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INDESTRUCTIBLE RELEASE MECHANISM FOR BLASTING CARTRIDGES

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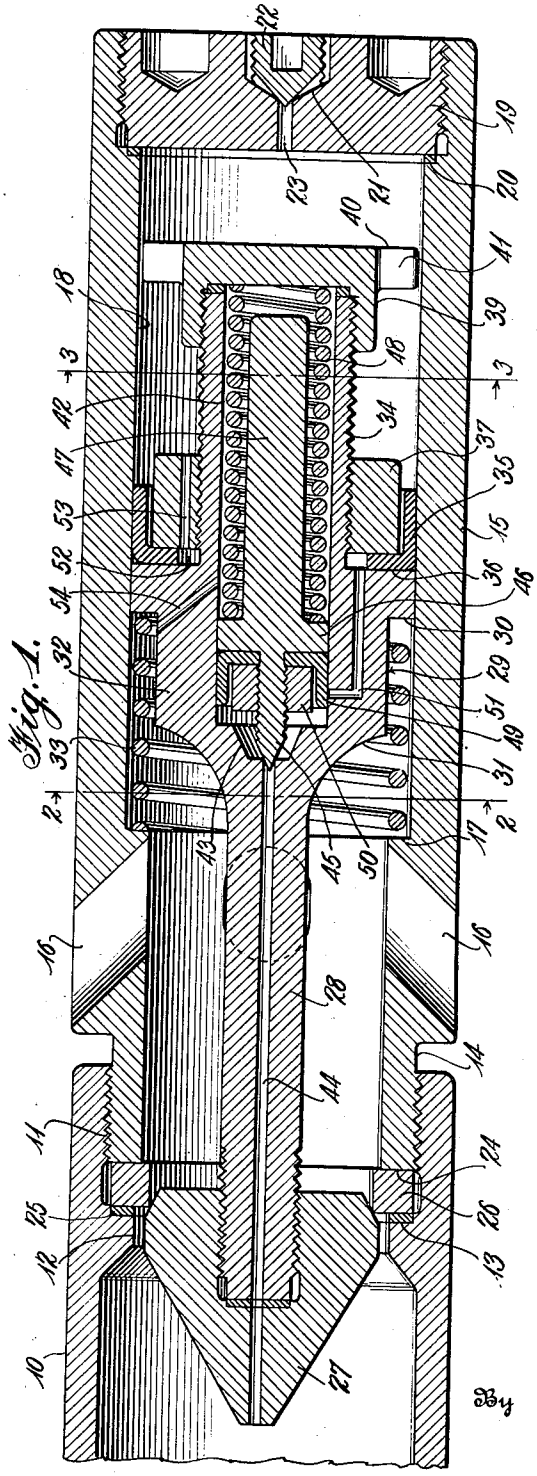


Fig. 1.

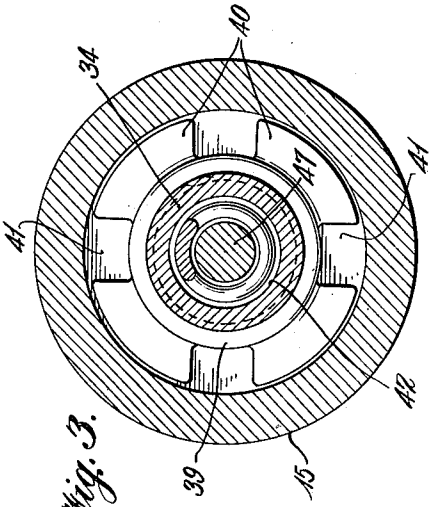


Fig. 3.

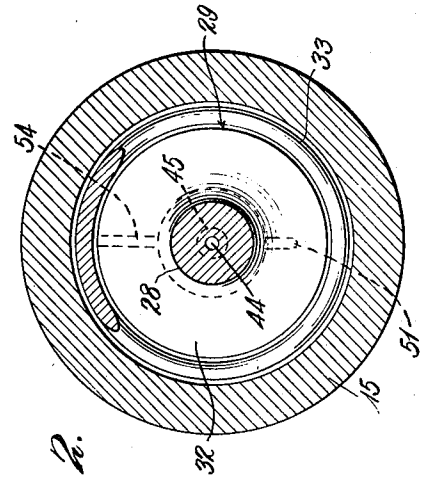


Fig. 2.

