

[54] **DETONATOR ASSEMBLY, AND
BOOSTER AND BLASTING SYSTEM
CONTAINING SAME**

[75] Inventor: **Hiram E. Driscoll**, Hurley, N.Y.
[73] Assignee: **Hercules Incorporated**, Wilmington,
Del.
[22] Filed: **March 20, 1970**
[21] Appl. No.: **21,305**

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

[56] **References Cited**

UNITED STATES PATENTS

1,968,565	7/1934	Mallet	102/27
2,325,742	8/1943	Clark	102/29 X
2,652,775	9/1953	Swanson	102/29 X
2,944,485	7/1960	Ely et al.	102/24
3,021,786	2/1962	Miller et al.	102/27
3,106,892	10/1963	Miller	102/27
3,256,814	6/1966	Kruppenbach et al.	102/24
3,306,201	2/1967	Noddin	102/27
3,431,851	3/1969	Kern et al.	102/24

Primary Examiner—Verlin R. Pendegrass
Attorney—S. Grant Stewart

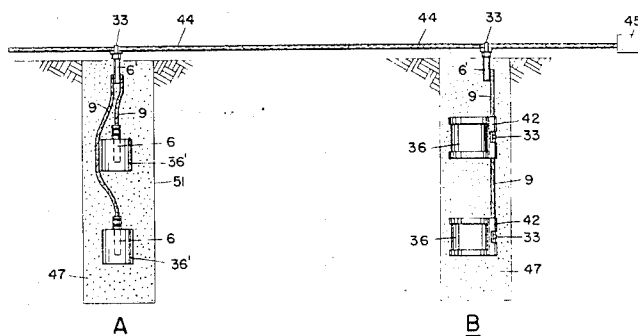
[57] **ABSTRACT**

A non-electrically initiated detonator assembly comprising a shell containing an impact-sensitive ignition composition, and a detonator cord disposed outside the shell for detonation to provide, and direct, resulting explosive energy into the shell for percussion initiation of the ignition composition. In preferred practice, the shell is closed by an empty primed rifle cartridge casing and the detonator cord is supported in operative relationship with the primer end of the casing.

Also provided is an non-electrically initiatable detonator assembly containing the impact-sensitive charge and including means for support of the detonator cord in the requisite detonating relationship.

Further provided is a booster unit containing a detonator assembly above described; and a pattern shooting system containing a plurality of the booster assemblies and providing for reduced above-the-ground trunk line noise, eliminating need heretofore for delay means in the down line(s) and providing for assembly of a plurality of boosters in each bore hole on a single down line.

