

Oct. 11, 1955

J. L. SMITH

2,720,169

MATERIAL BREAKING CARTRIDGE

Filed Feb. 21, 1952

Fig. 1.

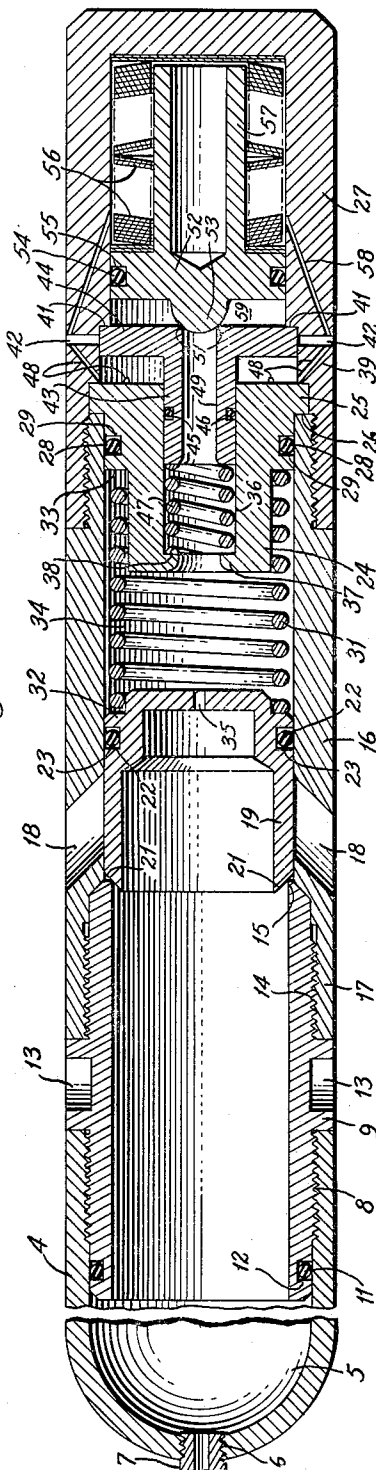


Fig. 2.

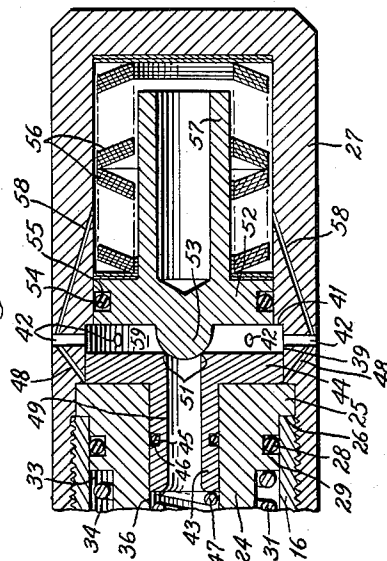
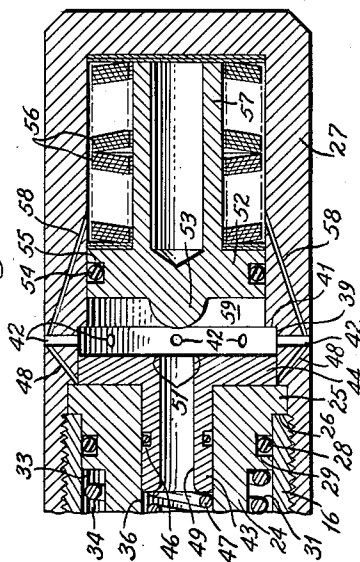


Fig. 3.



INVENTOR

John L. Smith

BY *L. Donald Myers*
ATTORNEY

1

2,720,169

MATERIAL BREAKING CARTRIDGE

John L. Smith, Chicago, Ill., assignor to Cardox Corporation, Chicago, Ill., a corporation of Illinois

Application February 21, 1952, Serial No. 272,880

12 Claims. (Cl. 102—25)

This invention relates to new and useful improvements in material breaking cartridges of the type employing a high pressure gas as the work performing medium, the release of the gas being controlled by a quick acting, full opening valve.

Cartridges employing a highly compressed charge of air or other gases for breaking down coal in mines and for other similar operations are well-known and have been widely used in recent years. Such cartridges may be precharged with a liquefied gas or with a solid which will produce a large volume of gas when heated or burned or they may be charged with a highly compressed gas after they are positioned for operation. Regardless of the manner in which the cartridge receives its charge, however, it is of primary importance that the charge be quickly and completely released upon operation of the cartridge and that the cartridge may be easily and rapidly reconditioned for subsequent use.