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INDESTRUCTIBLE RELEASE MECHANISM FOR BLASTING CARTRIDGES

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24 Claims. (Cl. 102—6)

This invention relates to new and useful improvements in indestructible release mechanism for blasting cartridges.

The primary object of this invention is to provide mechanism for releasing blasting charges from indestructible cartridges or shells and wherein the release mechanism is of an indestructible character and is susceptible of being adjusted to release charges at different work performing pressures.

A further important object of the invention is to provide indestructible release mechanism for blasting cartridges which is completely embodied in a discharge cap adapted to be detachably associated with a cartridge or shell.

A still further important object of the invention is to provide indestructible release mechanism which will operate to effect discharge of a blasting medium from a cartridge or shell and wherein the blasting medium may take the form of carbon dioxide gas generated by intensely heating liquid carbon dioxide or highly compressed air.

Another object of the invention is to provide indestructible release mechanism which operates automatically to effect discharge of a blasting medium from a cartridge or shell when the pressure of said blasting medium reaches a predetermined value within the shell and wherein the discharge mechanism is operated entirely by the pressure of the blasting charge within the cartridge or shell.

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 numerals are employed to designate like parts throughout the same,

Figure 1 is a longitudinal sectional view of the indestructible release mechanism embodying this invention,

Figure 2 is a transverse sectional view taken on line 2—2 of Figure 1, and

Figure 3 is a transverse sectional view taken on line 3—3 of Figure 1.

In the drawing, wherein for the purpose of illustration is shown a preferred embodiment of this invention, the reference character 10 designates an indestructible cartridge or shell which is intended to receive a blasting charge that is to be released at a desired work performing pressure into the material to be broken down. The blasting charge may take the form of liquid carbon dioxide which is to be intensely heated by a chemical heater unit, or the like for converting the liquid carbon dioxide into gas at a relatively high pressure. For a complete understanding of the mechanism of a cartridge charged with carbon dioxide, reference may be had to the patent issued to Dent Ferrell et al., 1,805,541, on May 19, 1931. The blasting charge within the cartridge 10 also may take the form of air, or other gas compressed at a pressure less than the desired final blasting pressure at which the charge is to be released. The final blasting pressure may be obtained by intensely heating the initially compressed gas charge with either a chemical heater unit or a permanent electric resistance unit. Cartridges receiving charges of the above two designated characters are known in the trade as precharged cartridges. The trade also is familiar with what is termed post-charged cartridges. Cartridges of this character are charged after they are placed in a blast or drill hole. The charge usually takes the form of a compressed gas, such as air, which is delivered to the cartridge from a portable compressor unit or from a portable storage tank or receiver unit. It will be understood, as the description of the release mechanism embodying this invention proceeds that the said mechanism will operate very effectively to release the charge from a post-charged cartridge when air, or other gases, is compressed in the cartridge 10 to the pressure at which the release mechanism is set to operate.

Figure 1 illustrates the discharge end of the cartridge 10. This end is provided with an internally threaded terminal portion 11. Spaced axially inwardly of this threaded portion is a shoulder or restriction 12. This shoulder forms a seat 13, in the manner illustrated.

Threadedly connected to the extremity 11 of the cartridge 10 is an externally threaded, reduced portion 14 of a tubular discharge cap 15. Spaced outwardly of the reduced portion 14, the cap is provided with a series of obliquely arranged discharge ports 16. A shoulder 17 is formed in the bore of the discharge cap 15 by the formation of an enlarged cylinder or chamber portion 18 within the cap bore.

Threadedly connected to the outer end of the discharge cap 15 is a closure plug 19. A packing ring or gasket 20 is arranged between the closure plug 19 and an adjacent surface of the cap 15 to prevent leakage between these two elements. Threadedly mounted in a pocket 21 formed in the plug 19 is a valve member 22 which may be backed off to permit fluid trapped in the cylinder 18 to be discharged through the port 23, formed in the plug 19. The utility of this valve 22 will be fully explained at a later point.