11 Claims, 14 Drawing Figures



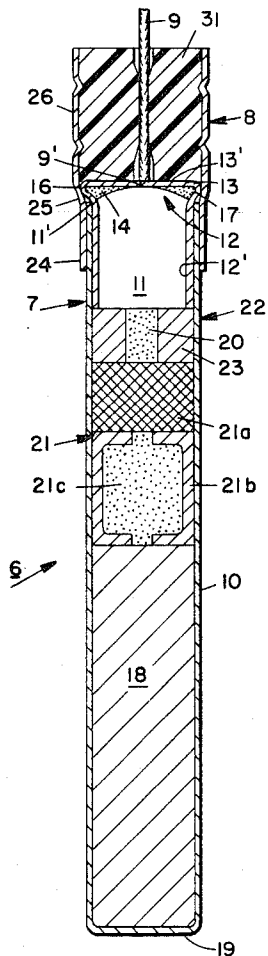


FIG. 1

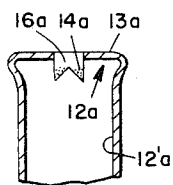


FIG. 3

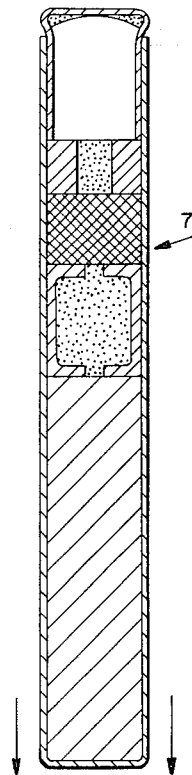


FIG. 1A

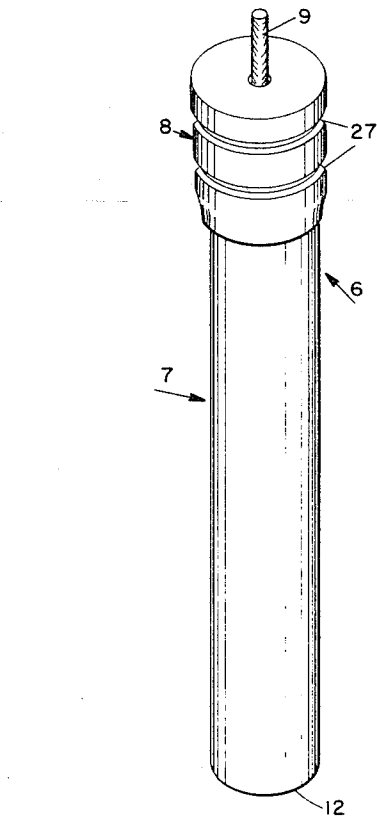


FIG. 1C

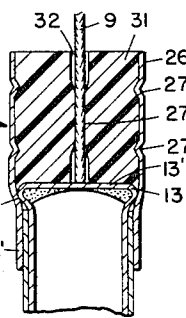
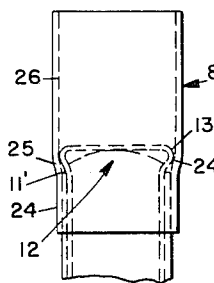


FIG. 1B

HIRAM E. DRISCOLL
INVENTOR

S Grant Stewart

BY

ATTORNEY

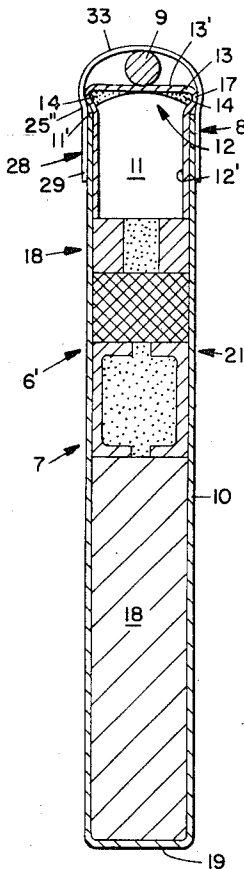


FIG. 2

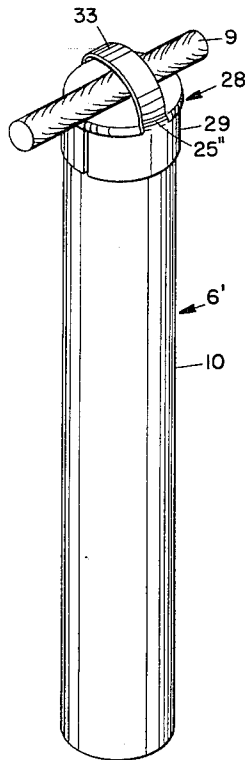


FIG. 2A

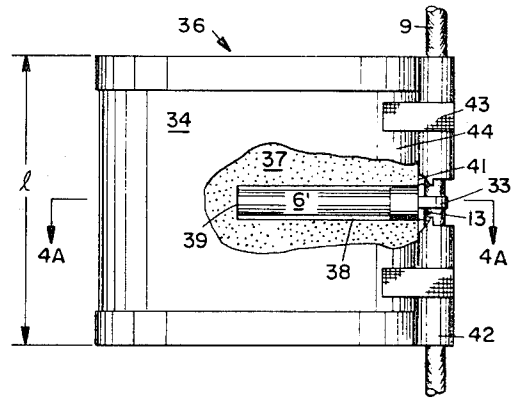


FIG. 4

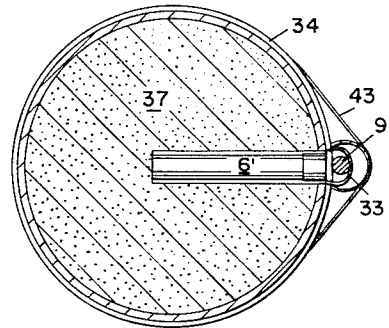


FIG. 4A

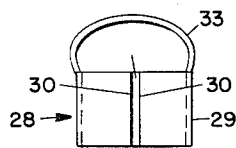
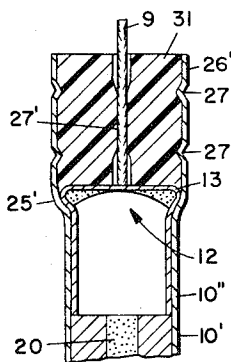


