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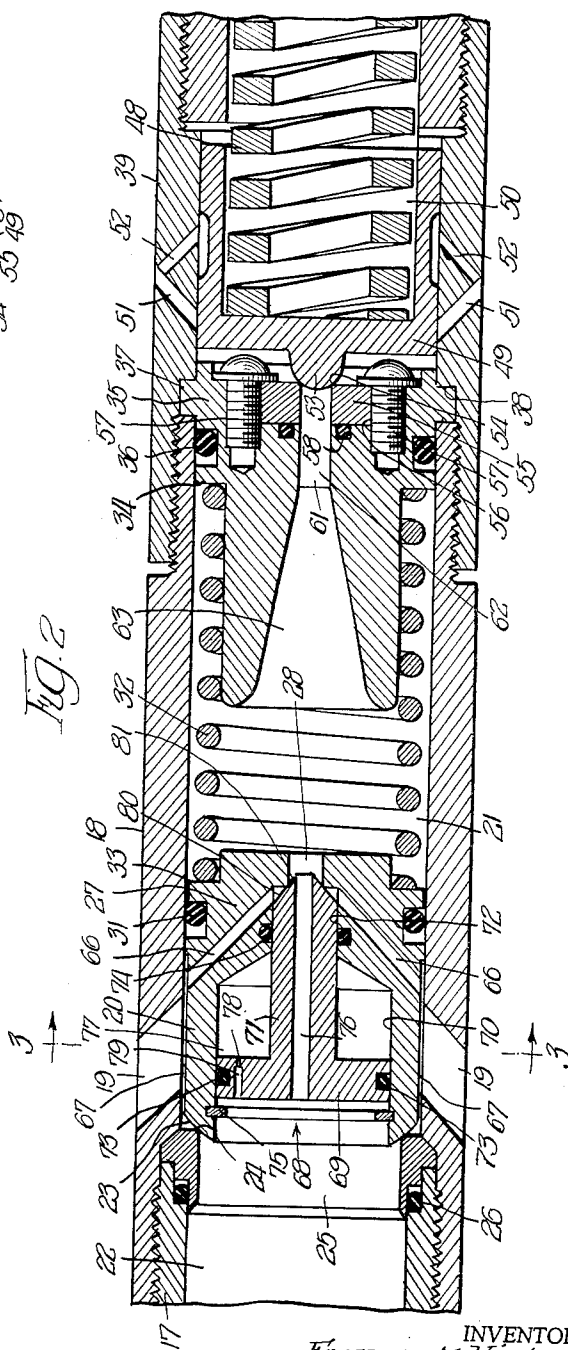
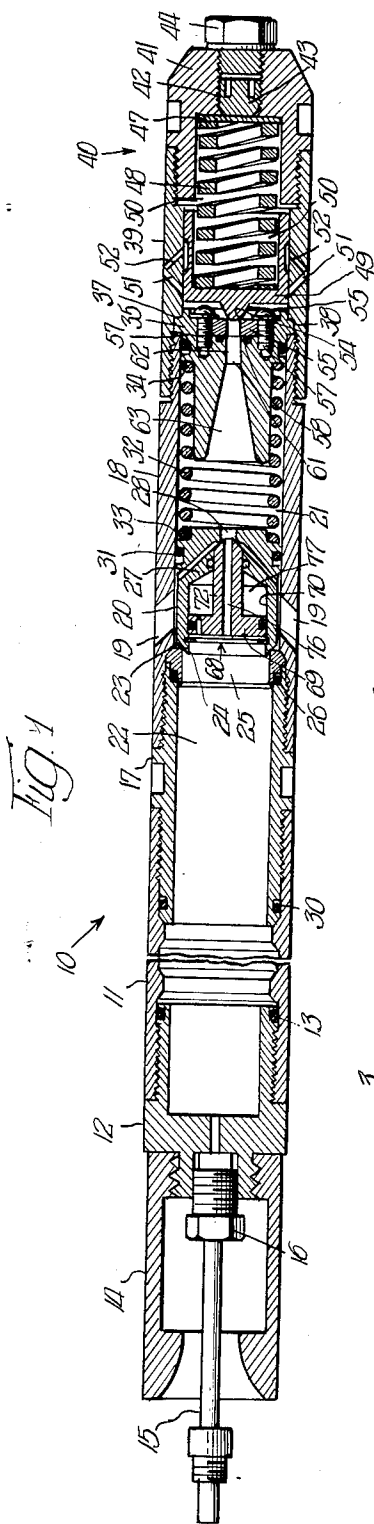
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3,090,307