The seat 13 of the cartridge or shell 10 and the extremity 24 of the reduced portion 14 of the discharge cap 15 have confined between the same a packing ring 25 and a hardened metallic ring 26. This metallic ring is intended to function as a seat for the valve head 27 which is threadedly connected to the rod or stem 28 of a piston 29

which is located within the cylinder or chamber 18 of the discharge cap 15.

The piston 29 is formed with a portion 30 which slidably fits the bore of the cylinder or chamber 18. From the enlarged portion 30 of the piston to the conical portion 31 which blends into the rod or stem 28, the piston is provided with a reduced cylindrical portion 32. The difference in diameter between the portions 30 and 32 of the piston provides a shoulder arranged in opposition to the shoulder 17 formed in the discharge cap 15. A spring 33 is interposed between these two shoulders to function as preliminary seating means for the valve head 27.

The piston 29 outwardly of its enlarged portion 30 is formed with a reduced extension 34 which is externally screw-threaded. A cup leather 35 is held against the surface 36 of the piston portion 30 by means of a ring or nut 37.

Threadedly connected to the extremity of the reduced piston portion 34 is a spider or guide head 39. Figure 3 discloses this spider or guide head as including the radially projecting fins 40 which are arranged in circumferentially spaced relation to provide the series of openings 41.

The portions 30, 32 and 34 of the piston 29 are bored to form a cylinder 42. The outer end of this cylinder is closed by the spider 39. The inner end of this bore or cylinder has formed in its wall a frusto-conical pocket 43. Extending from the inner end wall of this pocket through the rod or stem 28 and the axis of the valve head 27 is a passageway 44 which establishes communication between the interior or bore of the cartridge 10 and the bore or cylinder 42 of the piston 29.

A valve 45 is arranged to control communication between the passageway 44 and the bore 42 of the piston. Formed integrally with the valve 45 is a plunger 46 which is slidably fitted within the bore 42 of the piston. Projecting axially from the plunger 46 is a stem 47 which is encircled by a compression spring 48. One end of the spring 48 bears against the surface of the plunger 46 while the other end of the spring bears against the inner surface of the spider 39. This spring functions to retain the valve 45 seated to prevent flow of fluid from the passageway 44 into the bore 42 of the piston 29.

A cup leather 49 is retained against the plunger 46 by means of a retaining nut 50. The cup leather 49 functions, during axial movement of the plunger 46, as a valve for controlling flow of fluid through the by-pass 51 which extends from the bore 42 of the piston to and through the surface 36 of the piston portion 30. It will be noted that the central opening of the cup leather 35 is of a proper diameter to provide a chamber 52 which communicates with the by-pass 51 and is of annular formation. The nut 37 is provided with one or more axial passageways 53 which communicate with the annular chamber 52.

A port 54 is provided to vent the portion of the bore 42 of the piston 29 which is arranged between the plunger 46 and the inner face of the spider 39.

The indestructible release mechanism embodying this invention functions in the following manner to automatically release a blasting charge from the cartridge 10 when the pressure of the charge reaches a predetermined value:

It will be noted that the valve head 27 seats in the direction of discharge of the blasting medium from the cartridge 10. The pressure of the blasting charge within the cartridge, therefore, normally functions to retain the valve head 27 seated against the ring 26. The pressure of the charge within the cartridge 10 is delivered through the passageway 44 to the valve 45 which is carried by the plunger 46. Due to the relatively small area of the passageway 44, the valve 45 is subjected to a comparatively small force. The spring 48 should be of proper strength to retain the valve 45 seated until the desired blasting pressure is obtained within the cartridge 10; for example, a pressure of from 10,000 to 15,000 lbs. per square inch. When such a pressure is obtained in the cartridge 10, the valve 45 will be unseated. A slight opening movement of the valve 45 will permit pressure to build up within the bore 42 of the piston 29 between the inner end of this bore and the plunger 46. This pressure will act against the cup leather 49 and the nut 50 to force the plunger 46 axially against the pressure of the spring 48. It will be appreciated that the cup leather 49 will function to prevent leakage of the blasting medium past the plunger 46. Should any of the blasting medium leak past the cup leather, the same will be vented through the port 54 to the exterior of the piston. It will be appreciated, therefore, that a pressure can not build up in back of plunger 46 which would result in premature closing of valve 45.

