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(54) THERMAL DETONATION ENERGY—INITIATABLE BLASTING CAPS, AND DETONATION SYSTEM AND METHOD

(71) We, HERCULES INCORPORATED, a Corporation of the State of Delaware, United States of America, of 910 Market Street, City of Wilmington, State of Delaware, United States of America, do hereby declare the nature of this invention and in what manner the same is to be performed to be particularly described and ascertained in and by the following statement:—

10 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
 15 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
 20 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
 25 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, after with a
 30 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,
 35 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
 40 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 nonelectric blasting cap assembly, a nonelectric 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 nonelectric blasting cap is provided which comprises a shell; an initiator charge in said shell ignitable in response to action of the thermal detonation energy of an explosive gas mixture, said shell containing an open space adjacent said initiator charge; a first conduit means extending from outside said shell into said space in direct open communication with said initiator charge so as to convey an explosive gas mixture as a confined stream into a detonating position in said open space for responsive ignition of said initiator charge; 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 comprising a second conduit means 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 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 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 the now preferred practice, a blasting cap of the invention comprises an elongated shell, having a plug end 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 the primer and ignition charges, extending in that order toward said plug closure; first conduit means comprising a first tube extending from outside said shell through said plug closure and opening into said open space. Said second conduit means may comprise a passage-way in a side wall of the shell, or an additional tube extending through said closure plug.

Further in accordance with the invention a detonator system for one or more main charges is provided which comprises a plurality of spaced apart nonelectric blasting caps according to the invention; and 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 the 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 accompanying 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/boron, and lead oxide/manganese.

Tube 19 is generally a plastic tube, as for example .103" OD by .060" 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. 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 Fig. 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 1

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" OD by 0.125" 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 .103" OD by 0.060" 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 2—1/2 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 BaO₂/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 1/4" OD by 1/8" 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 1/8" 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
75	2.0	Hydrogen	4.87	3050
	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 2000 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.

WHAT WE CLAIM IS:—

1. A nonelectric blasting cap which comprises: a shell; an initiator charge in said



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" OD by 0.125" 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 .103" OD by 0.060" 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 2—1/2 minutes, the resulting explosive gas mixture was initiated upstream from the caps by spark generated as illustrated with reference to Fig.

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1.4	Propane	.25	2746
6.0	Methane	2.0	969

Example 3

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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 2000 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.

WHAT WE CLAIM IS:—

1. A nonelectric blasting cap which comprises: a shell; an initiator charge in said



shell ignitable in response to action of the thermal detonation energy of an explosive gas mixture, 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 a detonating position in said open space for responsive ignition of said initiator charge; 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 comprising a second conduit means 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 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 initiator charge.

2. A blasting cap according to Claim 1, said shell being elongated, and having 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. A blasting cap according to Claim 2, said second conduit means comprising a passageway in a side wall of said shell.

4. A blasting cap according to Claim 2, said second conduit means comprising an additional tube extending through said closure plug.

5. A blasting cap according to any preceding Claim, 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 end closure plug.

6. A blasting cap substantially as described and shown in the accompanying drawings.

7. A detonator system for detonation of one or more main charges comprising a plurality of spaced apart nonelectric blasting caps as claimed in any preceding Claim, and 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.

8. A detonator system according to Claim 7, said third conduit means connecting with said first tube of a first 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 cap for series flow of confined, or purging, gas therethrough.

9. A detonator system according to Claim 8, with means for detonating said explosive gas when confined in said third conduit means.

10. A detonator system according to Claim 7, said third conduit means connecting at one end with a source of said explosive gas and extending outside said plurality of blasting caps, and the first tube member 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. A detonator system according to Claim 10, with means for detonating said explosive gas mixture when confined in said third conduit means upstream from said blasting caps.

12. A detonator system according to any of Claims 7 to 11 with 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.

13. A detonator system according to Claim 12, in detonating relationship with at least one main explosive charge.

14. A detonator system according to Claim 13, in which at least one said main explosive charge is cap-insensitive, and said detonator system includes booster charge means for detonation of said cap-insensitive charge.

15. A method 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 the 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 ignition 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.

16. A method according to Claim 15, wherein said confined explosive gas is passed



into and through a plurality of said blasting caps prior to detonating same.

17. A method according to Claim 15 performed with a blasting cap as claimed in any

5 of claims 1 to 6.

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