FIG. 2B

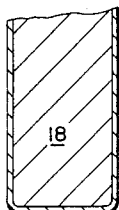


FIG. 1D

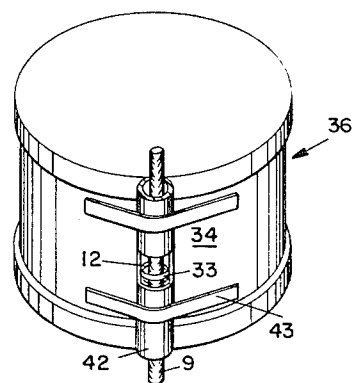


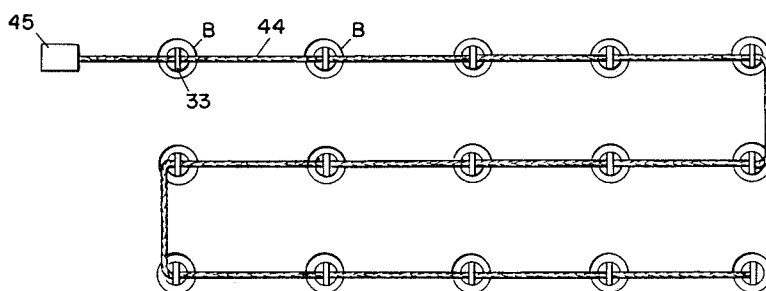
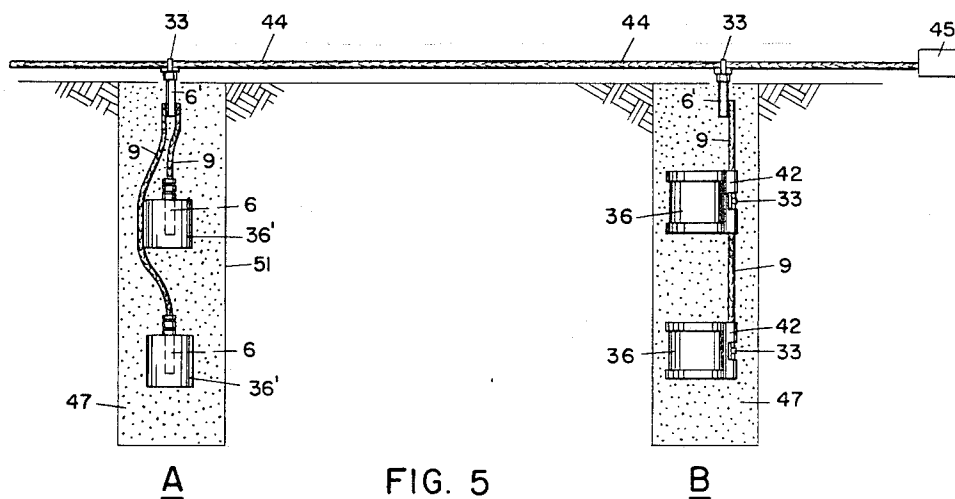
FIG. 4B

HIRAM E. DRISCOLL
INVENTOR

S. Grant Stewart

BY

ATTORNEY



HIRAM E. DRISCOLL
INVENTOR

S Grant Stewart

BY

ATTORNEY

DETONATOR ASSEMBLY, AND BOOSTER AND BLASTING SYSTEM CONTAINING SAME

This invention relates to a non-electrically fired detonator assembly including a combination of detonator cord and impact-sensitive charge as an initiator component, and particularly advantageously applied to down-line shooting systems. In one aspect, this invention relates to booster assemblies containing a detonator above described, and providing delayed non-electrical firing in a down line system without need for conventional delay means in the down line(s). In another aspect, this invention relates to trunk line-down line blasting (or shooting) systems containing one or more of such boosters and operable at reduced above-the-ground noise levels and, when desired, with fewer down lines in a bore hole containing a plurality of charges, than heretofore. In still another aspect, this invention relates to a non-electrically initiatable detonator assembly including means for operatively associating it with a detonator cord type initiator therefor. Other aspects will be apparent in light of the accompanying disclosure and the appended claims.

As is well known, detonators for explosives generally comprise a closed shell containing a base high explosive as the energy source, for detonation of a principal explosive charge, together with associated primer and initiator compositions. In operation, the ignition charge is initiated electrically or non-electrically and the remaining detonator components respond in the conventional manner.

Electrical initiation is susceptible to misfires by static electricity and stray currents, and other forms of electricity uncontrolled in the shooting environment. Non-electrical initiation of detonators has eliminated the accidental firing problem inherent in electrical firing and has involved initiation of the ignition component by action of a detonating fuse in direct contact therewith. In such practice, the detonating fuse has been extended into the detonator shell into the direct initiating contact. In that practice, water leakage at the shell-fuse interface and/or premature bursting of the shell in response to explosive force of detonation of the fuse, are often incurred with concomitant failure of the initiation. Further, assembly of such units in the field has not been feasible due to the need for insertion of the fuse into and through an open end of the shell, thus exposing the components to hand handling and to atmospheric moisture; and, precision assembly at the shell interface has not been a practical field type operation.

Patterned blasting, often also referred to as patterned shooting, involves synchronized firing of charges in a plurality of spaced bore holes; and in such systems involving non-electrical firing, the charges are initiated by energy delivered from a common above-the-ground line of detonating fuse, often referred to as a "trunk line" from which "down lines" of detonating fuse extend to the emplaced charges. In such systems it has been necessary to utilize a trunk line of sufficiently high core loading to assure detonation of the down lines. That practice has been highly objectionable due to the air blast accompanying detonation of the trunk line, and hence the inherently high above-the-ground noise level. Generally the trunk line core loading is in the order of from about 30 to 60 grains per foot (PETN

or equivalent). Further, in such trunk line-down line systems there has been the need for a separate down line for each detonator when a plurality of charges is emplaced in a single bore hole. In such operation, when more than two down lines are required, the available space is limited and the lines often become entangled to impair loading, and failure in some instances. Further, dependent upon the number of separate down lines in the bore hole, and the particular charge to be detonated, the total energy generated by detonation of the down lines is often sufficient to dead-press the charge to make it insensitive to subsequent initiation.