The primary object of this invention is to provide a compressed gas material breaking cartridge having an automatic charge release mechanism, located entirely in the discharge end of the cartridge, the operation of which is controlled to effect said release by suddenly increasing the gas pressure on one portion of the release mechanism when the pressure of the gas charge is increased to a predetermined value.

A further important object of the invention is to provide a compressed gas material breaking cartridge having an automatic charge release mechanism, located entirely in the discharge end of the cartridge, and including a plurality of sequentially operating valves, one of which is actuated by a sudden increase in the gas pressure on one of its surfaces when the pressure of the gaseous charge has been increased to a predetermined value.

A more specific object of the invention is to provide a compressed gas material breaking cartridge having an automatic charge release mechanism which includes a plurality of sequentially operating valves, the operation of which is initiated by an increase in the pressure of the gaseous charge to a predetermined value at which time one of the valves will snap into its open position.

Other objects and advantages of the invention will be apparent during the course of the following description.

In the accompanying drawing forming a part of this specification and in which like reference characters are employed to designate like parts throughout the same,

Figure 1 is a longitudinal sectional view of a material breaking cartridge embodying the invention,

Figure 2 is a fragmentary, longitudinal sectional view of the cartridge illustrated in Fig. 1 showing the position of the venting mechanism when the cartridge is in an uncharged condition, and

Figure 3 is a fragmentary, longitudinal sectional view similar to Fig. 2 but showing the position of the venting mechanism during discharge of the cartridge.

In the drawing, wherein for the purpose of illustration is shown a preferred embodiment of the invention, and first particularly referring to Fig. 1, reference character

2

4 designates a cartridge body having a compressed gas charge receiving chamber 5. One end of the cartridge body 4 is provided with an internally threaded aperture 6 for connection with a length of tubing 7, or the like, through which a charge of compressed air, or other gas, is introduced into the chamber 5.

The threaded aperture 6 and tubing 7 comprise only one of several well-known methods of providing a charge of compressed gas in the chamber 5, and it is to be understood that the invention is not to be limited to the particular means disclosed. It is contemplated that the invention, also, may be used with equal efficiency when the charge of compressed gas is introduced into the chamber 5 as a liquefied gas or a decomposable solid.

The end portion of the body member 4 opposite the aperture 6 is internally threaded at 8 for connection with an adapter member 9. Sealing between the opposed surfaces of the cartridge body 4 and adapter member 9 is provided by the O-ring 11 which is seated in the groove 12 at the inner end portion of the adapter member. The central portion of the adapter member 9 is provided with two or more indentations 13 in its outer surface for co-operation with a spanner wrench which may be used in assembling and disassembling the threadedly connected parts. The outer end portion of the adapter member 9 is externally threaded at 14 and is formed with an end edge to be used as an annular main valve seat 15.

A discharge section 16 is internally threaded at its inner end portion 17 for connection with the outer end of the adapter 9 and is provided with a circumferentially aligned row of discharge or release ports 18 which are positioned closely adjacent the valve seat 15 and are of sufficient number and total cross-sectional area to effect rapid release of the gas from the cartridge chamber 5. The discharge section 16 is of tubular construction and has an inner diameter that is slightly greater than that of the annular valve seat 15.

A piston type main valve 19 is positioned in the discharge section 16 for longitudinal movement between its seated and fully opened positions. The valve 19 is of hollow cylindrical construction and has an open inner end and a substantially closed outer end. The open inner end of the valve is beveled at its periphery to provide a seating surface 21 for engagement with the valve seat 15. The closed outer end portion of the valve 19 has an O-ring 22 positioned in the circumferential groove 23 to provide a seal between the valve and the inner surface of the discharge section 16. The valve 19, therefore, at all times seals the discharge ports 18 from the interior of the discharge section 16 and, when the valve is in its closed position, seals the discharge ports 18 from the charge release chamber 5.

Positioned in the outer end of the discharge section 16 is a pilot valve support 24 having a radial flange 25 that is rigidly clamped against the annular end surface 26 of the discharge section by the venting extension 27 which is threadedly connected to the outer end of the discharge section. Sealing between the support 24 and the inner surface of the discharge section 16 is provided by an O-ring 28 seated in the circumferential groove 29 formed in the outer surface of the support 24. Positioned between the main valve 19 and the support 24 is a spring 31 having its opposite end portions seated against radial shoulders 32 and 33 of the valve 19 and support 24, respectively, to urge the valve toward its seat 15.

