

[54] **THERMAL DETONATION ENERGY-INITIATABLE BLASTING CAPS, AND DETONATION SYSTEM AND METHOD**

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- [22] Filed: **Dec. 20, 1973**
- [21] Appl. No.: **426,979**

[57] **ABSTRACT**

A nonelectrically initiated blasting cap containing an initiation charge ignitable in response to action of thermal detonation energy of an explosive gas mixture, including conduit means for emplacing a confined stream of the explosive gas in detonating position in the blasting cap for the responsive ignition.

Also provided in a system including a plurality of the above blasting caps spaced apart for detonation of one or more main charges, together with additional conduit means for conveying the explosive gas to the plurality of blasting caps for the emplacement, and means for detonation of the thus emplaced explosive gas.

Method, including passing a stream of the explosive gas along the emplacement route, for purging the system prior to the detonation, is also provided.

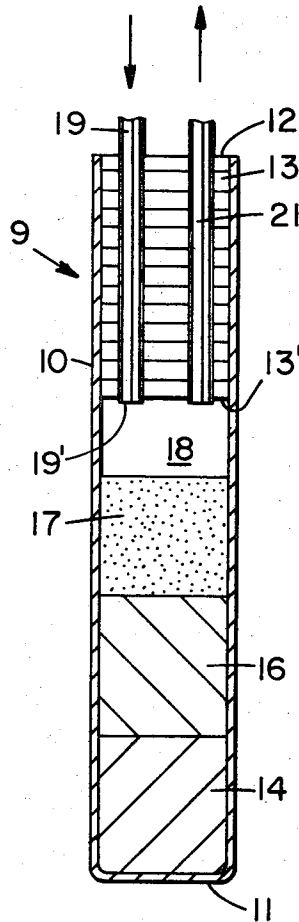
- [52] U.S. Cl. **102/23; 102/29**
- [51] Int. Cl. **F42d 1/04; F42b 3/10**
- [58] Field of Search **102/22-24, 102/27-29**

[56] **References Cited**

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17 Claims, 6 Drawing Figures



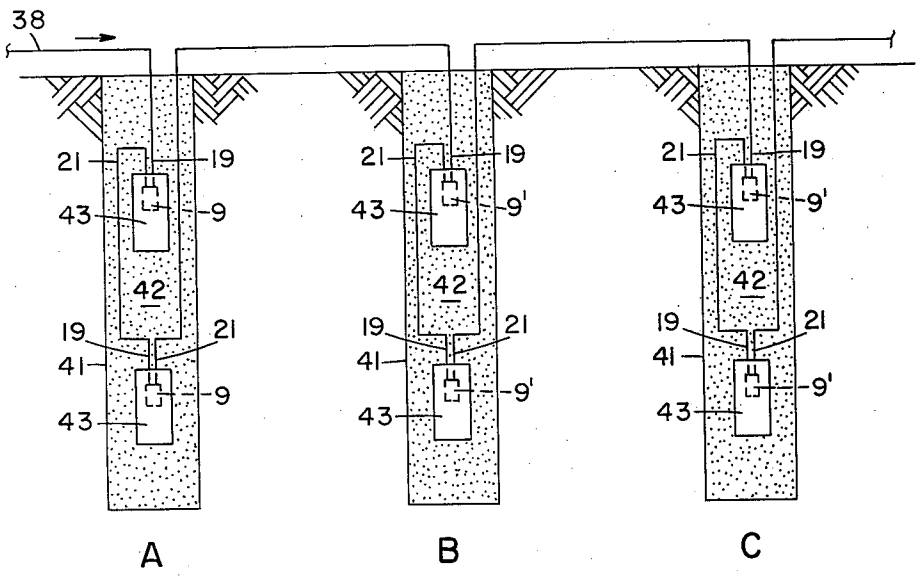
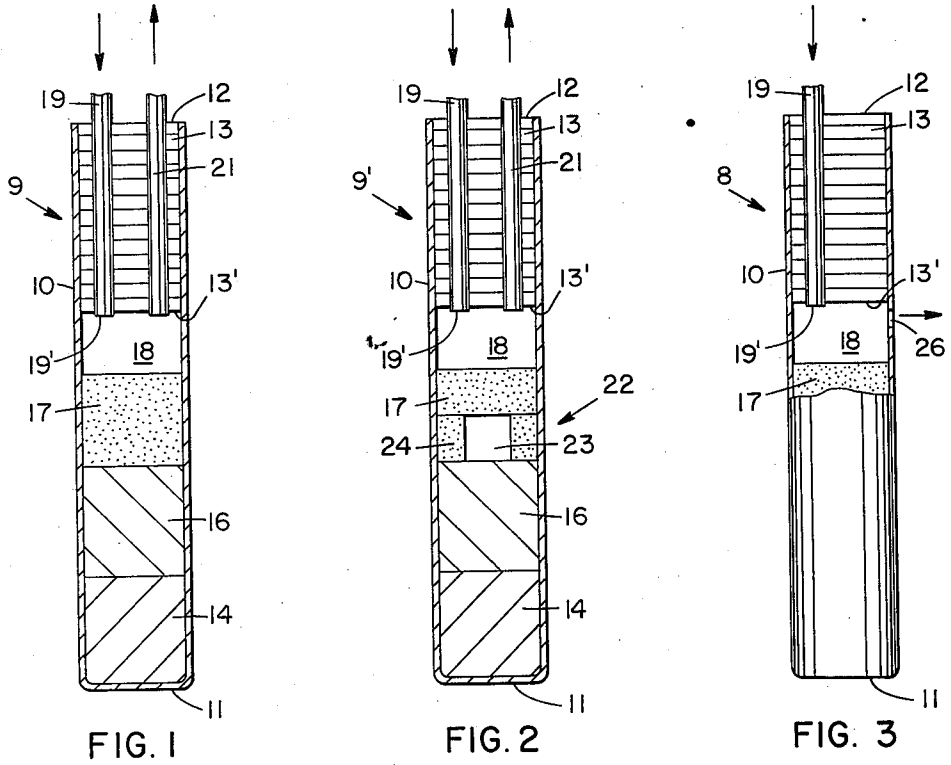