Any delay means required between firing of any two charges in a patterned blasting system has necessarily been inserted at requisite points in the down lines, which practice has required time-consuming handling at the shooting site, both from the standpoint of assembling the lines with associated delay means, and the susceptibility of the parts to hang-up on the bore walls during emplacement, particularly when bore hole space is at a premium.

This invention is concerned with non-electrically initiated detonator assemblies utilizing a detonator fuse, or cord, in combination with an impact-sensitive ignition charge, which are readily and reliably assembled in the field, are secured from failure ordinarily caused by premature bursting of the shell or faulty seal at the shell-fuse interface, and percussion initiatable without need for conventional impact means, are initiatable, when desired, in any suitable plurality by a single down line, provide for substantial reduction of above-ground noise inherent in conventional trunk line-down line systems, provide for blasting without often-incurred dead-press of the main explosive charge, and provide for delay initiation of a plurality of boosters in a shooting pattern without the need for conventional delay means in the down line(s). The invention is further concerned with a delay patterned down line-trunk line shooting system without the need for delay means in the down lines; and with booster type initiators providing delayed booster action in a down line system independently of down line delay means utilized heretofore.

In accordance with the invention, a detonator for explosives of the type comprising a closed shell containing an ignition composition and associated charges responsive to ignition of the ignition composition, is provided, in which the ignition composition is impact-sensitive and is supported in the shell so as to be initiated in response to force of percussion applied from outside said shell to an external surface thereof, and a detonator cord is disposed in its entirety outside the closed shell interior for detonation to provide, and direct, resulting explosive energy as said force of percussion. In some instances, it is advantageous, and in others it is required, that the impact-sensitive ignition composition be supported in confinement in the shell so as to first be compressed in response to the applied percussion force. Generally, the shell is elongated and the impact-sensitive ignition composition is supported adjacent an interior end wall of the shell so as to be initiated in response to force of percussion applied to the external surface of the shell at that end; and the detonator cord is supported adjacent that end of the shell.

In now preferred practice, the detonator shell is elongated and is closed at one end by a conventional empty

primed rifle cartridge casing with the primer charge (at the primer end) facing the closed shell interior, and with delay fuse, primer composition and base charge components spaced in that order from the primer end of the casing. The base charge is detonatable in response to detonation of the primer composition which in turn is detonatable in response to burning of the delay fuse, the latter ignitable, and burning, in response to percussion ignition of the primer charge. The empty primed rifle cartridge casing can be either rim or center-fired.

In one embodiment of preferred practice, including the empty primed cartridge casing end closure, the detonator cord, preferably of low energy loading, say in the order of from 0.1 to 25 grains per foot (PETN or equivalent), extends toward the shell and terminates substantially coaxially therewith in adjacent, and often abutting, relationship with the external primer end surface of the casing closure; and, in another embodiment, the detonator cord extends adjacently across the external surface of the primer end of the casing.

Any suitable support for the detonator cord in position for detonation to direct the explosive energy as the necessary force of percussion can be utilized. In now preferred practice, including an empty primed cartridge casing end closure, the primer end of the casing extends radially from the elongated shell axis beyond the confines of the subjacent shell portion and a tubular member is secured around the detonator shell, subjacent the radially extending primer end and extends coaxially around the primer end, in connecting and supporting relationship with suitable means adjacent the exterior surface of the primer end for, in turn, supporting the detonator cord in the requisite operating position. One form of such tubular support means includes an open end section of the extended tubular support member containing, and supporting, one end of the detonating cord in substantially abutting relationship with the exterior of the primer end of the casing; and another form includes a loop member encompassing the primer end of the casing and connecting at its ends with the subjacent tubular support member, and through which the detonator cord extends laterally in supported operative position. In another embodiment of support for the detonator cord, the detonator shell is an integral unit including an open end of enlarged cross section, and the primer end of the casing is disposed intermediate the two shell sections with the detonator cord supported, at one end, within the adjacent open end of the shell in the above described adjacent relationship with the primer end.

The invention also provides a non-electrically initiatable detonator assembly, comprising a closed shell and an impact-sensitive ignition composition supported therein, as above described, and means for supporting a detonator cord type initiator, for said assembly, outside said closed shell for detonation to provide, and direct, resulting explosive energy as the required force of percussion.

The invention further provides a booster assembly containing a detonator assembly above described to provide novel delayed pattern shooting, and a patterned shooting system containing a plurality of such booster assemblies in which there is a marked reduction in the above-the-ground noise level and in which,

when a plurality of charges are confined in a single bore hole, a single down line can be utilized.