Formed within the discharge section 16 and between the main valve 19 and support 24, is a main control chamber 34 which is in communication with the charge release chamber 5 through an aperture 35 in the closed outer end of the main valve. Extending axially through the support 24 is an enlarged passageway 36 of substantially greater diameter than the aperture 35 in the main

valve 19. The inner end of the passageway 36 is formed with a radially inwardly extending flange 37, the inner surface of which provides a spring seat 38 and the outer surface of which is rounded to facilitate flow of gas into the passageway.

The venting extension 27 extends axially outwardly from the pilot valve support 24 and is provided with a cylindrical bore portion 39 in axial alignment with the passageway 36 of said support which is of substantially greater diameter than the passageway 36. The remainder of the bore of the extension 27 is enlarged to form a pilot valve seat 41. Main venting ports 42 extend radially outwardly from the enlarged portion of the bore at points adjacent the pilot valve seat 41. The main venting ports 42 are of sufficient number and total cross-sectional area to effect rapid release of the gas flowing through the passageway 36, as will be later described.

A piston type pilot valve 43 is positioned in the passageway 36 of the support 24 for longitudinal movement and is formed with a radially outwardly extending flange 44 having its peripheral surface in sliding engagement with the enlarged portion of the bore of the venting extension 27 between the pilot valve seat 41 and the said support.

Sealing is provided between the opposed surfaces of the pilot valve 43 and the passageway 36 by an O-ring 45 positioned in the circumferential groove 46 in the valve. A spring 47 is positioned between the spring seat 38 of the support 24 and the annular end surface of the pilot valve 43 to urge the pilot valve in an axially outward direction toward its seat 41. When in its seated position, the pilot valve flange 44 engages the seating surface 41 of the bore of the venting extension 27 to completely seal the main venting ports 42. The space between the flange 44 of the pilot valve 43 and the end surface of the support 24 is maintained substantially at atmospheric pressure by relief ports 48.

Extending axially through the pilot valve 43 is an enlarged passageway 49 which is rounded at its inner end portion to facilitate the flow of gas thereinto and the outer end portion of which is shaped to provide an annular regulating valve seat 51. Positioned in the bore 39 axially outwardly of the pilot valve 43 is a piston type regulating valve 52 having a hemispherical projection 53 on its inner face for engaging the valve seat 51 to seal the outer end of the passageway 49. Sealing is provided between the peripheral surface of the regulating valve 52 and the bore portion 39 by an O-ring 54 positioned in the groove 55. Positioned between the regulating valve 52 and the closed outer end of the venting extension 27 is a Belleville spring which is formed of a plurality of dished ring spring members 56 arranged in two opposed stacks. It will be appreciated that the particular arrangement of the spring members 56 may be varied to regulate the strength and deflection of the spring unit as required. The regulating valve 52 is provided with a cylindrical projection 57 which extends axially outwardly through the openings in the spring members 56 and serves to guide the valve and limit the extent of its outward movement. The space in which the spring members 56 are positioned is maintained at substantially atmospheric pressure by relief ports 58.

The bore of the venting extension 27 forms a pilot control chamber 59 between the opposed surfaces of the pilot and regulating valves 43 and 52, respectively. Inasmuch as the pilot valve 43 and regulating valve 52 are movable in the same or in opposite axial directions, the location of the pilot control chamber 59 will vary with movement of the valves in the same direction from their initial positions, as illustrated in Fig. 2 to the positions illustrated in Fig. 1, while movement of the valves 43 and 52 in opposite axial directions will cause the pilot control chamber 59 to be expanded, as illustrated in Fig. 3, and will place the venting ports 42 in communication with the pilot control chamber 59 and the main control chamber 34 through the passageways 36 and 49. In other words, the venting ports 42 will be placed in open

communication with the main control chamber 34 only upon movement of both of the valves 43 and 52 into their open positions.