MATERIAL BREAKING CARTRIDGE

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4 Sheets-Sheet 1



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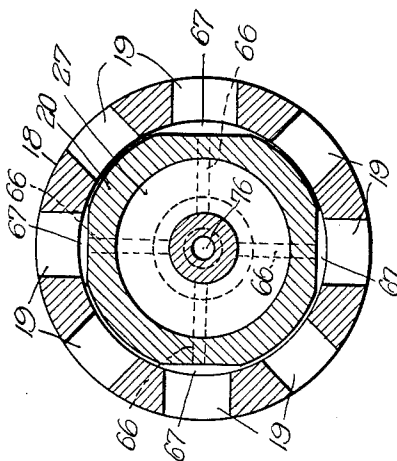
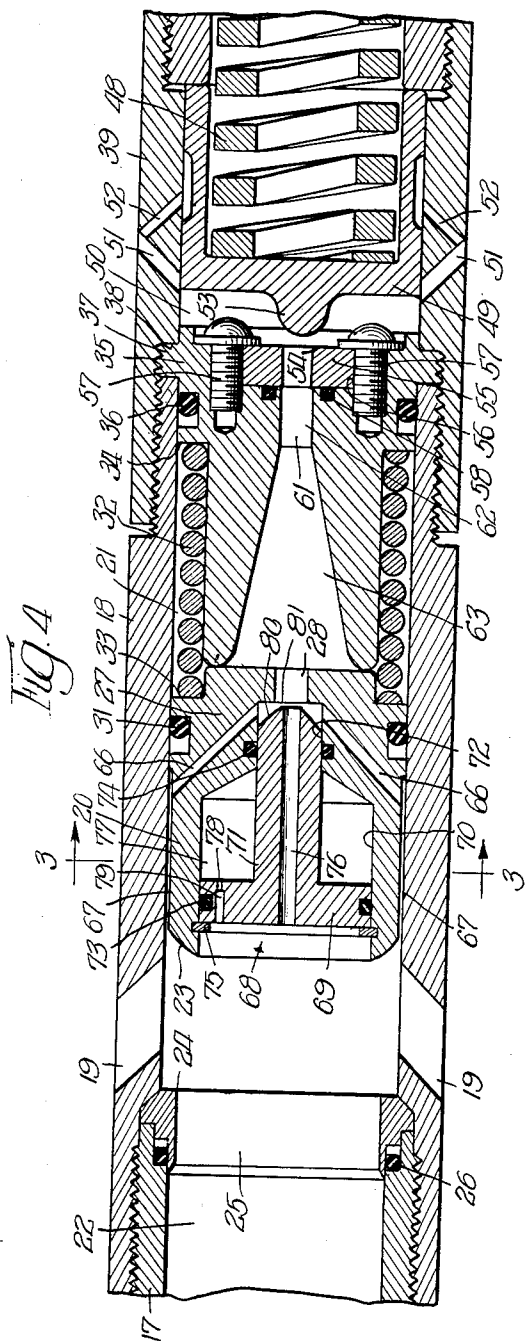


Fig. 3.

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3,090,307

MATERIAL BREAKING CARTRIDGE

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13 Claims. (Cl. 102-25)

This invention relates, generally, to material breaking cartridges and it has particular relation to such devices for use in coal mines for knocking down coal although its use is not so limited. It constitutes an improvement over the material breaking cartridge disclosed in application Serial No. 813,505, filed May 15, 1959, now abandoned, and application Serial No. 839,878, filed September 14, 1959, both assigned to the assignee of this application.

As pointed out in application Serial No. 813,505, the construction of the material breaking cartridge is such that the discharge valve recloses when the pressure in the release chamber falls to a pressure which is substantially less than the pressure required for blasting and necessary to open the control valve. The reason for this is that the control valve automatically closes at this lower pressure. Then, due to the air under pressure that is trapped in the control chamber, the discharge valve recloses and holds the reduced pressure in the release chamber. Under certain circumstances it is desirable that the discharge valve remain open to substantially completely discharge the release chamber on reclosure of the control valve. For example, when the release chamber is fully discharged, there is no likelihood of the discharge valve opening inadvertently when the cartridge subsequently is handled in transferring it to another drilled hole in the coal face for another shot.

One satisfactory solution to the problem involved in the trapping of air in the control chamber is to provide a relief for this pressure through the main lateral discharge ports as described in application Serial No. 839,878. In that construction a cover is provided over the end of the discharge valve adjacent the release chamber and a series of radial ports is provided underneath the cover through which the air pressure is equalized in the release and control chambers when the release chamber is being filled with the compressed gas. These radial ports are so positioned in the discharge valve that, once it has been opened, they provide a bleed down for the control chamber to the radial discharge ports so that, even when the control valve is closed and the control chamber no longer is in communication through the discharge ports controlled by the discharge valve to the atmosphere, it remains in communication with the atmosphere through the radial ports as long as gas under pressure continues to be supplied to the release chamber. Such a construction relies upon the provision of a definite annular clearance space between the cover at the end of the discharge valve and the juxtaposed inner peripheral surface of the means which provides the valve seat against which the discharge valve seals to hold the charge in the release chamber. The present invention improves upon the bleed down construction just described in the use of a bleed down valve in the manner herein described.