FIG. 6

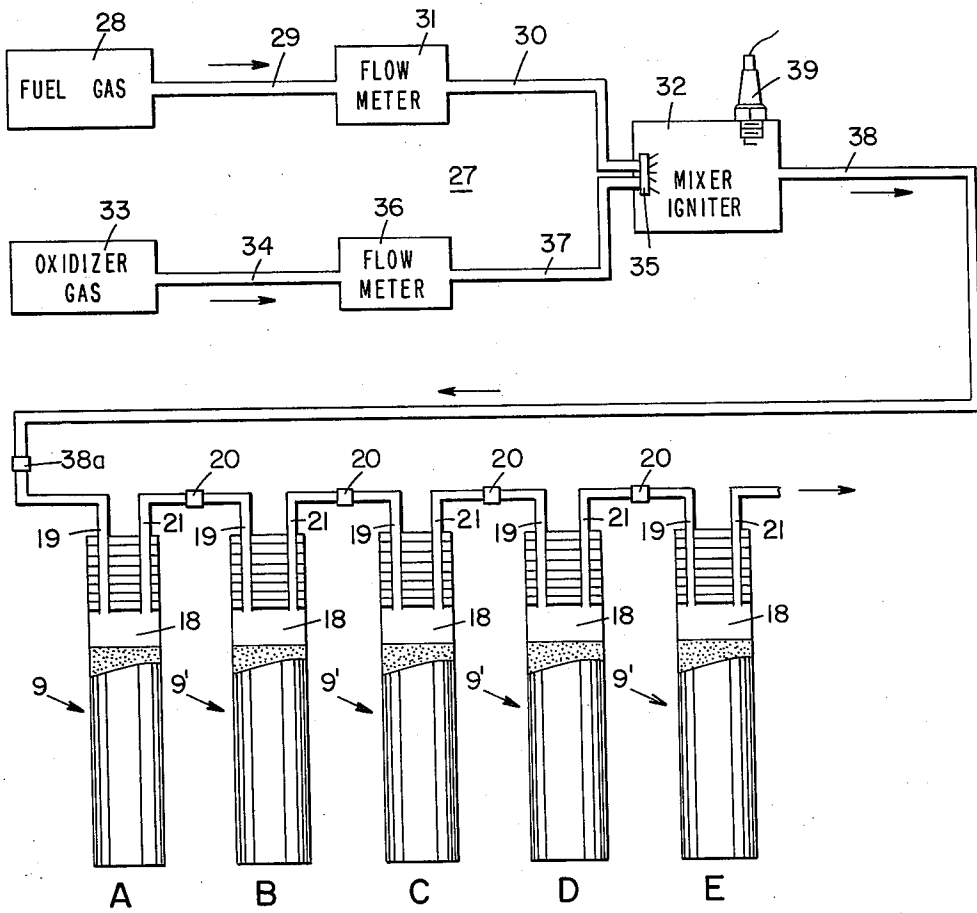


FIG. 4

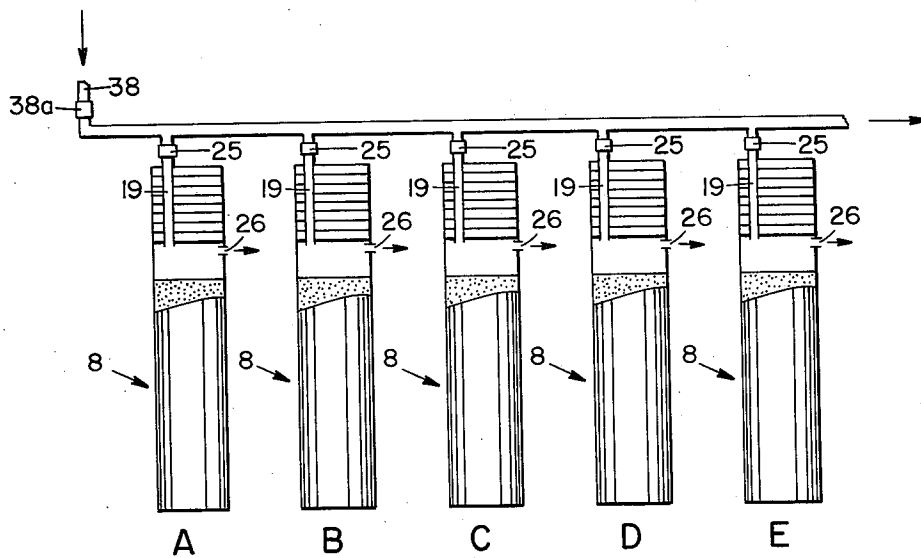


FIG. 5

THERMAL DETONATION ENERGY-INITIATABLE BLASTING CAPS, AND DETONATION SYSTEM AND METHOD

This invention relates to nonelectric blasting caps initiated by explosive energy from detonation of an explosive gas mixture. In one aspect, this invention relates to a detonator system, including a plurality of blasting caps above described, together with means for emplacing an explosive gas mixture in initiating relationship therewith and then detonating the gas mixture. A further aspect of the invention relates to a method including detonation of a stream of an explosive gas mixture after emplacing it for detonation in ignition relationship with a responsively ignitable initiator charge(s) for the initiation of one or more main charges. Other aspects will be apparent in light of the accompanying disclosure and the appended claims.

Nonelectric blasting caps generally comprise a closed shell loaded with base, primer and ignition charges in that order, often with a delay charge intermediate the primer and ignition charges, for initiation by action of a detonator cord extending into the cap shell in ignition relationship with the ignition system. The primer charge is detonatable in response to burning of the delay, or ignition, charge and the base charge is detonatable in response to detonation of the primer charge. The delay charge, or fuse, is disposed to burn over a predetermined time duration to delay communication of the ignition charge with the primer for the detonation. Other types of nonelectric type blasting caps include those such as of the squib or deflagrating types, in which the ignitable initiator charge can be the only charge in the blasting cap, or it can be operatively associated with one or more additional charges.

In the utilization of detonator cord type initiators in the initiation of delay blasting caps, the resulting force of detonation causes rupture of the cap shell often with undue venting of heat and pressure developed in the ignition area with failure to ignite the delay fuse and hence failure of the shot. Often, the choice of main explosive charge to be detonated by a detonator cord type initiator is limited to that which is not directly responsive to detonation of the cord. Further, a detonator cord type initiator