The invention is further described with reference to the drawings in which all like parts are designated by like numbers, and of which:

FIG. 1 is a cross-sectional view of one embodiment of detonator assembly of the invention, FIGS. 1A and B illustrate means for assembling the detonator assembly of FIG. 1, and tubular means external to the shell for support of the detonator cord in operative position, FIG. 1C is a perspective view of the assembly of FIG. 1, and FIG. 1D is the same as FIG. 1 except that the detonator shell is an integral unit inclusive of an open end for support of the detonator fuse;

FIG. 2 is a cross-sectional view illustrating another embodiment of detonator assembly of the invention and is the same as that of FIG. 1 except that it illustrates alternative means for support of the detonator cord, FIG. 2A is a perspective view of the assembly of FIG. 2, and FIG. 2B is an auxiliary view of the detonator cord support member of FIG. 1, including means for emplacing it around the detonator shell;

FIG. 3 is a cross-sectional view of a conventional empty primed center-fired rifle cartridge casing that can be utilized in place of the rim-fired casing shown in each of FIGS. 1-1D, 2 and 2A;

FIG. 4 is an elevation, in part section, of a now preferred booster unit containing a detonator system of the invention, FIG. 4A is a view taken along the line A-A of FIG. 4, and FIG. 4B is a perspective view of the booster unit of FIG. 4;

FIG. 5 illustrates a trunk line-down line system of the invention including a plurality of booster charge units, above referred to, in each bore hole, FIG. A (of FIG. 5) showing emplaced booster units containing a detonator assembly of FIG. 1, and FIG. B (of FIG. 5) showing emplaced booster units containing a detonator assembly of FIG. 2; and

FIG. 6 illustrates hook-up of a plurality of bore holes of FIGS. 5A and/or 5B in a suitable trunk line-down line shooting pattern.

Referring to FIG. 1, detonator assembly 6 comprises percussion initiatable detonator 7 supported in tubular support member 8 in operable communication with a detonator cord 9, as a source of energy for percussion initiation of detonator 7. Detonator 7 comprises closed elongated shell 10 containing ignition, delay, primer and base charge compositions as further described herein. Shell 10 is closed at top end 11 by a conventional rim-fired empty primed rifle cartridge casing assembly 12 coaxially extending into shell 10 through top end 11, open, and casing 12', end first, with primer end 13 disposed across top end 11 as a closure therefor and containing conventional impact-sensitive primer charge 14 supported for rim-firing, in peripheral cavity 16. Cartridge casing 12' is disposed in close interference, watertight fit with the inner wall of shell 10. Primer end 13 adjacent terminating peripheral end 11' of shell 10 is adjacent, and generally seated against, shell end 11', the latter functioning as an anvil to facilitate ignition of charge 14 in response to percussion force for the requisite percussion initiation. Primer end 13 extends radially from the axis of shell 10 beyond the confines of shell 10 to form peripheral lip 17 protruding beyond the outer side wall of shell 10 for as-

sociation with tubular support member 8 described more fully hereafter.

High explosive charge 18 is disposed in closed end 19 of shell 10, opposite primer end 13. Primer composition 21 in shell 10 is any suitable primer type composition intermediate high explosive charge 18 and primer charge 14, the latter in cavity 16 of primer end 13. Delay fuse assembly 22 contains a slow burning composition as a delay fuse core 20 supported in lead tube 23 and is of the type conventionally used as a delay element in electric blasting caps. Delay assembly 22 is disposed intermediate primer composition 21 and primer charge 14. Delay composition 20 is ignitable in response to direct contact with flame emitted from ignition of primer charge 14 and is spaced from charge 14 in such ignitable relationship therewith. The primer composition of assembly 21 is ignitable (21a) and detonatable (21c) in response to heat and flame emitted from burning of delay fuse composition 20 and is disposed adjacent delay fuse composition 20 in such detonating relationship therewith. High explosive charge 18 is detonatable in response to detonation of the primer composition of assembly 21 and is disposed adjacent assembly 21 in that detonating relationship.

In preferred practice, and as specifically illustrated, primer assembly 21 comprises two diazodinitrophenol portions 21a and 21c. Wafer 21a is pressed above, and superposed on, elongated capsule 21b, which extends within, and substantially coaxially with, shell 10 in closing or near closing relationship therewith. Capsule 21b is open at each end and is superposed on base charge 18 and contains the second diazodinitrophenol charge portion 21c of density lower than that of wafer 21a. Diazodinitrophenol wafer 21a is ignitable in response to contact with flame from ignition of delay fuse 20 and the second charge portion 21c is detonatable in response to heat developed by ignition of wafer charge 21a to thereby in turn cause detonation of base charge 18.

When utilizing an empty primed rim-fired or center-fired rifle cartridge casing as an end closure for the detonator assembly, the rifle cartridge casing 12' portion can be of any desired length, such as in the order of about three-eighths inch. From about 3 to 4 grains of the primer charge 14 is generally contained in the cavity 16 although the amount is variable, dependent upon the particular detonator requirements. The detonator 7 is generally cylindrical, and generally from about 1 to 5 inches in length by about 0.190 to 0.450 inch in diameter.