Accordingly, among the objects of this invention are: To provide for venting the control chamber of a material breaking cartridge in a new and improved manner; to provide a time delay in the operation of the discharge valve on reclosure of the control valve after which the discharge valve recloses; to vent the control chamber relatively quickly once the pressure in it has been lowered sufficiently to permit the discharge valve to open to increase the speed of its opening movement and thus the rate at which the material breaking charge flows out of

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the release chamber; to employ a bleed down valve in the discharge valve for controlling additional venting of the control chamber; to hold the bleed down valve closed in response to the equalized pressure in the release and control chambers and to open it when this equalized pressure is reduced below the pressure in a bleed down chamber defined by the bleed down valve and the discharge valve; to charge the bleed down chamber at a substantially lesser rate than the rate at which the pressure is equalized in the release and control chambers; to arrange the bleed down valve to be subject directly to the gas pressure in the release chamber for closing it; to arrange the bleed down valve to be subject directly to the gas pressure in the control chamber for closing it; and to employ the bleed down valve to vent the release chamber for a predetermined period of time after the material breaking charge is released by opening of the discharge valve.

Other objects of this invention will, in part, be obvious and in part appear hereinafter.

This invention is disclosed in the embodiments thereof shown in the accompanying drawings and it comprises the features of construction, combination of elements and arrangement of parts that will be exemplified in the constructions hereinafter set forth and the scope of the application of which will be indicated in the appended claims.

For a more complete understanding of the nature and scope of this invention reference can be had to the following detailed description, taken together with the accompanying drawings, in which:

FIGURE 1 is a longitudinal sectional view of a material breaking cartridge in which the present invention is embodied, the cartridge being shown with the discharge valve, the control and the bleed down valve in the closed position;

FIGURE 2 is a longitudinal sectional view, at an enlarged scale, of the discharge end of the material breaking cartridge shown in FIGURE 1 and again showing the valves in the closed positions;

FIGURE 3 is a vertical sectional view taken generally along the line 3-3 of FIGURE 2;

FIGURE 4 is a view, similar to FIGURE 2, but showing the discharge valve, the control valve and the bleed down valve in the open positions in the initial discharging condition;

FIGURE 5 is a view, similar to FIGURE 2, but showing a modified construction for the discharge valve and the bleed down valve, the latter being reversed from its position as shown in FIGURE 2;

FIGURE 6 is a view, similar to FIGURE 5, but showing the bleed down valve in the open position;

FIGURE 7 is a vertical sectional view showing another arrangement of discharge valve and the bleed down valve that can be employed in practicing this invention; and

FIGURE 8 is a view, similar to FIGURE 7, but showing the bleed down valve in open position.

Referring now particularly to FIGURES 1, 2, 3 and 4 of the drawings, it will be observed that the reference character 10 designates, generally, a material breaking cartridge in which the present invention is embodied. It includes a cartridge tube 11, preferably formed of high strength steel, and having a length depending upon the desired capacity of the cartridge 10. At the left end of the cartridge tube 11 there is a tube top 12. The tube top 12 is threaded into the left end of the cartridge tube 11 and an O-ring 13 is provided therebetween for sealing purposes. At the left end of the tube top 12 there is a tube nose portion 14. 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 through a blowdown valve to a suitable source of high pressure air which can be supplied by a suitable high pressure compressor. The blowdown valve is arranged not only to control the flow of compressed gas to the cartridge tube 11 but also to the atmosphere, if desired.

At the right end of the cartridge tube 11 there is provided an extension adapter 17. It is threaded into an interior thread at this end of the cartridge tube 11. A discharge head body, tubular in shape, is indicated at 18 and it is threaded onto the extension adapter 17. The tubular head body 18 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 a tubular discharge valve 20. The discharge valve 20 slides in a cylindrical control chamber 21 which is located within the discharge head body 18. The control chamber 21 is positioned endwise of a release chamber 22 which is formed in the cartridge tube 11 and extension adapter 17 where the gas charge is held in compressed state prior to being released through the lateral ports 19 on movement of the discharge valve 20 to the right to the open position.

As pointed out, the tubular discharge valve 20 closes off the lateral ports 19 until the gas pressure is to be released for blasting purposes. The discharge valve 20 at its left end is provided with a convex annular surface 23 that is arranged to have sealing engagement with an annular knife edge 24 which is formed on a replaceable valve seat 25 of hardened steel which is held in place on the right end of the extension adapter 17 by the tubular discharge head body 18 when it is threaded in place as shown in the drawings. It is this sealing engagement with the knife edge 24 that prevents the discharge of the compressed gas in the release chamber 22 through the lateral ports 19. An O-ring 26 is interposed between the replaceable valve seat 25 and the extension adapter 17 for sealing purposes.

The right end of the discharge valve 20 has a closure 27 which is provided with a passageway 28 to permit the flow of compressed gas into the control chamber 21 from the release chamber 22 at a rate that will equalize the gas pressures therein when the release chamber 22 is being charged through the air supply tube 15. During the charging operation these pressures are substantially the same.

The usual seals can be provided for the extension adapter 17 and for the discharge valve 20. As shown, an O-ring 30 is interposed between the extension adapter 17 and the cartridge tube 11. An O-ring 31 is located in a suitable peripheral groove in the discharge valve 20 and it provides sealing engagement between it and the inner cylindrical surface of the control chamber 21. These O-rings and the other O-rings referred to herein are of sufficient size as to completely fill the respective groove and to extend beyond the adjacent peripheral surface in order to provide the required sealing action.