often functions to prepressurize the explosive, thus resulting in decreased energy from the main charge. Still further, detonation utilizing a detonator cord type initiator is extremely noisy and is the subject of many complaints associated with blasting operations; and detonator initiator cord, PETN (or equivalent) filled, is subject to all precautionary measures required for handling explosives, and is, of course, subject to shipping restrictions.

This invention is concerned with a nonelectrically initiated blasting cap assembly, a nonelectrically initiated detonator system, and a method for nonelectrical initiation, providing for the elimination of numerous problems associated with the use of detonator cord type initiators.

In accordance with the invention, a nonelectrically initiated blasting cap is provided which comprises a shell; an initiator charge in said shell ignitable in response to action of thermal detonation energy of an explosive gas mixture; a first conduit means extending into said shell in communication with said initiator charge so as to convey an explosive gas mixture as a confined stream into detonating position for responsive

ignition of said initiator charge; and a second conduit means extending from the zone of said communication to the outside of said shell, whereby a stream of said explosive gas mixture can be continuously passed from said first conduit means through said zone of communication and through said second conduit means to purge said zone of gases other than said explosive gas mixture and thereafter explosive gas mixture in said first conduit means can be detonated for propagation of resulting thermal detonation energy to said communication zone for ignition of said initiator charge.

The second conduit means, above described, is generally a tubular member extending through an end, or side wall, of the shell so as to convey an exit flow of the explosive gas mixture from the zone of communication in the shell during the purge, and to an adjacent, and similar, blasting cap, when a plurality of such blasting caps are components of a detonator system described more fully hereinafter. However, in another embodiment, the second conduit means is a passageway, or opening, through a side wall of the cap shell thus similarly providing the exit flow of explosive gas mixture from the shell for the purging action.