Axial movement of the plunger 46 with the cup leather 49 will move the latter to uncover the inner end of the by-pass 51. The blasting medium, then will flow from the cartridge 10 through the passageway 44 into the bore 42 of the piston and from said bore through the by-pass 51 into the annular chamber 52. The blasting medium will be discharged from the chamber 52 into the cylinder or chamber 18 formed in the discharge cap 15 through the ports 53. The pressure of the blasting medium will build up in the chamber or cylinder 18 of the discharge cap until it susbtantially equals the pressure within the chamber of the cartridge 10 or until it reaches a value which, acting upon the exposed surfaces of the nut 37 and cup leather 35 and the spider 39 will overcome the pressure within the cartridge 10 which is functioning to retain the valve head 27 against the ring 26. It will be appreciated that the cup leather 35, the nut 37 and the spider 39 provide a total area which is in excess of the area or diameter of the valve head 27. The pressure built up within the chamber 18 of the discharge cap 15, therefore, will function to move the valve head 27 off of its seat. Unseating of the valve head 27 will permit the blasting charge to be released from the cartridge 10 into the discharge cap 15 and outwardly through the discharge ports 16.

It will be appreciated that the cup leather 35 will effect a seal between the piston 29 and the chamber 18 to permit pressure to be built up in the chamber. This blasting medium delivered to the chamber 18 normally will be exhausted therefrom by slowly leaking past the cup leather 35. If, however, the cup leather so tightly seals the chamber 18 that the charge will not leak past the said cup leather, the valve 22 may be backed away from its seat to reduce the pressure within the chamber to atmospheric pressure. The mechanism then will be in readiness to receive and effect release of a second charge from the cartridge chamber.

It further will be appreciated that by varying the strength of the spring 48, the pressure at which the blasting charge will be released from the cartridge 10 may be varied.

It is to be understood that the form of this in-

vention 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 blasting cartridge having a chamber for receiving a blasting charge the pressure of which is to be built up to the desired blasting pressure, release means for the blasting charge, a control chamber, means in said control chamber for opening said release means when a portion of the blasting charge is admitted to the control chamber and for holding open said release means as long as the blasting charge remains in the control chamber, and means carried by the control chamber means and subjected to the pressure of the charge in the first-mentioned chamber for establishing communication between the two chambers when the pressure of the blasting charge reaches a predetermined value and for maintaining said communication until the blasting charge has been entirely released.

2. In combination, a blasting cartridge having a chamber for receiving a blasting charge the pressure of which is to be built up to the desired blasting pressure, a discharge cap attached to the cartridge, and means embodied in the discharge cap for releasing the charge from said chamber when the pressure of the charge reaches a predetermined value, said means including a charge releasing valve held closed by the pressure of the charge, a piston connected to the valve for opening and holding open the same when subjected to the pressure of the charge, and means operated by the pressure of the charge for subjecting the piston to the charge pressure and for maintaining said piston so subjected until the pressure in the blasting charge chamber drops to atmospheric pressure.

3. In combination, a blasting cartridge having a chamber for receiving a blasting charge the pressure of which is to be built up to the desired blasting pressure, a discharge cap attached to the cartridge, and means embodied in the discharge cap for releasing the charge from said chamber when the pressure of the charge reaches a predetermined value, said means including a charge releasing valve held closed by the pressure of the charge, a piston connected to the valve for opening and holding open the same when subjected to the pressure of the charge, and means carried by said piston and operated by the pressure of the charge for subjecting the piston to the charge pressure and for maintaining said piston so subjected until the pressure in the blasting charge chamber drops to atmospheric pressure.

4. In combination, a blasting cartridge having a chamber for receiving a blasting charge the pressure of which is to be built up to the desired blasting pressure, a discharge cap attached to the cartridge, and means embodied in the discharge cap for releasing the charge from said chamber when the pressure of the charge reaches a predetermined value, said means including a charge releasing valve held closed by the pressure of the charge, a hollow piston connected to the valve for opening and holding open the same when subjected to the pressure of the charge, and means located in the bore of the piston for causing the piston to be subjected to the charge pressure and for maintaining said piston so subjected until the pressure in the blasting charge chamber drops to atmospheric pressure.