The discharge valve 20 is biased toward the left into closed position by a coil compression spring 32. It will be observed that the spring 32 at the left end bears against an annular shoulder 33 on the discharge valve 20. At the other end the spring 32 bears against an annular shoulder 34 which forms a part of a valve seat member 35. An O-ring 36 provides the sealing engagement between the valve seat member 35 and the discharge head body 18. The valve seat member 35 has an annular flange 37 which is held by a shoulder 38 on a control valve body 39 in the position at the right end of the discharge head body 18.

The right end of the control valve body 39 is closed by a cap that is indicated, generally, at 40. The cap 40 includes an internally threaded portion 41 with centrally located threads 42 for receiving an adjusting screw 43. A cap screw 44 closes the outer end of the cap 40, as shown.

The adjusting screw 43 bears against a shim 47 and the arrangement is such as to vary the tension of a coil compression spring 48 that is located within the cap 40 for reaction against a control valve 49 which is slidable in a cylindrical control chamber 50 that is formed in the control valve body 39. The control valve 49 is arranged to close off vents or ports 51 otherwise placing the control chamber 50 in communication with the atmosphere. Auxiliary vents or ports 52 are provided to maintain atmospheric air pressure on the right side of the control valve 49.

Formed integrally with the control valve 49 is a hemispherical protuberance 53 which is arranged to have line contact engagement with a knife edge 54 that is formed around an opening through a hardened annular insert 55 which is positioned in a counterbore 56 formed in the flange 37. The hardened insert 55 is held in place by screws 57 and an O-ring 58 provides sealing engagement between it and the main portion of the valve seat member 35.

Extending through the valve seat member 35 is a single discharge opening 61 a minor portion 62 of which has the same diameter as the diameter of the opening through the hardened insert 55. A major portion 63 of the discharge opening 61 flares to the left from the minor portion 62 into the control chamber 21.

The construction thus far described is substantially the same as that disclosed in application Serial No. 813,505, above referred, and it operates in the manner described therein. After the discharge valve 20 is opened in response to a lowering of the pressure in the control chamber 21 by opening of the control valve 49, the control valve 49 recloses under the influence of the spring 48 and sufficient air under pressure may be trapped in the control chamber 21 to reclose the discharge valve 20. The compressed air may continue to flow into the release chamber 22 for an appreciable time even though the control valve in the connection to the air supply tube 15 is promptly shut off once the operator hears the report incident to the initial opening of the discharge valve 20. While the air pressure in the supply line and the release chamber 22 is substantially lower under these conditions than under the fully charged condition, still the air pressure in both the release chamber 22 and in the control chamber 21 may be substantial. Because of the likelihood of accidental discharge, it may be hazardous to handle the cartridge 10 when it is partly charged.

In accordance with the present invention provision is made for bleeding down the control chamber 21 under operating conditions involving the reclosure of the control valve 49. For this purpose, as shown more clearly in FIGURES 2, 3 and 4 of the drawings, bleed down ports 66 are provided through the closure 27 of the discharge valve 20 to place the passageway 28 in communication with segmental passageways 67 along the external surface of the discharge valve 20. As shown in FIGURE 3 four bleed down ports 66 are provided and in conjunction with them there are four segmental passageways 67 which register with four of the eight lateral ports 19 to which the blasting charge is released from the release chamber 22 to the atmosphere. A bleed down valve, shown generally at 68, is slidably mounted on the discharge valve 20 for controlling the connection between the bleed down ports 66 and the passageway 28.

The bleed down valve 68 includes a cylindrical head 69 which is slidable within the discharge valve 20 along its inner cylindrical surface 70. Extending from the cylindrical head 69 is a cylindrical stem 71 the right end of which is slidable in a counterbore 72 within the closure 27 and coaxial with the passageway 28. O-rings 73 and 74 serve to provide sealing engagement between the cylindrical head 69 and the right end of the cylindrical stem 71, respectively, with the inner cylindrical surface 70 of the discharge valve 20 and the surface of the counterbore 72. A snap retaining ring 75 limits the movement

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of the cylindrical head 69 with respect to the discharge valve 20. An opening 76 extends coaxially through the cylindrical head 69 and the stem 71 and constitutes an extension of the passageway 28. It will be understood that the compressed gas flows through the opening 76 and the passageway 28 into the control chamber 21 at such a rate that the pressure therein is equalized with the pressure in the release chamber 22 with the result that these pressures are maintained substantially equal.

Since the same unit pressure is applied to the discharge valve 20 at the opposite end, provision is made to have a larger effective area at the right end of the discharge valve 20 than is present at the left end. Thus, the area at the left end of the discharge valve 20 which is exposed to the pressure in the release chamber 22 is the area of the circle along which the annular knife edge 24 extends less the cross sectional area of the opening 76. The area of the discharge valve 20 at the right end exposed to the air pressure in the control chamber 21 is the area of a circle along the inner cylindrical surface of the control chamber 21 less the cross sectional area of the opening 76. Because of these different areas, the differential action of the air pressures on the discharge valve 20 in addition to the force exerted by the coil compression spring 32 holds the discharge valve 20 in sealing engagement with the annular knife edge 24 until the relationship is upset by the opening of the control valve 49 and the lowering of the pressure in the control chamber 21 to such an extent that the force exerted on the left end of the discharge valve 20 by the compressed air in the release chamber 22 is sufficient to move the discharge valve 20 to the open position.