The operation of the cartridge when compressed air, or other gas, is employed, will be described as follows:

The cartridge, in an uncharged condition but connected to a suitable source of supply of compressed air, or other gas, by the feed line 7, is placed in a previously prepared drill hole formed in the working face of the material to be broken down, such as coal in a mine. At this time the charge release chamber 5 of the cartridge body 4 is sealed from the discharge ports 18 by the engagement of the main valve 19 with its seat 21 and by the O-ring 22. The charge release chamber 5, however, is in communication with the main control chamber 34 through the aperture 35 in the main valve 19. The main control chamber 34 is similarly sealed from the pilot control chamber 59 and from the main venting ports 42 by the engagement between the regulating valve 52 and its seat 51, as illustrated in Fig. 2, and by the O-ring 45. The regulating valve 52 is urged into its seated position by the opposed forces of the spring members 56 acting on the regulating valve and the spring 47 acting on the pilot valve. Movement of both of the valves 43 and 52 into the positions illustrated in Fig. 2 is due to the substantially greater force exerted by the spring members 56.

The compressed air delivered to the charge release chamber 5 will rapidly build up the pressure therein to the desired work performing value. During this charging of the chamber 5, compressed air is permitted to flow into the main control chamber 34 through the aperture 35 in the valve 19 so that the pressures in the charge release and main control chambers are substantially equal at all times. The pressure in the pilot control chamber 59, however, will remain at substantially atmospheric pressure due to the closed condition of the regulating valve 52 to prevent the flow of gas through the passageway 49.

At this time, the main valve 19 will be maintained in its seated or closed position by the force of the spring 31 and by the differential in the forces acting upon the opposite ends of the valve. In other words, the effective surface area of the valve 19 exposed to the fluid pressure in the main control chamber 34 is greater than the effective surface area of the valve exposed to the fluid pressure in the charge release chamber 5 so that the forces acting on the valve 19 are unbalanced in a direction to maintain the valve in its closed position. The effective surface areas on opposite ends of the valve 19 may be considered as being equal to the cross-sectional area of the main control chamber 34 and the cross-sectional area of the valve seat 15, each minus the cross-sectional area of the aperture 35.

During the initial portion of the charging period, the pilot valve 43 and regulating valve 52 will be moved from their positions, as illustrated in Fig. 2, into intermediate positions, as illustrated in Fig. 1. This joint movement of the valves 43 and 52 is effected by the force of the spring 47 and the pressure of the gas in the main control chamber 34 acting on the annular end surface of the pilot valve and on the surface portion of the hemispherical projection 52 which closes the passageway 49. It will be noted that during this joint movement of the valves 43 and 52, the valve 43 is moved from its open position into its closed position while the valve 52 remains in its closed position, against its seat 51, to prevent the flow of gas from the main control chamber 34 into the pilot control chamber 59.

During movement of the valves 43 and 52 into the positions illustrated in Fig. 1, in which the pilot valve flange 44 is seated against the surface 41 and the venting ports 42 are sealed from communication with the pilot control chamber 59, the spring members 56 will be partially compressed or flattened but will continue to exert a substantial force opposing the pressure of the gas in the main control chamber 34. Upon seating of the radial flange 44 of the pilot valve 43 against the seating surface 41, the force

exerted on the regulating valve 52 by the spring 47 and the pilot valve 43 can no longer effect movement of the regulating valve or compress the spring members 56. The valves 43 and 52, therefore, will remain in the positions illustrated in Fig. 1 until the pressure of the gas in the main control chamber 34 has been increased to a predetermined work performing value.

The spring elements 56 are so formed and arranged that when the pressure of the gas in the main control chamber 34 acting on the exposed surface area of the hemispherical projection 53 has reached the predetermined work performing value, the regulating valve 52 will be moved slightly away from its seat 51. The Belleville type of spring members 56 is particularly adapted to the high load and limited deflection to which it is subjected by movement of the valve 52. It will be appreciated, however, that a suitable helical type spring could be used in place of the spring members 56.

After the valve 52 has been moved from its seated position, gas from the main control chamber 34 will flow through the passageways 36 and 49 into the pilot control chamber 59 and will cause a rapid increase in the pressure within the chamber which will act upon the opposed surfaces of the pilot valve 43 and the regulating valve 52 to move both of the valves in opposite directions into their fully open positions. The movement of the pilot valve 43 into its open position is effected by the application of the increased pressure of the gas in the pilot control chamber 59 to the exposed surface of the radial flange 44 which is of much greater effective area than the opposed annular end surface of the valve 43 which is exposed to the pressure in the main control chamber 34. The opening of the regulating valve 52 is similarly effected by the application of the increased pressure in the pilot control chamber 59 to the surface of the valve which is exposed to the pilot control chamber 59 and is of much greater effective area than the hemispherical surface portion which was initially exposed to the passageway 49 in the pilot valve 43.