5. In combination, a blasting cartridge having a chamber for receiving a blasting charge the pressure of which is to be built up to the desired blasting pressure, a discharge cap attached to the cartridge, and means embodied in the discharge cap for releasing the charge from said chamber when the pressure of the charge reaches a predetermined value, said means including a charge releasing valve held closed by the pressure of the charge, a hollow piston having a rod connected to the valve for opening and holding open the valve when the piston is subjected to the pressure of the charge, a passageway through the valve and rod connecting the charge receiving chamber and the bore of the piston, and means in the piston bore for establishing and maintaining flow of the blasting charge through said passageway until the charge is exhausted to cause the piston to be subjected to the charge pressure, said last mentioned means comprising a valve sealing the piston bore end of the said passageway and a differential pressure piston connected to the valve.

6. In combination, a blasting cartridge having a chamber for receiving a blasting charge the pressure of which is to be built up to the desired blasting pressure, a discharge cap attached to the cartridge, and means embodied in the discharge cap for releasing the charge from said chamber when the pressure of the charge reaches a predetermined value, said means including a charge releasing valve held closed by the pressure of the charge, a hollow piston having a rod connected to the valve for opening and holding open the valve when the piston is subjected to the pressure of the charge, a passageway through the valve and rod connecting the charge receiving chamber and the bore of the piston, and means in the piston bore for establishing and maintaining flow of the blasting charge through said passageway until the charge is exhausted to cause the piston to be subjected to the charge pressure, said last-mentioned means including a spring pressed valve.

7. In combination, a blasting cartridge having a chamber for receiving a blasting charge the pressure of which is to be built up to the desired blasting pressure, a discharge cap attached to the cartridge, and means embodied in the discharge cap for releasing the charge from said chamber when the pressure of the charge reaches a predetermined value, said means including a charge releasing valve held closed by the pressure of the charge, a hollow piston having a rod connected to the valve for opening and holding open the valve when the piston is subjected to the pressure of the charge, a passageway through the valve and rod connecting the charge receiving chamber and the bore of the piston, and means in the piston bore for establishing and maintaining flow of the blasting charge through said passageway until the charge is exhausted to cause the piston to be subjected to the charge pressure, said last-mentioned means including a spring seated blasting pressure opened compound valve assembly.

8. In combination, a blasting cartridge having a chamber for receiving a blasting charge the pressure of which is to be built up to the desired blasting pressure, a discharge cap detachably connected to said cartridge, a ring forming a valve seat clamped between portions of the cartridge and the discharge cap, a valve for controlling communication between the cartridge and the discharge cap, and charge pressure operated mechanism in the discharge cap for unseating said valve.

9. In combination, a blasting cartridge having

a chamber for receiving a blasting charge the pressure of which is to be built up to the desired blasting pressure, a discharge cap threadedly connected to the cartridge, valve seat forming means clamped between portions of the cartridge and discharge cap, a valve engaging said valve seat means on the cartridge side of the latter, and charge pressure operated means in the discharge cap for moving the valve inwardly of the cartridge to unseat the valve.

10. In combination, a blasting cartridge having a chamber for receiving a blasting charge the pressure of which is to be built up to the desired blasting pressure, a discharge cap threadedly connected to the cartridge, a valve seat forming ring and a packing ring clamped between portions of the cartridge and said cap, a valve head held against said seat by the pressure of the charge within the cartridge, mechanism within the discharge cap for unseating said valve head when said mechanism is subjected to the pressure of the charge within the cartridge, and means operated by the charge pressure for controlling application of said charge pressure to said mechanism.

11. In combination, a blasting cartridge having a chamber for receiving a blasting charge and provided with a discharge orifice, and differential release mechanism operated by the blasting charge when the pressure of the same reaches a predetermined value for discharging the blasting charge, said mechanism comprising a discharge orifice control valve normally subjected to the pressure of the blasting charge, a piston of greater transverse area than said valve operatively connected to the latter and normally subjected to atmospheric pressure when said chamber is charged, means operated by the blasting charge when the pressure of the same reaches the desired value for causing the piston to be subjected to and moved by the pressure of the charge to effect opening of said valve, and means for causing the piston to maintain said valve open until the blasting charge is completely discharged.

