber and having a cylindrical end portion adjacent said release ports with its peripheral surface uniformly spaced from the inner wall of said release chamber, an annular discharge valve slidably mounted in said release chamber in sealing relation to said release ports and telescoped with said cylindrical end portion of said valve closure member, a filling of gas in said control chamber at predetermined pressure holding said annular discharge valve in closed position, the volume of said control chamber into which said annular discharge valve moves being substantially greater than the extent to which it is reduced by the entry of said annular discharge valve, the ends of said annular discharge valve being subject, respectively, to the gas pressure in said control chamber and the gas pressure in said release chamber, the area of the end of said annular discharge valve subject to the gas pressure in said control chamber being substantially greater than the area of the other end of said annular discharge valve subject to the gas pressure in said release chamber whereby upon application of material breaking gas pressure in said release chamber sufficient to initiate movement of said annular discharge valve into said control chamber and toward open position said annular discharge valve thereupon moves into said control chamber and uncovers said release ports to permit the material breaking gas in said release chamber to be discharged through said release ports, said valve closure member having a passageway therethrough placing said release chamber in communication with said control chamber to provide said filling of gas from said release chamber, and normally open valve means in said passageway responsive to pressure in said release chamber for closing off said passageway when a predetermined pressure exists in said release chamber.

2. In combination; a cartridge body having arranged therein successively longitudinally thereof in the order named a cylindrical release chamber in which a material breaking charge of compressed gas is to be developed and from which the charge is to be released, lateral gas charge release ports, and a cylindrical control chamber; means for connecting said cartridge body to a source of compressed gas to supply the same directly to said release chamber, a valve closure member secured to said cartridge body in said control chamber and having a cylindrical end portion adjacent said release ports with its peripheral surface uniformly spaced from the inner wall of said release chamber, an annular discharge valve slidably mounted in said release chamber in sealing relation to said release ports and telescoped with said cylindrical end portion of said valve closure member, spring means biasing said annular discharge valve to said sealing relation with said release ports, a filling of gas in said control chamber at predetermined pressure holding said annular discharge valve in closed position, the volume of said control chamber into which said annular discharge valve moves being substantially greater than the extent to which it is reduced by the entry of said annular discharge valve, the ends of said annular discharge valve being subject, respectively, to the gas pressure in said control chamber and the gas pressure in said release chamber, the area of the end of said annular discharge valve subject to the gas pressure in said control chamber being substantially greater than the area of the other end of said annular discharge valve subject to the gas pressure in said release chamber whereby upon application of material breaking gas pressure in said release chamber sufficient to initiate movement of said annular discharge valve into said control chamber and toward open position said annular discharge valve thereupon moves into said control chamber and uncovers said release ports to permit the material breaking gas in said release chamber to be discharged through said release ports, said valve closure member having a passageway therethrough placing said release chamber in communication with said control chamber to provide said filling of gas from said release chamber, and normally open valve means in said passageway responsive to pressure in said release chamber for closing off said passageway when a predetermined pressure exists in said release chamber.

3. In combination; a cartridge body having arranged therein successively longitudinally thereof in the order named a cylindrical release chamber in which a material breaking charge of compressed gas is to be developed and from which the charge is to be released, lateral gas charge release ports, and a cylindrical control chamber; an annular valve seat in said cartridge body adjacent one side of said lateral gas charge release ports, a valve closure member secured to said cartridge body in said control chamber and having a cylindrical end portion adjacent the opposite side of said release ports with its peripheral surface uniformly spaced from the inner wall of said release chamber; an annular discharge valve slidably mounted in said release chamber in sealing engagement at one end with said annular valve seat, closing off said release ports, telescoped with said cylindrical end portion of said valve closure member, and having an annular area normal to its longitudinal axis subject to the gas pressure in said cylindrical release chamber; sealing means between said discharge valve and said cylindrical control chamber and between said discharge valve and said cylindrical end portion of said valve closure member whereby a pressure tight division is provided between said release chamber and said control chamber, a filling of gas in said control chamber at predetermined pressure holding said annular discharge valve in closed position so long as the force exerted thereby on said annular discharge valve exceeds the force exerted thereon by the gas pressure in said cylindrical release chamber, and means for introducing a charge of compressed gas directly into said cylindrical release chamber at its end opposite said control chamber, the ends of said annular discharge valve being subject, respectively, to the gas pressure in said control chamber and the gas pressure in said release chamber, the area of the end of said annular discharge valve normal to its longitudinal axis and subject to the gas pressure in said control chamber being substantially greater than said annular area of said annular discharge valve subject to the gas pressure in said release chamber whereby upon application of material breaking gas pressure in said release chamber sufficient to initiate movement of said annular discharge valve into said

control chamber and toward open position said annular discharge valve thereupon moves into said control chamber and uncovers said release ports to permit the material breaking gas in said release chamber to be discharged through said release ports said valve closure member having a passageway therethrough placing said release chamber in communication with said control chamber to provide said filling of gas from said release chamber, and normally open valve means in said valve closure member responsive to pressure of gas in said release chamber for closing off said passageway when a predetermined pressure exists in said release chamber.

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