It will be observed that a bleed down chamber 77 extends around the cylindrical stem 71 between the right surface of the cylindrical head 69 and the left surface of the closure 27. The O-rings 73 and 74 provide effective seals for the ends of the bleed down chamber 77. A bleed down port 78 places the bleed down chamber 77 in communication with the release chamber 22 through a counter bore 79 in the cylindrical head 69. The effective cross sectional area of the bleed down port 78 is substantially less than the effective cross sectional area of the opening 76 through the cylindrical head 69 and the cylindrical stem 71 through which the compressed gas flows to equalize the pressure in the control chamber 21 with the pressure in the release chamber 22. Because of this relationship of cross sectional areas, when the release chamber 22 is being charged with compressed gas, the bleed down chamber 77 is charged at a lesser rate and consequently the pressure within the bleed down chamber 77 is substantially less than the equalized pressure in the release chamber 22 and in the control chamber 21. During the charging operation of the bleed down valve 68 is held closed since the right end of the counterbore 72 is vented to the atmosphere through the bleed down ports 66 while the pressure being built up in the release chamber 22 acts against the cylindrical head 69, less the area of the right end of the stem 71 exposed to the same pressure, and causes the tapered end 80 of the stem 71 to engage tightly the knife edge 81. When the equalized pressure in the control chamber 21 builds up to such a value, determined by the area of the protuberance 53 exposed to the pressure in the control chamber 21 and the force exerted by the coil compression spring 48, the control valve 49 opens to place the control chamber 21 in communication with the atmosphere through the discharge opening 61, the control chamber 50 and the vents 51. As described, the differential pressure holding the discharge valve 20 closed is reduced and it opens to permit the gas charge in the release chamber 22 to flow out of the lateral ports 19. The equalized pressure in the release chamber 22 and in the control chamber 21 is reduced quickly below the pressure in the bleed down chamber 77. Previously the equalized pressure acting on the left side of the cylindrical head 69 was

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effective to hold the bleed down valve 68 in the closed position shown in FIGURE 2 with a tapered end 80 of the stem 71 in sealing engagement with an annular knife edge 81 at the left end of the passageway 28. As soon as the pressure in the bleed down chamber 77 becomes greater than the pressure in the release chamber 22 and in the control chamber 21, the bleed down valve 68 no longer is held in the closed position and is opened as result of the relatively high pressure in the bleed down chamber 77. The retaining ring 75 limits the opening movement of the bleed down valve 68 as shown in FIGURE 4 of the drawings. Since the bleed down ports 66, under these conditions, communicate directly with the passageway 28, the control chamber 21 is in direct communication with the atmosphere therethrough and through the segmental passageways 67 and the lateral ports 19. Consequently, air cannot be trapped in the control chamber 21. As pointed out the effective cross sectional area of the bleed down port 78 is substantially less than the effective cross sectional area of the opening 76 through the bleed down valve 68. Accordingly, the pressure in the bleed down chamber 77 is not rapidly reduced on opening of the discharge valve 20. The bleed down valve 68 is held in the open position for a substantial time and until the equalized pressure again is applied to the left side of the cylindrical head 69 when the cartridge 10 is being recharged to close the bleed down valve 68 and close off the bleed down ports 66.

It will be understood that the charge of air in the bleed down chamber 77 leaks out through the bleed down port 78 and thus the reclosure of the bleed down valve 68 is permitted. However, this requires several seconds and thus a substantial time delay is provided before the discharge valve 20 can be reclosed. However, when the cycle is completed and the bleed down valve 68 is closed, the discharge valve 20 engages the annular knife edge 24 under pressure in accordance with the differential action previously described and positive closing thereof is assured. This minimizes the likelihood of leakage at the junction between the convex annular surface 23 and the annular knife edge 24.

FIGURES 5 and 6 of the drawings show another embodiment of the invention. Since many of the parts of the material breaking cartridge 10, which are shown in the preceding figures, are also employed in the construction shown in FIGURES 5 and 6, the same reference characters are applied to a considerable extent. Generally it is stated that the difference in construction is with respect to the arrangement of the discharge valve in conjunction with the bleed down valve to be in somewhat reversed positions from those previously described.