The amount of high explosive 18 in the detonator assembly 7 of FIG. 1 is often greater than that utilized as base charge in a conventional No. 6 or 8 blasting cap. For example, the amount of PETN, as charge 18 in FIG. 1, is generally in the order of from about 0.2 to 2.0 grams as compared with about 0.4 gram utilized as base charge in a conventional No. 8 electric blasting cap. The amount of primer composition, e.g., charge 21a plus 21c, is generally about the same as utilized in a conventional No. 8 blasting cap, e.g., from 0.10 to 0.5 gram.

The detonator element 7 can be assembled in any suitable manner such as by insertion of an empty primed rim-fired or center-fired rifle cartridge casing into the open end 11 of a fuse cap of standard design

containing the requisite delay, primer and base compositions, i.e., which comprises an elongated shell containing a base explosive charge and primer and delay compositions superposed thereon and containing an empty (open) end portion, adjacent the delay, normally intended for accepting a detonator fuse.

Although the detonator 7 of FIG. 1 is illustrated with reference to a rim-fired closure assembly 12, any suitable percussion initiating means can be utilized, a particularly now preferred alternative being a center-fired cartridge casing of conventional design shown in FIG. 3, which is the same as assembly 12 of FIG. 1 except that the impact-sensitive ignition composition, i.e., the primer charge, is supported in the conventional manner at the center of the primer end; and parts of FIG. 3 corresponding to those of FIG. 1 are designated by the same, but lettered, numbers.

Any suitable base charge 18 and primer assembly 21 can be utilized in the detonator of FIG. 1, as for example, a base explosive charge 18 such as pentaerythritol tetranitrate, pentolite, cyclonite, tetryl, RDX, cyclotol, and the like; and a primer composition such as diazodinitrophenol, lead azide and mercury fulminate. Primer charge 14 components include potassium perchlorate, lead styphnate, mercury fulminate, antimony sulfide, and lead azide, and mixtures of such materials as are well known in the munitions art and often utilized as "primer" charge in 0.22 caliber rifle cartridges. Delay fuse compositions 20 of the core or wafer type, include those normally utilized in the delay blasting cap art including lead oxide/boron, 98/2; red lead/boron, 98/2; barium peroxide/tellurium/selenium, 40/40/20; barium peroxide/selenium, 84/16; barium peroxide/tellurium, 60/40; red lead/boron/snow floss, 73/7/20; and barium peroxide/tellurium/selenium/solder powder, 30/30/15/25. The delay fuse composition of core or wafer type is generally pressed into the shell at say about 5000 p.s.i.

Low energy detonator cord 9, external in its entirety to the closed interior of shell 10, extends into direct operative communication at its terminating end 9' with the exterior surface 13' of primer end 13 for detonation to provide resulting explosive force for percussion impact against primer end wall 13' to responsively ignite charge 14 in cavity 16.

In the embodiment shown, detonator cord 9 extends toward primer end 13 into direct, and abutting, contact with primer end 13 at a central, generally substantially coaxial, point thereon and is supported, as it extends toward primer end 13, coaxially within tubular support member 8, by suitable packing 31, as further illustrated herein below.

Tubular support member 8 is formed from two connecting end sections 24 and 26 having different diametric cross sections. The forward tubular connector section 24 has an inside diametric cross section less than the outside diametric cross section of primer end 13 but greater than the outside diametric cross section of shell 10; and the rearward end section 26 of member 8 has a diametric cross section slightly greater than that of primer end 13. The two tubular sections 24 and 26 terminate their adjacent ends in spaced apart planes perpendicular to the longitudinal axis of the shell, and connect at their adjacent ends by wall portion 25 extending rearwardly and laterally, from tubular section

24 and around primer end 13 to tubular section 26 so as to form a seat support for primer end 13 at, and beneath lip 17. Alternatively, the adjacent ends of sections 24 and 26 can terminate in a common plane perpendicular to the shell axis with seating of primer end 13 on the laterally extending, and connecting, shell wall portion.

As illustrated with reference to FIGS. 1A and 1B, detonator 7 can be assembled, as described hereinabove, and then inserted, base end 19 first, coaxially into rearward section 26 of tubular connector 8 and then with continued insertion through forward tubular section 24 until primer end 13 is seated on wall portion 25, as shown with reference to the dotted lines, and arrows, of FIG. 1A. A suitable plastic material 31, such as neoprene, silicon rubber, natural rubber, or polyvinyl chloride, is disposed in tubular section 26 of connector 8, as shown with reference to FIG. 1B and contains axially disposed bore 32, and with detonator fuse 9 extending into and through bore 32 into abutting relationship with the exterior surface 13' of primer end 13. Detonator cord 9 is supported in bore 32 by crimps 27 imposed peripherally about the exterior of tubular section 26 with resulting indentation 27' against detonator cord 9 to rigidly support cord 9 in the requisite, generally abutting, relationship with the primer end of the casing closure.