The opening of the pilot valve 43 and regulating valve 52 provides open communication from the main control chamber 34 through the passageways 36 and 49 and the pilot control chamber 59 to the main venting ports 42 for the rapid release of gas from the main control chamber. This release of gas from the main control chamber 34 will quickly lower the pressure in this chamber to a value at which the pressure of the gas in the charge release chamber 5 of the cartridge body 4 will move the main valve 19 into its fully open position. In other words, the pressure of the gas in the release chamber 5 then being much greater than that of the gas in the main control chamber 34, the valve 19 will be opened and the gas charge in the chamber 5 will be released through the charge release ports 18. Upon discharge of the cartridge, the flow of gas through the feed line 7 will be cut off in any desired manner at a point in the line which is remote from the cartridge.

The successive operation of the valves 52, 43, and 19 is extremely rapid. The release of the gas charge from the chambers 5 and 34 reduces the pressures in the chambers to such an extent that the main valve 19, pilot valve 43 and regulating valve 52 are quickly returned to their initial positions by the springs 31, 47 and 56, respectively, to recondition the cartridge for a subsequent operation.

It is to be understood that the form of this invention herewith shown and described is to be taken as a preferred example of the same and that various changes in the shape, size, and arrangement of parts may be resorted to without departing from the spirit of the invention or the scope of the subjoined claims.

Having thus described the invention, I claim:

1. In combination, a cartridge having a chamber from which a material breaking charge of compressed gas is to be released, lateral gas charge release ports, a control chamber, and venting ports arranged successively longi-

tudinally of said cartridge, a first valve for controlling release of the gas charge from said gas release chamber through the release ports and being exposed to the pressure of the gas in said control and release chambers with a greater effective surface area exposed to said control chamber than to said release chamber, means for equalizing the gas pressures in the release and control chambers, resilient means urging said valve into its closed position, and venting means for automatically releasing the gas from said control chamber to the venting ports to cause the gas in the release chamber to open the valve when the pressure in said chambers reaches a predetermined value, said venting means comprising a second valve having opposed surfaces of different effective areas with the surface of smaller effective area exposed to the pressure of the gas in said control chamber and the surface of larger effective area exposed to atmospheric pressure through said venting ports, said second valve being movable by an increase of said pressure to a value below said predetermined value into a position for closing said venting ports, and a third valve responsive to an increase in the pressure of the gas in said control chamber to said predetermined value for movement into its open position to expose the surface of said second valve having the larger effective area to the pressure of the gas in said control chamber and move the second valve into a position for opening said venting ports to effect said automatic release.

2. In combination, a cartridge having a chamber from which a material breaking charge of compressed gas is to be released, lateral gas charge release ports, a main control chamber, and venting ports arranged successively longitudinally of said cartridge, a first valve for controlling release of the gas charge from said gas release chamber through the release ports and being exposed to the pressure of the gas in said main control and release chambers with a greater effective surface area exposed to said main control chamber than to said release chamber, means for equalizing the gas pressures in the release and main control chambers, resilient means urging said valve into its closed position, and venting means for automatically releasing the gas from said main control chamber to the venting ports to cause the gas in the release chamber to open the valve when the pressure in said chambers reaches a predetermined value, said venting means comprising a second valve having opposed surfaces of different effective areas with the surface of smaller effective area exposed to the pressure of the gas in said main control chamber, said second valve being movable by the gas pressure in the main control chamber into a position for closing said venting ports, a third valve having a surface in spaced relationship with the surface of said second valve having the larger effective area to form a pilot control chamber therebetween, said third valve being movable by an increase in the pressure of the gas in said main control chamber to said predetermined value into its open position to permit gas to flow from said main control chamber to said pilot control chamber to increase the gas pressure in the latter chamber to a value at which the second valve is moved into a position for opening said venting ports to effect said automatic release and at which the third valve is maintained in its open position during the release.