12. In combination, a blasting cartridge having a chamber for receiving a blasting charge and provided with a discharge orifice, and differential release mechanism operated by the blasting charge when the pressure of the same reaches a predetermined value for discharging the blasting charge, said mechanism comprising a discharge orifice control valve normally subjected to the pressure of the blasting charge, a piston of greater transverse area than said valve operatively connected to the latter and normally subjected to atmospheric pressure when said chamber is charged, a flow path for conducting a portion of the blasting charge from said chamber to one side of said piston, a spring loaded valve for controlling said flow path adapted to be unseated by the blasting charge when the pressure of the same reaches the desired value, and means for effecting and maintaining full opening of the spring loaded valve.

13. In combination, a blasting cartridge having a chamber for receiving a blasting charge and provided with a discharge orifice, and differential release mechanism operated by the blasting charge when the pressure of the same reaches a predetermined value for discharging the blasting charge, said mechanism comprising a discharge orifice control valve normally subjected to the pressure of the blasting charge, a piston of greater transverse area than said valve operatively connected to the latter and normally subjected to atmospheric pressure when said chamber is charged, a flow path for conducting a portion of the blasting charge from said chamber to one side of said piston, a spring loaded valve for controlling said flow path adapted to be unseated by the blasting charge when the pressure of the same reaches the desired value, and means operated by the pressure of the charge flowing past said unseated valve for effecting and maintaining full opening of the latter.

14. In combination, a blasting cartridge having a chamber for receiving a blasting charge and provided with a discharge orifice, and differential release mechanism operated by the blasting charge when the pressure of the same reaches a predetermined value for discharging the blasting charge, said mechanism comprising a discharge orifice control valve normally subjected to the pressure of the blasting charge, a piston of greater transverse area than said valve operatively connected to the latter and normally subjected to atmospheric pressure when said chamber is charged, a flow path for conducting a portion of the blasting charge from said chamber to one side of said piston, a spring loaded valve for controlling said flow path adapted to be unseated by the blasting charge when the pressure of the same reaches the desired value, and a plunger subjected to the pressure of the charge flowing past the unseated valve for effecting and maintaining full opening of the latter.

15. In combination, a blasting cartridge having a chamber for receiving a blasting charge the pressure of which is to be built up to the desired blasting pressure, release means for the blasting charge, a control chamber, means in said control chamber for opening said release means when a portion of the blasting charge is admitted to the control chamber, means carried by the control chamber means and subjected to the pressure of the charge in the first-mentioned chamber for admitting the blasting charge to the control chamber when the pressure of the blasting charge reaches a predetermined value, and means for maintaining the control chamber subjected to the pressure of the blasting charge until the entire charge is released.

16. In combination, a blasting cartridge having a chamber for receiving a blasting charge the pressure of which is to be built up to the desired blasting pressure, a discharge cap attached to the cartridge, and means embodied in the discharge cap for releasing the charge from said chamber when the pressure of the charge reaches a predetermined value, said means including a charge release valve held closed by the pressure of the charge, a piston connected to the valve for opening the same when subjected to the pressure of the charge, means operated by the pressure of the charge for subjecting the piston to the charge pressure, and means for maintaining the piston subjected to the charge pressure until the entire charge is released.

17. In combination, a blasting cartridge having a chamber for receiving a blasting charge the pressure of which is to be built up to the desired blasting pressure, a discharge cap attached to the cartridge, and means embodied in the discharge cap for releasing the charge from said chamber when the pressure of the charge reaches a predetermined value, said means including a charge release valve held closed by the pressure of the charge, a piston connected to the valve for opening the same when sub-

jected to the pressure of the charge, means carried by said piston and operated by the pressure of the charge for subjecting the piston to the charge pressure, and means for maintaining the piston subjected to the charge pressure until the entire charge is released.

18. In combination, a blasting cartridge having a chamber for receiving a blasting charge the pressure of which is to be built up to the desired blasting pressure, a discharge cap attached to the cartridge, and means embodied in the discharge cap for releasing the charge from said chamber when the pressure of the charge reaches a predetermined value, said means including a charge releasing valve held closed by the pressure of the charge, a hollow piston connected to the valve for opening the same when subjected to the pressure of the charge, means located in the bore of the piston for causing the piston to be subjected to the charge pressure, and means for maintaining the piston subjected to the charge pressure until the entire blasting charge is released.