FIG. 1C is a perspective view of the detonator assembly of FIG. 1 assembled as illustrated with reference to FIGS. 1A and 1B.

FIG. 1D illustrates a detonator assembly of the invention, the same as that of FIG. 1 except that the detonator shell 10' comprises closed end section 10'' along a major portion of its length, and diametrically enlarged open end section 26' in series, and integral, therewith, and the primer end 13 of the casing closure 42 is in closing relationship with the shell 10' adjacent the shell side wall portion 25' intermediate, and connecting, the two sections 10'' and 26'. The detonating cord 9, external to the closed interior of shell 10', extends into open and rearward end 26' and is crimp-supported therein in the manner described with reference to FIGS. 1-1C. The facing, or opposing, peripheral ends of shell sections 10'' and 26' each terminate in a plane substantially perpendicular to the shell axis. In the embodiment shown, the two planes are spaced apart so that the wall portion 25' extends outwardly and around primer end 13 toward open end section 26'. However, in another embodiment, the terminating and opposing peripheral ends of sections 10'' and 26' can be in a common plane perpendicular to the shell axis, in which event shell wall portion 25' is disposed at substantially a right angle to the side walls of shell sections 10'' and 26'. In each embodiment, the primer end 13 is generally seated on the connecting shell portion 25'.

In the fabrication of the assembly of FIG. 1D, the closed shell section 10'' is loaded with the required delay, primer and base charge compositions and the cartridge casing closure member 12 is inserted into open end 26' for seating of primer end 13 as described herein with subsequent emplacement of the detonator cord 9 in open end 26' supported by the plastic closure 31.

An often preferred connector means for support of the detonator cord 9 in operative relationship with the primer charge 14 in the primer end 13 is illustrated with reference to FIG. 2. Referring to FIG. 2, connector assembly 28 comprises tubular member 29 of substantially the same inside and outside diametric cross section shown with reference to tubular member 24 of FIG. 1. Thus, tubular member 29 has an inside diametric cross section less than that of primer end 13 which is disposed radially from the shell axis beyond the confines of shell 10 but has a greater outside diametric cross section than that of shell 10, and is disposed coaxially with shell 10 about the exterior wall thereof immediately subjacent lip 17 of primer end 13. Loop 33 extends from the end of tubular member 29 subjacent primer end 13 around the lip 17 of primer 13 to connect as an inverted U at the other end, with tubular member 29 subjacent primer end 13 so that the loop 33 connects with tubular member 29 at substantially opposite points on the periphery of member 29 to thereby encompass primer end 13. Loop 33, as an inverted U, faces its interior toward the exterior surface 13' of primer end 13 sufficiently to support detonator cord 9 laterally across and, as shown, generally in direct contact with the exterior primer end surface 13' in operative relationship with primer charge 14 to responsively cause percussion initiation of primer charge 14. Other embodiments of loop 33 structure can often be advantageously utilized. Thus, loop member 33 can be crimped onto, and around, a subjacent portion of cord 9; or, it can integrally include a pair of wing type members laterally extending therefrom in opposite directions along separate length portions of the cord, and crimped on to the respective adjacent cord lengths.

The end loop portions 25'' extend around lip 17 immediately subjacent primer end 13 to tubular member 29 so as to serve as a seat 25'' for the primer end 13, and they often tend to function as an anvil for the requisite percussion initiation. A perspective view of the detonator assembly 6' of FIG. 2 is shown with reference to FIG. 2A; and FIG. 2B shows another view of the connector assembly 28 of FIGS. 2 and 2A except that the tubular member 29 is in open position for slipping around the primer end of assembly 7 during fabrication of the assembly 6'. Thus, tubular member 29 is split along a side wall throughout the entire length thereof to provide a void strip 30 so as to permit the connector assembly 29 to be assembled with detonator 7. In this manner, void strip 30 permits tube section 29 to be spread sufficiently openwise for lateral and coaxial insertion of detonator 7 into tubular member 29 with primer end 13 seated adjacent tubular member 29 and against the loop portion 25'' extending around primer end 13. In this embodiment, the material from which tube member 29 is fabricated is of sufficient elasticity to permit tube 29 to recover its shape subsequent to emplacement of the detonator 7 therein.

In the use of a plurality of booster charges in a bore hole of a trunk line-down line system, it is generally required that the detonations be delayed so as to provide a suitable time sequence for the plurality of shots. Heretofore in such systems in which more than one booster connects with the same down line, the delay means has necessarily been employed in the down line, thus increasing the complexity and bulk of the down

line portion of the system. However, non-electrically fired boosters of the invention contain a detonator assembly, above described, and hence each contains individual delay means and can accordingly be utilized in plurality in a hook-up with a common down line without the need for conventional hook-up of separate delay means in the down line.