In now preferred practice, a blasting cap of the invention comprises a closed elongated shell, including a plug end closure member; base, primer and ignition charges, with or without a delay charge intermediate the primer and ignition charges, extending in that order toward the plug closure from the opposite shell end, and said ignition charge spaced from said ignition plug to provide a resulting intermediate open space; a first tube extending into said shell through the plug closure and terminating in direct communication with said open space; and a second tube extending from the above described open space through at least a portion of the plug closure to the outside of said shell.

Further in accordance with the invention, a detonator system for one or more main charges is provided which comprises a plurality of spaced apart nonelectrically initiated blasting caps, each said blasting cap comprising (1) a shell, (2) an initiator charge in said shell ignitable in response to action of thermal detonation energy of an explosive gas mixture, (3) a first conduit means extending into said shell into communication with said initiation charge so as to convey an explosive gas mixture as a confined stream into detonating position for responsive ignition of said initiator charge, or to convey said explosive gas mixture as a purge stream for the zone of said communication and (4) a second conduit means extending from said zone to the outside of said shell for egress purge flow of the explosive gas mixture from said zone; a third conduit means external to said plurality of blasting caps connecting through each said first conduit means for conveying a confined stream of said explosive gas mixture thereinto; and means for detonating said explosive gas mixture when confined in said third conduit means.

Further in accordance with the invention, a method is provided for initiating a nonelectric blasting cap for the detonation of a main charge, wherein said blasting cap contains an initiator charge ignitable in response to action of thermal detonation energy of an explosive gas mixture, said method comprising passing an explosive gas mixture into said blasting cap and into operative communication therein with said initiator charge for detonation and responsive ignition of said ignition charge and then from the zone of said communication

to the outside of said blasting cap to purge said zone of gases other than said explosive gas, thereafter retaining said explosive gas mixture as a confined stream along the path of said purge and detonating same upstream from said blasting cap, and propagating resulting thermal detonation energy along said path into ignition relationship with said initiator charge.

The invention is further illustrated with reference to the drawings of which

FIG. 1 illustrates a zero delay type blasting cap of the invention, including a pair of tubular members supported in an ignition plug end closure for ingress and egress of the explosive gas mixture during the purge operation, and thereafter for ingress of thermal detonation energy from detonation of the explosive gas mixture;

FIG. 2 is a delay type blasting cap otherwise the same as that of FIG. 1;

FIG. 3 is the same as FIGS. 1 or 2 except that in lieu of the egress flow tube, an open passageway is disposed in the side wall of the shell for egress of the explosive gas mixture during the purge operation;

FIG. 4 illustrates a plurality of any of the blasting caps of FIGS. 1 and 2 as elements of a detonator system of the invention;

FIG. 5 is the same as FIG. 4 except that it illustrates a plurality of blasting caps of FIG. 3;

FIG. 6 illustrates an embodiment of blasting system of the invention including a plurality of blasting caps of either or both of FIGS. 1 and 2 supported for detonation of a series of separate main explosive charges; and FIGS. 4-6 particularly illustrate method of the invention. Like parts in the drawings are designated by like numbers.

Referring to FIG. 1 elongated shell 10 of zero delay type blasting cap 9 is integrally closed at bottom end 11 and is closed at the opposite end 12 by ignition plug end closure 13. Base explosive charge 14, primer charge 16 and ignition charge 17 extend in that order in shell 10 from bottom end 11 toward closure plug 13, and ignition charge 17 is spaced from inner face 13' of plug 13 to provide resulting intermediate void space, or cavity, 18.

A first tube 19 extends from outside shell 10 through plug closure 13 into communication with charge 17 through void space 18. A second tube 21 extends through plug 13 from a point in communication with void space 18 to a point outside shell 10.

Base charge 14 is detonatable in response to detonation of primer charge 16 and primer 16 is detonatable in response to ignition of ignition charge 17. Base charge 14 is any suitable high explosive charge such as PETN, RDX, Tetryl, or the like, for detonation to produce explosive energy for detonation of a main explosive charge in detonating relationship therewith. Exemplary of primer charges 16 are diazodinitrophenol, often a diazodinitrophenol system of the well known type including a top layer for ignition in response to ignition of the charge 17 and a lower-and higher-density layer detonatable in response to ignition of the top layer. Further exemplary primer charges 16 are diazodinitrophenol/potassium chlorate, lead azide and mercury fulminate. Ignition charge 17 is any suitable charge utilized in an ignition/primer/base charge blasting cap assembly, with or without a delay charge intermediate the ignition and primer charges, and ignitable in response to action of thermal detonation energy of

an explosive gas mixture, illustrative of which are lead-selenium, lead-tin/selenium, tin/selenium, red lead/iron, and lead oxide/manganese.