19. In combination, a blasting cartridge having a chamber for receiving a blasting charge the pressure of which is to be built up to the desired blasting pressure, a discharge cap attached to the cartridge, and means embodied in the discharge cap for releasing the charge from said chamber when the pressure of the charge reaches a predetermined value, said means including a charge releasing valve held closed by the pressure of the charge, a hollow piston having a rod connected to the valve for opening the valve when the piston is subjected to the pressure of the charge, a passageway through the valve and rod connecting the charge receiving chamber and the bore of the piston, and means in the piston bore for controlling the flow of the blasting charge through said passageway to cause the piston to be subjected to the charge pressure and to be maintained subjected to said charge pressure until the entire blasting charge is released.

20. In combination, a blasting cartridge having a chamber for receiving a blasting charge the pressure of which is to be built up to the desired blasting pressure, a discharge cap attached to the cartridge, and means embodied in the discharge cap for releasing the charge from said chamber when the pressure of the charge reaches a predetermined value, said means including a charge release valve held closed by the pressure of the charge, a hollow piston having a rod connected to the valve for opening the latter when the piston is subjected to the pressure of the charge, a passageway through the valve and rod connecting the charge receiving chamber and the bore of the piston, means in the piston bore for controlling flow of the blasting charge through said passageway to cause the piston to be subjected to the charge pressure, said last-mentioned means including a spring pressed valve, and means for holding said spring pressed valve open until the entire blasting charge is released.

21. In combination, a blasting cartridge having a chamber for receiving a blasting charge the pressure of which is to be built up to the desired blasting pressure, a discharge cap attached to the cartridge, and means embodied in the discharge cap for releasing the charge from said chamber when the pressure of the charge reaches a predetermined value, said means including a charge releasing valve held closed by the pressure of the charge, a hollow piston having a rod connected to the valve for opening the latter when the piston is subjected to the pressure of the charge, a passageway through the valve and rod connecting the charge receiving chamber and the bore of the piston, means in the piston bore for controlling flow of the blasting charge through said passageway to cause the piston to be subjected to the charge pressure, said last-mentioned means including a blasting pressure operated compound valve assembly, and means for holding said valve assemblies open until the entire blasting charge is released.

22. In combination, a blasting cartridge having a chamber for receiving a blasting charge and provided with a discharge orifice, and differential release mechanism operated by the blasting charge when the pressure of the same reaches a predetermined value for discharging the blasting charge, said mechanism comprising a discharge orifice control valve normally subjected to the pressure of the blasting charge, a piston of greater transverse area than said valve operatively connected to the latter and normally subjected to atmospheric pressure when said chamber is charged, means operated by the blasting charge when the pressure of the same reaches the desired value for causing the piston to be subjected to and moved by the pressure of the charge to effect opening of said valve, and means for maintaining the piston subjected to the charge pressure until the entire blasting charge is released.

23. In combination, a blasting cartridge having a chamber for receiving a blasting charge the pressure of which is to be built up to the desired blasting pressure, release means for the blasting charge, a control chamber, means in said control chamber for opening said release means when a portion of the blasting charge is admitted to the control chamber, and means carried by the control chamber means and subjected to the pressure of the charge in the first-mentioned chamber for admitting the blasting charge to the control chamber when the pressure of the blasting charge reaches a predetermined value and for maintaining said control chamber subjected to the blasting charge pressure until the pressure in the first-mentioned chamber drops to atmospheric pressure.

24. In combination, a blasting cartridge having a chamber for receiving a blasting charge the pressure of which is to be built up to the desired blasting pressure, a discharge cap attached to the cartridge, and means embodied in the discharge cap for releasing the charge from said chamber when the pressure of the charge reaches a predetermined value, said means including a charge releasing valve held closed by the pressure of the charge, a hollow piston having a rod connected to the valve for opening the latter when the piston is subjected to the pressure of the charge, a passageway to the valve and rod connecting the charge receiving chamber and the bore of the piston, and means in the piston bore for controlling flow of the blasting charge through said passageway to cause the piston to be subjected to the charge pressure, said last-mentioned means including a needle valve and a plunger valve successively subjected to the charge pressure.

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