3. In combination, a cartridge having a chamber from which a material breaking charge of compressed gas is to be released, lateral gas charge release ports, a control chamber, and venting ports arranged successively longitudinally of said cartridge, a first valve for controlling release of the gas charge from said gas release chamber through the release ports and being exposed to the pressure of the gas in said control and release chambers with a greater effective surface area exposed to said control chamber than to said release chamber, means for equalizing the gas pressures in the release and control chambers, resilient means urging said valve into its closed position,

and venting means for automatically releasing the gas from said control chamber to the venting ports to cause the gas in the release chamber to open the valve when the pressure in said chambers reaches a predetermined value, said venting means comprising a second valve having a passageway therethrough and providing opposed surfaces of different effective areas with the surface of smaller effective area exposed to the pressure of the gas in said control chamber, said second valve being movable by the gas pressure in said control chamber into a position for closing said venting ports, and a third valve for controlling the flow of gas through the passageway in said second valve and being exposed to the pressure of the gas in said control chamber, said third valve being movable into its open position by an increase in the gas pressure in the control chamber to said predetermined value to permit gas from the control chamber to flow through the passageway and rapidly increase the gas pressure on the surface of said second valve having the larger effective area and to move said second valve into a position for opening said venting ports to effect said automatic release.

4. In combination, a cartridge having a chamber from which a material breaking charge of compressed gas is to be released, lateral gas charge release ports, a main control chamber, and venting ports arranged successively longitudinally of said cartridge, a first valve for controlling release of the gas charge from said gas release chamber through the release ports and being exposed to the pressure of the gas in said main control and release chambers with a greater effective surface area exposed to said main control chamber than to said release chamber, means for equalizing the gas pressures in the release and main control chambers, resilient means urging said valve into its closed position, and venting means for automatically releasing the gas from said main control chamber to the venting ports to cause the gas in the release chamber to open the valve when the pressure in said chambers reaches a predetermined value, said venting means comprising a second valve positioned between said main control chamber and said venting ports and having a passageway therethrough, a third valve normally seated across said passageway, and a pair of springs urging said second and third valves in opposite directions toward each other to seat the latter across the passageway, said second and third valves having spaced opposed surfaces to provide a pilot control chamber therebetween and each having a surface of smaller effective area than its opposed surface exposed to the pressure of the gas in said main control chamber, said second and third valves being jointly movable by an increase in the pressure of the gas on said last mentioned surfaces to a value below said predetermined value and said third valve being separately movable by an increase in the pressure to said predetermined value to permit gas to flow from the main to the pilot control chamber, the flow of gas into the latter causing a sudden increase in the pressure therein to move the second valve into a position for opening the venting ports to effect said automatic release.

5. In combination, a cartridge having a chamber from which a material breaking charge of compressed gas is to be released, lateral gas charge release ports, a control chamber, and venting ports arranged successively longitudinally of said cartridge, a first valve for controlling release of the gas charge from said gas release chamber through the release ports and being exposed to the pressure of the gas in said control and release chambers with a greater effective surface area exposed to said control chamber than to said release chamber, means for equalizing the gas pressures in the release and control chambers, resilient means urging said valve into its closed position, and venting means for automatically releasing the gas from said control chamber to the venting ports to cause the gas in the release chamber to open the valve when the pressure in said chambers reaches a predetermined

value, said venting means comprising a pilot valve positioned between said main control chamber and said venting ports and having a passageway therethrough, a regulating valve normally seated across said passageway and having a surface spaced from the opposed surface of said pilot valve to provide a pilot control chamber therebetween, and a spring urging said regulating valve into its seated position across said passageway, said pilot and regulating valves each having a surface of smaller effective area than its opposed surface exposed to the pressure in said main control chamber for limited combined movement of both valves by an increase in the pressure to a value below said predetermined value to partially compress said spring, said regulating valve being separately movable into its open position by a further increase in the gas pressure to said predetermined value, the opening of said regulating valve effecting said automatic release of gas through said pilot control chamber.

6. In combination, a cartridge having a chamber from which a material breaking charge of compressed gas is to be released, lateral gas charge release ports, a control chamber, and venting ports arranged successively longitudinally of said cartridge, a first valve for controlling release of the gas charge from said gas release chamber through the release ports and being exposed to the pressure of the gas in said control and release chambers with a greater effective surface area exposed to said control chamber than to said release chamber, means for equalizing the gas pressures in the release and control chambers, resilient means urging said valve into its closed position, and venting means for automatically releasing the gas from said control chamber to the venting ports to cause the gas in the release chamber to open the valve when the pressure in said chambers reaches a predetermined value, said venting means comprising a pilot valve positioned between said main control chamber and said venting ports and having a passageway therethrough, a regulating valve normally seated across said passageway and having a surface spaced from the opposed surface of said pilot valve to provide a pilot control chamber therebetween, and a plurality of dished ring spring members urging said regulating valve into its seated position across said passageway, said pilot and regulating valves each having a surface of smaller effective area than its opposed surface exposed to the pressure in said main control chamber for limited combined movement of both valves by an increase in the pressure to a value below said predetermined value to partially flatten the dished spring members, said regulating valve being separately movable by an increase in the gas pressure to said predetermined value to increase the load on said spring members and effect sudden and complete opening of the regulating valve, the opening of said regulating valve effecting said automatic release of gas through said pilot control chamber.