Tube 19 is generally a plastic tube, as for example 0.103 inch OD by 0.060 inch ID and formed from polyethylene; and confines a stream of the explosive gas mixture for flow into void space 18; and tube 21 is the same, or similar in design and composition to tube 19. Tube 21, in communication with void space 18, serves to convey a stream of explosive gas mixture from void space 18, during the purging operation and, as an element of the detonator system of the invention, to direct propagating detonation energy from open space 18.

In the operation of blasting cap assembly 9, a stream of an explosive gas mixture such as a mixture of oxygen with a fuel such as manufactured gas, acetylene, hydrogen, or hydrogen/methane, is passed into open space 18 through tube 19 and is thus emplaced so that, upon detonation, the resulting thermal detonation energy propagates into ignition relationship with ignition charge 17. Prior to ignition of charge 17, substantially all gas initially present in open space 18 must be replaced by the explosive gas mixture from tube 19, and that is accomplished by passing a stream of the explosive gas through tube 19, open space 18 and then tube 21 to purge the open space 18 free from such initially present gas.

FIG. 2 illustrates another embodiment, which is the same as that of FIG. 1 except that the blasting cap 9' is of the delay type and contains a delay fuse assembly 22 intermediate the ignition 17 and primer 16 charges. Often charge 17 of FIG. 2 differs in composition from that of FIG. 1 to the extent necessary to assure a sufficiently hot ignition for delay fuse 23, which is conventionally disposed as a core 23 in a swaged metal tube 24 in ignitable relationship with ignition charge 17 and in detonating relationship with primer 16. Often, in a delay cap system such as of FIG. 2, a wafer type charge (not specifically shown) which has a higher heat of reaction than that of charge 17 and serves as a supplemental source of heat for ignition of the delay fuse, is positioned subjacent charge 17. Such wafer type charges are generally utilized in combination with longer burning and hence less ignition sensitive delay charges as disclosed in U.S. Pat. No. 3,776,135.

FIG. 3 illustrates a blasting cap 8 which is the same as the blasting caps of FIGS. 1 and 2 except that in lieu of the tube 21, a conduit, or passageway 26, extends from open communication with cavity 18 through a side wall of shell 10.

Referring to FIG. 4, a series of five blasting caps A-E inclusive, can be any of blasting caps 9 and 9' of FIGS. 1 and 2, each for being disposed in detonating relationship with a booster or main explosive charge (neither shown) and are in series with the discharge line from a gas mixing and ignition system 27, comprising fuel gas supply 28 connecting through line 29, gas flow control meter 31 and line 30 with gas mixing/ignition chamber 32; and oxidizer gas supply 33 connecting through line 34, flow control meter 36 and line 37 with gas mixing/ignition chamber 32.

In operation of the system 27, a suitable fuel gas, generally a manufactured gas, or hydrogen, is passed from supply 28 via line 29, through flow meter 31 which in turn controls the requisite rate of flow and pressure of fuel gas through line 30 to mixing chamber 32 for mixing therein with oxidizer gas from supply 33. Similarly

the oxidizing gas is passed from supply 33 via line 34, through flow meter 36 which in turn controls the requisite rate of flow and pressure of oxidizer gas through line 37 in the required proportions for the mixing step in chamber 32. The relative proportions of fuel and oxidizer are predetermined to provide an explosive gas mixture which is then ignited in chamber 32 by spark generated by action of spark plug 39 operatively extending into chamber 32 for that purpose.

Conduit 38 extends from chamber 32 and connects through a suitable collar, or sleeve, type connector 38a with inlet tube 19 of a first blasting cap 9 of the series A-E to convey flow of the explosive gas mixture from chamber 32 through tube member 19, void space 18 and exit flow tube 21, and in series through each of the successive caps B-E to thereby purge each void space 18 of substantially all gas other than that from line 38. Tube 21 of each of blasting caps 4A-D connects with tube 19 of the succeeding blasting cap of the series A-E by any suitable means, such as by a plastic collar, or sleeve, connector 20.

In the purge, the stream of explosive gas mixture from line 38 is passed in series through tube 19, open space 18 and tube 21 of each of caps A-E; and the flow of explosive gas through the series A-E is maintained for a time duration sufficient to complete the requisite purge of all blasting cap cavity portions 18, generally a period of at least about one minute often from five to ten minutes dependent upon the flow variables involved.

Upon completion of the purging action, and with the flow of the explosive gas mixture in line 38 at the desired pressure and flow rate levels, the ignitor member 39 is actuated, and, by action of the spark, the explosive gas mixture thus emplaced for detonation and responsive ignition of the ignition charge, is detonated. Check valve system 35 in chamber 32 precludes back pressure flow of explosive energy into the upstream flow and supply stream. The detonation wave front then travels, confined in line 38 and each of tubes 19 and 21 through each cavity 18 in series A-E. Although at the end of the purge period, the explosive gas mixture flow is generally continued through line 38 for the detonation, the flow can be terminated for subsequent detonation of the emplaced, but nonflowing, explosive gas mixture.