It will be observed in FIGURES 5 and 6 of the drawings that a tubular discharge valve 86 is slidably mounted in the control chamber 21 and that it corresponds, generally, to the tubular discharge valve 20 previously described. However, the discharge valve 86 has a closure 87 at its left end which carries an annular convex surface 88 for sealing engagement with the annular knife edge 24 on the replaceable valve seat 25. It will be recalled that it is this sealing engagement which retains the charge of compressed gas within the release chamber 22 during the charging operation and prevents release of this gas charge through the lateral ports 19 until the device is called upon to operate in the manner described. The pressure in the control chamber 21 is equalized through a passageway 89 in the closure 87 which corresponds to the passageway 28 in the discharge valve 20 previously described. An annular packing 90 around the right end of the discharge valve 86 provides a sealed connection between it and the inner surface of the control chamber 21. A clamp ring 91 holds the packing 90 in place and the coil compression spring 32 reacts against it to bias the discharge valve 86 toward the closed position where it overlies the lateral ports 19.

In order to prevent the trapping of compressed gas in

the control chamber 21 after the control valve 49 has been reclosed bleed down ports 92 are formed in the closure 87 at the left end of the discharge valve 86 and they place the passageway 89 in communication with segmental passageways 93 extending along the periphery of the discharge valve 86 in the manner that the segmental passageways 67 extend along the periphery of the discharge valve 20. The bleed down ports 92 are closed off by a bleed down valve, shown generally at 94, and carried by and slidably mounted on the discharge valve 86. It will be noted that the bleed down valve 94 has a cylindrical head 95 at the right end which is adjacent the control chamber 21. This is the reverse of the arrangement shown in FIGURES 2 and 4 of the drawings. However, the cylindrical head 95 is subject to the equalized pressure in the release chamber 22 and the control chamber 21 in essentially the same manner that the cylindrical head 69 of the bleed down valve 68 is subjected to this same equalized pressure. The cylindrical head 95 is slidable along an inner cylindrical surface 96 of the discharge valve 86. Extending to the left from the cylindrical head 95 is a cylindrical stem 97 which is guided at its left end in a counter bore 98 in the closure 87. Associated with the cylindrical head 95 is an O-ring 99 and similarly an O-ring 100 is associated with the left end of the stem 97 where it interfits with the counter bore 98. The O-rings 99 and 100 provide sealed connections between the bleed down valve 94 and the discharge valve 86. The bleed down valve 94 is limited in its movement to the right by an overlying inner annular portion 101 of the clamp ring 91.

The air pressure in the release chamber 22 is equalized with the air pressure in the control chamber 21 by the passage of compressed air through the passageway 89 and through an opening 102 registering therewith and extending through the stem 97 and the cylindrical head 95. As before, the same differential pressure action is applied to the discharge valve 86 to hold the annular convex surface 88 in sealing engagement with the annular knife edge 24 of the valve seat 25 during the charging operation.

The bleed down valve 94 in conjunction with the discharge valve 86 forms a bleed down chamber 103 which extends around the stem 97 and between the closure 87 at the left end and the cylindrical head or piston 95 at the right end. The bleed down chamber 103 is charged with compressed air through a bleed down port 104 which communicates with a counter bore 105 with the control chamber 21. The effective cross sectional area of the bleed down port 104 is substantially less than the effective cross sectional area of the opening 102 through the bleed down valve 94 with the result that the air pressure builds up in the bleed down chamber 103 at a substantially slower rate than the pressure is equalized in the control chamber 21 with that in the release chamber 22 through the passageway 89 and the opening 102. During the charging operation the pressure in the bleed down chamber 103, being substantially less than that in the control chamber 21 and in the release chamber 22, permits the equalized pressure to hold the bleed down valve 94 in the closed position shown in FIGURE 5 where a tapered end 106 of the cylindrical stem 97 is in sealing engagement with an annular knife edge 107 at the right end of the passageway 89. The bleed down valve 94 also is held closed due to the relationship between the area of the cylindrical head 95 and the area of the left end of the stem 97 both exposed to the same pressure and to the fact that the counterbore 98 is vented to the atmosphere through the bleed down ports 92.

FIGURE 6 of the drawings is different from FIGURE 5 only in showing the bleed down valve 94 in the open position. The discharge valve 86 is shown in the closed position although it will be understood that it moves to the open position, such as that shown in FIGURE 4 of the drawings, on opening of the control valve 49 and the

lowering of the pressure in the control chamber 21. The bleed down valve 94 moves to the position shown in FIGURE 6 when the equalized pressure in the control chamber 21 is reduced, in the manner described, to such an extent that the pressure in the bleed down chamber 103 is sufficient to react against the left side of the cylindrical head 95 and move it to the right against the juxtaposed surface of the inner annular portion 101 of the clamp ring 91. When this occurs, the passageway 89 communicates through the bleed down ports 92 with the segmental passageways 93 and thence to the lateral ports 19 since the tapered end 106 of the stem 97 is moved out of sealing engagement with the annular knife edge 107 at the right end of the passageway 89.

The construction shown in FIGURES 5 and 6 of the drawings, like that shown in the preceding figures, is effective to eliminate the trapping of air in the control chamber 21 and in the release chamber 22. Also, as before, the discharge valve 86 is returned to sealing engagement with the annular knife edge 24 under pressure when the cartridge is recharged. Thus positive closing of the discharge valve 86 is assured. The relationship between the effective cross sectional area of the bleed down port 104 to the effective cross sectional area of the opening 102 is such that the bleed down valve 94 remains open for several seconds once it is open and thus provides a corresponding time delay before reclosure to permit resetting of the discharge valve 86 in the closed and sealed position.