7. In combination, a cartridge having a chamber from which a material breaking charge of compressed gas is to be released, lateral gas charge release ports, a main control chamber, venting ports, and a pilot control chamber arranged successively longitudinally of said cartridge, a main valve for controlling the release of gas from said charge release chamber through said release ports, a spring urging said main valve into its closed position, a pilot valve for controlling the release of gas from said main control chamber to said venting ports, a spring urging said pilot valve into its closed position, said main and pilot valves being movably positioned between the release and main control chambers and the main control and pilot control chambers, respectively, and exposed to the gas pressures in their adjacent chambers with the main valve having a greater effective surface area exposed to the main control chamber and the pilot valve having a greater effective surface area exposed to the pilot control chamber, means for equalizing the pressures in said release and main control chambers, the pressure in said pilot control chamber remaining at a relatively

low value, and means responsive to an increase in the gas pressure in said main control chamber to a predetermined value for suddenly increasing the gas pressure in said pilot control chamber to move said pilot valve into its open position.

8. In combination, a cartridge having a chamber from which a material breaking charge of compressed gas is to be released, lateral gas charge release ports, a main control chamber, venting ports, and a pilot control chamber arranged successively longitudinally of said cartridge, a main valve for controlling the release of gas from said charge release chamber to said release ports, a spring urging said main valve into its closed position, a pilot valve for controlling the release of gas from said main control chamber through said venting ports, a spring urging said pilot valve into its closed position, said main and pilot valves being movably positioned between the release and main control chambers and the main control and pilot control chambers, respectively, and exposed to the gas pressures in their adjacent chambers with the main valve having a greater effective surface area exposed to the main control chamber and the pilot valve having a greater effective surface area exposed to the pilot control chamber, means for equalizing the pressures in said release and main control chambers, and valve means for controlling the pressure in said pilot control chamber to cause the pressure to remain at a relatively low value during charging of the cartridge, said valve means being exposed to the pressure of the gas in said main control chamber and responsive to an increase in the gas pressure to a predetermined value to suddenly admit gas from said main control chamber to said pilot control chamber for rapidly increasing the pressure in the latter, and moving said pilot valve into its open position.

9. In combination, a cartridge having a chamber from which a material breaking charge of compressed gas is to be released, lateral gas charge release ports, a main control chamber, venting ports, and a pilot control chamber arranged successively longitudinally of said cartridge, a main valve for controlling the release of gas from said charge release chamber to said release ports, a spring urging said main valve into its closed position, a pilot valve for controlling the release of gas from said main control chamber through said venting ports, a spring urging said pilot valve into its closed position, said main and pilot valves being movably positioned between the release and main control chambers and the main control and pilot control chambers, respectively, and exposed to the gas pressures in their adjacent chambers with the main valve having a greater effective surface area exposed to the main control chamber and the pilot valve having a greater effective surface area exposed to the pilot control chamber, means for equalizing the pressures in said release and main control chambers, a valve for controlling the pressure in said pilot control chamber to cause the pressure to remain at a relatively low value during charging of the cartridge, said last mentioned valve being positioned in said pilot control chamber and exposed to the pressure of the gas in said main control chamber for movement in response to an increase in the pressure to a predetermined value to suddenly admit gas from said main control chamber to said pilot control chamber for rapidly increasing the pressure in the latter and moving said pilot valve into its open position.