In some instances one or more of the tubes 19 and 21 may fail to confine the explosive energy, in which event the detonation rate of the particular explosive gas is sufficiently high to permit the detonation wave front to travel ahead of the tube breakage so that the latter does not preclude series travel of the detonation wave front through the series of caps.

FIG. 5 illustrates another embodiment of detonator system of the invention the same as that in FIG. 4 except that blasting caps 8 of FIG. 3 are in lieu of those of FIGS. 1 or 2. In the embodiment of FIG. 5, a continuous stream of an explosive gas mixture from chamber 32 is passed through line 38 as a manifold supply connecting by suitable connector means, such as a collar or sleeve 25, with each of the caps A-E respectively to supply a stream of explosive gas mixture through each tube 19 into each corresponding void space 18A-E; and in lieu of the series type purging action of FIG. 4, the explosive gas mixture from each void space 18 is discharged therefrom through the conduit, or opening, 26 in a side wall of each cap assembly. As in FIG. 4,

after the requisite purging period, the explosive gas mixture in line 38 is detonated by action of spark generation means in chamber 32. The detonation front then travels along line 38 through each tube 19, to, in each instance, emplace the resulting thermal detonation energy in ignition contact with the ignition charge.

Referring to FIG. 6, each of the separate bore holes 41, in earth formation 40, of FIGS. 6A-C is loaded with any suitable cap-insensitive main explosive charge 42 such as an aqueous gel type explosive, a dynamite, prills/fuel oil, or the like. A pair of suitable boosters 43 is embedded in each of the main explosive masses. Each booster is cap-sensitive and is in detonating relationship with the main explosive charge adjacent thereto, and is initiated by action of a blasting cap system of the invention such as that of FIG. 4.

Thus in each bore hole 41A of FIG. 6, two booster units 43, e.g. each 500 grams of PETN, tetryl or the like, are embedded, and spaced apart, in explosive mass 42 to provide for detonation of the main explosive charge along its entire length. Each booster unit 43 contains a blasting cap 9 or 9' of FIGS. 1 or 2. The explosive gas mixture from chamber 32 is supplied via line 38 and passed in series through the entire plurality of blasting caps 9 and/or 9' in the separate booster charges in the three bore holes via tubes 19 and 21 of each blasting cap, as illustrated with reference to FIG. 4. The flow of explosive gas mixture from line 38 in series through the entire plurality of blasting caps in the bore holes 41A-C is continued until each void space 18 is substantially free from initially present gas, after which the flow of the explosive gas mixture stream is terminated or continued as desired, followed by detonation of the gas in chamber 32 and travel of the detonation wave front in series through each of the blasting caps in ignition relationship with the ignition charge therein. Dependent on whether a main charge is reliably cap-sensitive, a booster charge(s) may not be required, in which event one or more of the blasting caps are embedded directly in the main charge, and are purged and detonated.

The system of FIG. 6 containing delay caps regulates the burning time of each delay fuse and hence the delay between shots in each bore hole including when desired, a progressively longer delay time along the entire series of boosters in the bore holes of FIG. 6.

Although the invention is specifically illustrated with reference to delay and nondelay type blasting caps utilizing an ignition charge in combination with primer and base charges, with or without an intermediate delay charge, it is to be understood that the invention is applicable to blasting cap assemblies in which the initiator charge is the only charge in the blasting cap, or is utilized with one or more additional charges, exemplary of which blasting caps are those of the deflagrating or squib type. Hence, although ignition charges such as those hereinabove described with reference to the drawings are generally utilized in practice of the invention, other initiator charges often advantageously utilized include such as diazodinitrophenol, lead azide, tetrazine, HMX and RDX.

The invention is further illustrated with reference to the following examples.

EXAMPLE I

A stream of manufactured gas Type B comprising, on a volume basis, 24% methane, 3% ethane, 18% carbon

monoxide, and 55% hydrogen, was passed at a rate of 1.5 liters per minute at 50 psi together with a separate stream of oxygen at the rate of 1.5 liters per minute at 50 psi into a mixing chamber to form a resulting explosive gas mixture which was then passed from the mixing chamber through 100 feet of 0.25 inch OD by 0.125 inch ID polyethylene tubing and then in series through 108 blasting caps of the type specifically illustrated with reference to FIGS. 1 and 2. In each blasting cap, each tube 19 and 21 was 0.103 inch OD by 0.060 inch ID and formed from polyethylene; and extended two feet from the top of the ignition plug. Each tube connector, i.e. for each tube 21-19 connection, was a polyethylene collar type connector illustrated with reference to FIG. 4.