The construction shown in FIGURES 7 and 8 of the drawings, with two exceptions, is identical with the construction shown in FIGURES 5 and 6 of the drawings. Accordingly, the same reference characters have been applied where the parts are the same. In addition use of the parts from FIGURES 1 to 4, where identical, have been employed with the same reference characters.

One of the differences in the construction shown in FIGURES 7 and 8 over that shown in FIGURES 5 and 6 is the provision of a wave spring 110 between the right side of the cylindrical head 95 and the left side of the inner annular portion 101 of the clamp ring 91. The spring 110 acts in addition to the pressure applied to the right side of the cylindrical head 95 to hold the bleed down valve 94 in the closed position shown in FIGURE 7.

The other difference in the construction shown in FIGURES 7 and 8 over that shown in FIGURES 5 and 6 is in the provision of the passageway 89' having a substantially smaller cross sectional area than the passageway 89. Although the effective cross sectional area of the passageway 89' has been reduced, still the relationship in the assembly is such that the pressure in the control chamber 21 is equalized with the pressure in the release chamber 22. Further, the relationship between the effective cross sectional area of the bleed down port 104 with respect to the effective cross sectional area of the passageway 89' is such that the operation of the bleed down valve 94 remains essentially as previously described. However, by providing the passageway 89' with a relatively smaller effective cross sectional area than that of the opening 102 through the bleed down valve 94, the compressed gas in the release chamber 22 is not released initially at the rate that the compressed gas in the control chamber 21 is released and the control chamber 21 is rapidly vented through the bleed down ports 92 in addition to whatever venting is provided by the opening of the control valve 49. Because of this, the discharge valve 86 is relatively quickly moved to the full open position and this will occur even though the control valve 49 may close partly or entirely as the result of reduced pressure in the control chamber 21.

Using the construction shown in FIGURES 7 and 8 of the drawings, in addition to eliminating the trapping of air in the control chamber 21 and the release chamber 22, because of the relatively quick movement of the

discharge valve 86 to the open position, the compressed gas charge in the release chamber 22 is correspondingly more quickly released through the lateral ports 19 with the result that a heavier blasting action takes place. Because of the relatively small effective cross sectional area of the bleed down port 104, there is a substantial time delay in the reclosure of the bleed down valve 94 and the discharge valve 86 does not reset immediately after the charge of compressed gas has been released from the release chamber 22.

From the foregoing it will be observed that the bleed down valve 68 or the bleed down valve 94 is operable under the control of the equalized gas pressure in the control chamber 21 and in the release chamber 22. Thus, as shown in FIGURES 2 and 4 of the drawings, the cylindrical head of the bleed down valve 68 can be located adjacent the discharge end of the release chamber 22 while, as shown in FIGURES 5, 6, 7 and 8 of the drawings, the cylindrical head 95 of the bleed down valve 94 can be located adjacent the control chamber 21.

Since certain further changes can be made in the foregoing constructions and different embodiments of the invention can be made without departing from the spirit and scope thereof, it is intended that all matter shown in the accompanying drawings and described hereinbefore shall be interpreted as illustrative and not in a limiting sense.

What is claimed as new is:

1. In combination; a cylindrical cartridge body having arranged 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 providing an annular valve seat at the end of said release chamber adjacent said release ports, a cylindrical discharge valve slidable in said control chamber and overlying said release ports, means biasing one end of said discharge valve into sealing engagement with said valve seat, said discharge valve having a passageway therethrough to permit the flow of gas from said release chamber to said control chamber at a rate that will equalize the gas pressures in said control and release chambers while said sealing engagement is maintained with said valve seat, means for lowering the gas pressure in said control chamber to a value substantially below that of the gas in said release chamber thereby permitting the gas pressure in said release chamber to move said discharge valve away from said valve seat and to uncover said lateral gas charge release ports and the compressed gas to be discharged therethrough, said discharge valve having at least one bleed down port placing said control chamber in communication with one of said release ports, and a bleed down valve slidably carried by said discharge valve, said bleed down valve having a surface on one part acted on by the equalized gas pressure and in closed position another part closing off said bleed down port in response to said equalized gas pressure, said bleed down valve having another surface on said one part against which gas pressure derived from said equalized gas pressure reacts to urge said bleed down valve in a direction to move said other part to open said bleed down port, said bleed down valve holding said other part in position closing off said bleed down port until said discharge valve is moved as aforesaid whereupon said derived gas pressure moves said bleed down valve to open position and said control chamber is vented to the atmosphere through said bleed down port.

2. The invention, as set forth in claim 1, wherein the bleed down valve has a piston at one end of a stem, said piston and the other end of said stem slidably engage the discharge valve, sealing means are interposed between said piston and said other end of said stem respectively and said discharge valve, the bleed down chamber extends around said stem, an opening through said piston

and stem forms an extension of the passageway in said discharge valve, the bleed down port opens into said passageway, said other end of said stem closes off said passageway to close off said bleed down port, and the port means extends through said piston.