10. In combination, a cartridge having a chamber from which a material breaking charge of compressed gas is to be released, lateral gas charge release ports, a main control chamber, venting ports, and a pilot control chamber arranged successively longitudinally of said cartridge, a main valve for controlling the release of gas from said charge release chamber to said release ports, a spring urging said main valve into its closed position, a pilot valve for controlling the release of gas from said main control chamber through said venting ports, a spring urging said pilot valve into its closed position, said main and pilot

valves being movably positioned between the release and main control chambers and the main control and pilot control chambers, respectively, and exposed to the gas pressures in their adjacent chambers with the main valve having a greater effective surface area exposed to the main control chamber and the pilot valve having a greater effective surface area exposed to the pilot control chamber, said main valve having a restricted passageway therethrough for equalizing the pressures in said release and main control chambers, said pilot valve having an enlarged passageway therethrough for the free flow of gas from the main control to the pilot control chamber, and a regulating valve normally seated across said enlarged passageway to prevent the flow of gas therethrough and maintain the pressure in said pilot control chamber at a relatively low value during charging of the cartridge, said regulating valve having a surface portion exposed to the pressure of the gas in the main control chamber through said enlarged passageway and being movable by an increase in the pressure to a predetermined value to open the enlarged passageway and permit gas to flow therethrough for rapidly increasing the pressure in the pilot control chamber and moving said pilot valve into its open position.

11. In combination, a cartridge having a chamber from which a material breaking charge of compressed gas is to be released, lateral gas charge release ports, a main control chamber, venting ports, and a pilot control chamber arranged successively longitudinally of said cartridge, a main valve for controlling the release of gas from said charge release chamber to said release ports, a spring urging said main valve into its closed position, a pilot valve for controlling the release of gas from said main control chamber through said venting ports, a spring urging said pilot valve into its closed position, said main and pilot valves being movably positioned between the release and main control chambers and the main control and pilot control chambers, respectively, and exposed to the gas pressures in their adjacent chambers with the main valve having a greater effective surface area exposed to the main control chamber and the pilot valve having a greater effective surface area exposed to the pilot control chamber, said main valve having a restricted passageway therethrough for equalizing the pressures in said release and main control chambers, said pilot valve having an enlarged passageway therethrough for the free flow of gas from the main control to the pilot control chamber, a regulating valve for controlling the flow of gas through said enlarged passageway, and a spring urging said regulating valve into its seated position to close the enlarged passageway and maintain the pressure in said pilot control chamber at a substantially lower value than that in said main control chamber during charging of the cartridge, said regulating valve having a limited effective surface area and a larger effective surface area exposed to the pressure of the gas in said main control and pilot control chambers, respectively, for unseating the valve when the pressure of the gas in the main control chamber is increased to a predetermined value and for rapid movement of the valve into its fully opened position by the increase in the pressure of the gas in said pilot control chamber when the valve is unseated, said pressure increase also effecting opening of said pilot valve.

12. In combination, a cartridge having a chamber from which a material breaking charge of compressed gas is to be released, lateral gas charge release ports, a main control chamber, venting ports, and a pilot control chamber arranged successively longitudinally of said cartridge, a main valve for controlling the release of gas from said charge release chamber through said release ports, a spring urging said main valve into its closed position, a pilot valve for controlling the release of gas from said main control chamber to said venting ports, a spring urging said pilot valve into its closed position, said main and pilot valves being movably positioned between

11

the release and main control and pilot control chambers, respectively, and exposed to the gas pressures in their adjacent chambers with the main valve having a greater effective surface area exposed to the main control chamber and the pilot valve having a greater effective surface area exposed to the pilot control chamber, said main valve having a restricted passageway therethrough for equalizing the pressures in said release and main control chambers, said pilot valve having an enlarged passageway therethrough for the free flow of gas from the main control to the pilot control chamber, a regulating valve for controlling the flow of gas through said enlarged passageway, and a plurality of dished ring spring members arranged in axially opposed stacks against said regulating valve for urging the valve into its seated position to close the enlarged passageway and maintain the pressure in said pilot control chamber at a substantially lower value than that in said main control chamber during charging of the cartridge, said pilot valve and

12

said regulating valve being jointly movable for a limited distance by the pressure of the gas in said main control chamber to partially flatten said spring members, said regulating valve having a surface area exposed to the pressure of the gas in said main control chamber for movement by an increase in the pressure to a predetermined value to open said enlarged passageway and permit gas to flow therethrough for rapidly increasing the pressure in the pilot control chamber and moving said pilot valve into its open position.

References Cited in the file of this patent

UNITED STATES PATENTS

2,083,697	Dull	June 15, 1937
2,083,735	Noble	June 15, 1937
2,083,739	Osgood	June 15, 1937
2,083,978	Armstrong	June 15, 1937
2,122,706	Armstrong	July 5, 1938

15