Of the 108 caps, 20 were zero delays (avg. firing time 12 ms) having the configuration of FIG. 1 and the remaining caps were of the configuration of FIG. 2 except that a wafer type charge intermediate the ignition and delay charges, was utilized as a supplemental source of heat for ignition of the delay charges. Burning times of the cored delay charges of the remaining 88 blasting caps were varied which in the order of the firings were 21 caps having an average burning time of 1 second, 21 having an average burning time of 2.9 seconds, 21 having an average burning time of 4.5 seconds and 25 having an average burning time of 9 seconds. After purging the series of caps, as illustrated with reference to FIG. 4, over a period of 2½ minutes, the resulting explosive gas mixture was initiated upstream from the caps by spark generated as illustrated with reference to FIG. 4. All caps in the series fired in their assigned time order.

In each of the 108 blasting caps, the base charge was 0.40 gram PETN and the primer charge was 0.30 gram diazodinitrophenol, of which 0.06 gram was pressed on an open end capsule at a density of about 1.6 grams per cc. and the remainder was contained in the capsule at a density of about 1.10 grams per cc. In all caps the ignition charge was PbSn-Se 72/28 of which each zero delay cap contained 0.6 gram and each delay cap contained 0.4 gram. In all delay caps the wafer charge was Fe₂O₃/Al/B/PbSn/Se/Snow Floss (15.0/12.0/2.5/48.6/18.9/3.0), 0.20 gram; and the delay charge was BaO₃/Te/Se (40/40/20) in amount and length providing the respective 1, 2.9, 4.5 and 9 second average burning times.

EXAMPLE 2

A plurality of various explosive gas mixtures were fed, as a purge, through 100 feet of ¼ inch OD by ¼ inch ID polyethylene tubing having a wall and through two zero delay blasting caps of FIG. 1 spaced apart a distance of five feet by the same type ¼ inch tubing, as illustrated with reference to FIG. 4. After the purging action, the gas mixtures were detonated upstream from the delay caps as illustrated in FIG. 4, and the time between the firing of the two caps was basis for calculation of the detonation rate of the explosive gas mixture. Results of the tests are summarized as follows:

Detonation Rate of the Various Gas Mixtures

Oxygen Feed Rate liter/min.	Fuel Gas	Fuel Gas Feed Rate liter/min.	Avg. Det. Rate meters/second
2.0	Hydrogen	4.87	3050

-Continued

Detonation Rate of the Various Gas Mixtures

Oxygen Feed Rate liter/min.	Fuel Gas	Fuel Gas Feed Rate liter/min.	Avg. Det. Rate meters/second
1.4	Acetylene	1.4	3500
1.4	Propane	.25	2746
6.0	Methane	2.0	969

EXAMPLE 3

The procedure of Example 1 was repeated except that an oxygen flow rate of 0.2 liter per minute was utilized with a flow rate of manufactured gas Type B at 0.2 liter per minute in series with 99 delay blasting caps of FIG. 2 each delay charge having an average burning time of 9 seconds. Ninety-eight of the shots fired and the unsuccessful shot was found to be due to a break in the delay fuse column.

Although any suitable explosive gas mixture can be utilized in practice of the invention, those having relatively high detonation rates, such as at least about 2,000 meters per second are often advantageously utilized; and when a spark generating system, such as illustrated with reference to FIG. 4, is utilized, the preferred explosive gas mixture is one which yields carbon monoxide and carbon dioxide upon detonation to aid in sweeping water from the mixing and ignition system which would otherwise foul and corrode the spark generation element. Accordingly, any suitable organic fuel gas/oxygen/hydrogen is now a preferred explosive gas mixture utilized, including such gas mixture as manufactured gas Type B, and oxygen/methane/hydrogen mixtures.

It is to be understood that when referring herein to the term "thermal detonation energy," it is meant heat and flame produced by the detonation of the explosive gas mixture.

As will be evident to those skilled in the art, various modifications can be made or followed, in light of the foregoing disclosure and discussion, without departing from the spirit or scope of the disclosure or from the scope of the claims.

What I claim and desire to protect by Letters Patent is:

1. A nonelectrically initiated blasting cap which comprises a closed shell; an initiator charge in said shell ignitable in response to action of thermal detonation energy of an explosive gas mixture and said shell containing an open space adjacent said initiator charge; a first conduit means extending from outside said shell into said open space in direct open communication with said initiator charge so as to convey an explosive gas mixture as a confined stream into detonating position in said open space for responsive ignition of said initiator charge; a second conduit means permitting said open space to be purged of gases other than said explosive gas mixture prior to detonation of said confined stream for said responsive ignition extending from said open space to the outside of said shell, whereby a stream of said explosive gas can be continuously passed from said first conduit means through said open space and through said second conduit means to purge said open space as described and thereafter explosive gas in said first conduit means can be detonated for propagation of resulting thermal detonation energy to said open space for ignition of said ignition charge.