3. The invention, as set forth in claim 2, wherein the piston is at the end of the discharge valve adjacent the release chamber and the bleed down port is at the other end of said discharge valve adjacent said control chamber.

4. The invention, as set forth in claim 2, wherein the piston is at the end of the discharge valve adjacent the control chamber and the bleed down port is at the other end of said discharge valve adjacent the release chamber.

5. The invention, as set forth in claim 4, wherein the effective cross sectional area of the port means in the piston is substantially less than the effective cross sectional area of the opening through the piston and stem whereby the control chamber is relatively quickly vented, said discharge valve moves relatively quickly to open position, the material breaking charge is relatively quickly released, and there is a substantial time delay in the reclosure of said discharge valve once it has been opened.

6. In combination, a cylindrical cartridge body having arranged 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, a cylindrical control chamber, and a valve chamber having a vent to the atmosphere; means providing an annular valve seat at the end of said release chamber adjacent said release ports, a cylindrical tubular discharge valve slidable in said control chamber at one end thereof and overlying said release ports, said discharge valve having sealing engagement at one end with said valve seat and having a passageway therethrough to permit the flow of gas from said release chamber to said control chamber at a rate that will equalize the gas pressures in said control and release chambers while said sealing engagement is maintained with said valve seat, a control valve seat member forming a closure for the other end of said control chamber and having a discharge opening therethrough, a control valve closing said discharge opening and slidable in said valve chamber and responsive to increase in gas pressure in said control chamber to a predetermined value for placing said discharge opening in communication with said vent to reduce the control chamber pressure to a value substantially below that of the gas in said release chamber thereby permitting the gas pressure in said release chamber to move said discharge valve into said control chamber away from said annular valve seat and place said lateral gas charge release ports in direct communication with said release chamber, means biasing said control valve to closed position, a coil compression spring in said control chamber at one end reacting against said valve seat member and at its other end against said tubular discharge valve and biasing it toward closed position, said discharge valve having at least one bleed down port placing said control chamber in communication with one of said release ports, a bleed down valve slidably carried by said discharge valve, said bleed down valve having one part slidable within said discharge valve and a surface thereon acted on by said equalized gas pressure and another part in closed position closing off said bleed down port in response to said equalized gas pressure, said one part having another surface which together with an inner surface of said discharge valve defines a bleed down chamber, and port means between said surfaces on said one part placing said bleed down chamber in communication with the compressed gas, the effective cross sectional area of said port means being such that the pressure in said bleed down chamber is substantially less than that in said release and control chambers during the development of the charge of compressed gas therein whereby

said bleed down valve closes off said bleed down port until the gas pressure in said control chamber is lowered below the gas pressure in said bleed down chamber whereupon the gas pressure therein is effective to open said bleed down valve and said control chamber is vented to the atmosphere through said bleed down port in addition to the venting thereof through said discharge opening and through said vent.

7. The invention, as set forth in claim 6, wherein the bleed down valve has a piston at one end of a stem, said piston and the other end of said stem slidably engage the discharge valve, sealing means are interposed between said piston and said other end of said stem respectively and said discharge valve, the bleed down chamber extends around said stem, an opening through said piston and stem forms an extension of the passageway in said discharge valve, the bleed down port opens into said passageway, said other end of said stem closes off said passageway to close off said bleed down port, and the port means extends through said piston.

8. The invention, as set forth in claim 7, wherein the piston is at the end of the discharge valve adjacent the release chamber and the bleed down port is at the other end of said discharge valve adjacent said control chamber.

9. The invention, as set forth in claim 7, wherein the piston is at the end of the discharge valve adjacent the control chamber and the bleed down port is at the other end of said discharge valve adjacent the release chamber.

10. The invention, as set forth in claim 9, wherein the effective cross sectional area of the port means in the piston is substantially less than the effective cross sectional area of the opening through the piston and stem whereby the control chamber is relatively quickly vented, said discharge valve moves relatively quickly to open position, the material breaking charge is relatively quickly released, and there is a substantial time delay in the reclosure of said discharge valve once it has been opened.

11. The invention, as set forth in claim 1, wherein the bleed down port interconnects the passageway through the discharge valve and the one release port.

12. The invention, as set forth in claim 1, wherein the bleed down valve has an opening therethrough forming an extension of the passageway through the discharge valve through which the gas flows from the release chamber to the control chamber.

13. The invention, as set forth in claim 1, wherein the bleed down valve has the one part slidable within the discharge valve and the other surface on said one part together with an inner surface of said discharge valve defines a bleed down chamber, and port means between said surfaces on said one part placing said bleed down chamber in communication with the compressed gas, the effective cross sectional area of said port means being such that the pressure in said bleed down chamber is substantially less than the pressure in the release and control chambers during the development of the charge of compressed gas whereby said bleed down valve closes off said bleed down port until the gas pressure in said control chamber is lowered below the gas pressure in said bleed down chamber whereupon the gas pressure therein is effective to open said bleed down valve and said control chamber is vented to the atmosphere through said bleed down port.

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