2. In a blasting cap of claim 1, said shell being elongated, and a plug closure member therefor; an ignition charge, as said initiator, in spaced apart relationship with said plug to provide said open space; base, primer and said ignition charges, with or without a delay charge intermediate said primer and ignition charges, extending in that order toward said plug closure and said first conduit means comprising a tube extending from outside said shell through said plug closure and opening into said open space.

3. In a blasting cap of claim 2, said second conduit means comprising a passageway in a side wall of said shell.

4. In a blasting cap of claim 2, said second conduit means comprising an additional tube extending through said plug closure.

5. A detonator system for detonation of one or more main charges comprising a plurality of spaced apart nonelectrically initiated blasting caps, each said blasting cap comprising (1) a closed shell, (2) an initiator charge in said shell ignitable in response to action of thermal detonation energy of an explosive gas mixture and said shell containing an open space adjacent said initiator charge; (3) a first conduit means extending from outside said shell into said open space in direct open communication with said initiator charge so as to convey an explosive gas mixture as a confined stream into detonating position in said open space for responsive ignition of said ignition charge, or to convey said explosive gas mixture as a purge stream for said open space, and (4) a second conduit means extending from said open space to the outside of said shell for egress purge flow of said explosive gas mixture from said open space prior to detonation of said confined stream for said responsive ignition; a third conduit means external to said plurality of blasting caps connecting through each said first conduit means for conveying a confined stream of said explosive gas mixture thereinto; and means for detonating said explosive gas mixture when confined in said third conduit means.

6. In a detonator system of claim 5, each said blasting cap shell being elongated and a plug closure member therefor; an ignition charge, as said initiator charge, disposed in each said shell in spaced apart relationship with said closure plug therein to provide said open space; base, primer and said ignition charges in each said shell, with or without a delay charge intermediate said primer and ignition charges; extending in that order toward said plug closure; and said first conduit means in said each shell extending from outside said shell through said plug closure and opening into said open space.

7. In a detonator system of claim 6, each said blasting cap containing as said first conduit means a first tube extending through the closure plug thereof, and as said second conduit means a second tube extending through said closure plug.

8. In a detonator assembly of claim 6, each said blasting cap containing as said second conduit means a passageway in a side wall of the shell.

9. In a detonator system of claim 7 said third conduit

means connecting with said first tube of a first of a series of said blasting caps, and said first tube of each succeeding blasting cap connecting with said second tube of a preceding blasting cap so as to dispose said blasting caps for series flow of confined, or purging, gas therethrough.

10. In a detonator system of claim 8, said third conduit means extending outside said plurality of blasting caps, and the first conduit means of each blasting cap connecting in open communication with said third conduit means so as to receive a separate flow of said explosive gas mixture therefrom.

11. In a detonator system of claim 10, means for detonating said explosive gas mixture when confined in said third conduit means upstream from said blasting caps.

12. In a detonator system of claim 7, said shell of each said blasting cap being integrally closed at one end, and an ignition plug, as said plug closure, closing said shell at the other end; base, primer, delay and said ignition charges in each said blasting cap extending in that order toward said ignition plug from the integrally closed shell end; as said third conduit means, a third tube connecting at one end with a source of said explosive gas mixture and at the other end with said first tube of a first of a series of said blasting caps; and said first tube of each succeeding blasting cap connecting with said second tube of a preceding blasting cap so as to dispose said blasting caps for series flow of confined, or purging, gas therethrough.

13. In a detonator system of claim 12, means for mixing oxidizer and fuel ingredients to form said explosive gas mixture connecting with said third tube as said source of explosive gas mixture.

14. A detonator system of claim 13 in detonating relationship with at least one main explosive charge.

15. A detonator system of claim 14 in which at least one said main explosive charge is cap-insensitive, and said detonator system including booster charge means for detonation of said cap-insensitive charge.

16. A method for initiating a nonelectric blasting cap for the initiation of a main charge, wherein said blasting cap contains an initiator charge ignitable in response to action of thermal detonation energy of an explosive gas mixture, said method comprising passing an explosive gas mixture into said blasting cap and into operative communication therein with said initiation charge for detonation and responsive ignition of said initiation charge and then from the zone of said communication to the outside of said blasting cap to purge said zone of gases other than said explosive gas, thereafter retaining said explosive gas as a confined stream along the path of said purge and detonating same upstream from said blasting cap, and propagating resulting thermal explosive energy along said path into ignition relationship with said initiation charge.

17. A method of claim 16 wherein said confined explosive gas is passed into and through a plurality of said blasting caps prior to detonating same.

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