Booster assemblies of the invention are specifically illustrated with reference to FIGS. 4-4B. Referring to FIG. 4, shell 34 of booster assembly 36, having length 1 and closed at each end, contains booster charge 37, e.g., PETN, and well, i.e., tube, 38 extends, closed end 39 first, through shell side wall 41 into direct contact with charge 37. A detonator assembly 6' of FIG. 2 is supported in well member 38, base charge end first, with primer end 13 of case closure 12 adjacent the connecting loop portion 25'' intermediate loop 33 and tubular support member 29 as described with reference to FIG. 2. Detonator assembly 6' extends into well 38 so as to position the primer end 13 and connecting loop portion 25'' adjacent, and outside, well 38 generally with the loop portion 25'' seated against the adjacent and open terminating end of well 38. Detonator cord 9 extends lengthwise of shell 34, i.e., along the length 1, through tunnel 42 and loop 33 of detonator 6' and across primer end 13 of the casing closure 12, substantially in direct contact therewith; and hence, upon detonation, cord 9 is positioned to direct the resulting explosive energy to the primer end 13 as the necessary force for percussion initiation of the primer charge 14. Tunnel member 42 and detonator cord 9 are supported along the length of shell 34 by suitable straps 43. The detonator assembly 6' is supported within well 38 in any suitable manner, generally by close friction fit. The booster assembly of FIG. 4 is further illustrated with reference to the view A-A of FIG. 4, and is shown in perspective view with reference to FIG. 4B.

The utilization of a plurality of booster assemblies of the invention in a bore hole of a trunk line-down line system is illustrated with reference to FIG. 5 in which loaded bore holes A and B illustrate hook-up of boosters with detonator assemblies of FIGS. 1 and 2, respectively. Although for purpose of illustration, the system of FIG. 5 illustrates both embodiments of booster assembly, one or the other embodiment is generally used in any given system of bore holes. Also, it is to be understood that any suitable number of bore holes can be included in the system hook-up.

Referring to FIG. 5, above-the-ground trunk line 44, operatively connected with conventional trunk line initiating means 45, generally an electric blasting cap, is of low energy loading, generally of from 0.1 to 25 grains per foot and extends through each loop 33 of a detonator assembly 6' of FIG. 2 disposed at the mouth of each bore hole A and B.

Bore hole A is loaded with suitable explosive 47, often ANFO, which is generally subject to dead-press; and, a plurality, two in the present instance, of booster assemblies of the invention the same as illustrated with reference to FIG. 4, except that they are modified to accept and contain a detonator assembly of FIG. 1, are disposed at spaced apart points in explosive mass 47. Each booster in bore hole A is in suitably supported direct contact through a separate down line 9 from the detonator assembly 6 with the base charge of the

detonator assembly 6' at the mouth of the bore hole. Upon detonation of trunk line 44, the detonator at the mouth of the bore hole A is initiated and, upon detonation of its base charge, initiates each separate down line 9 to in turn detonate each booster charge and hence complete the shot in the bore hole.

In bore hole B, each of the plurality of booster assemblies is that of FIG. 4 and is hooked up with a common down line 9 extending through each of the respective loops 33 from direct contact with the base charge end of the detonator assembly 6' at the mouth of the bore hole B, for detonation in response to detonation of the down line 44 and subsequent detonation of the emplaced boosters in bore hole B.

The embodiment of shooting system illustrated with reference to bore hole B involving a booster assembly containing a detonator of FIG. 2, is preferred because it provides for use of a single, and common, down line, hence reducing the complexity of the system and eliminating need for handling a plurality of down lines, thus simplifying the emplacement of the charges and operation of the system. However, in all embodiments, the hook-up of FIG. 5 provides for independent delay means in each booster with elimination of need for delay in the down line required heretofore.

It is an important feature of the invention that, when desired, the detonator cord of the detonator assembly can be of low energy loading. This is advantageous from the standpoint of the marked reduction in above-the-ground noise level that has been unduly high, in the past, in the utilization of trunk lines having normal energy loading such as from 30 to 60 grains per foot (PETN or equivalent). It is a further feature of the invention that the detonator cord of the detonator assembly is at all times outside the closed interior of the detonator shell, and hence does not introduce risk of failure normally incurred through faulty seal at the cord-shell interface. Further, with the detonator cord entirely outside the closed shell interior, there are, particularly at the lower energy detonator cord 9 loadings, no failure possibilities due to bursting of the shell that often occur in conventional systems in which the detonator cord is led into the shell interior for direct contact with the detonator components. In embodiments utilizing higher energy loadings for cord 9, it is sometimes advantageous to insert a suitable energy absorbing disc intermediate the surface 13' of the primer end 13 and the detonator cord 9.

A hook-up of a plurality of bore holes A and/or B in a shooting pattern, in accordance with the invention, is further illustrated with reference to FIG. 6 in which, in accordance with preferred practice, all bore holes are loaded as specifically illustrated with reference to bore hole B of FIG. 5 utilizing a plurality of emplaced booster assemblies of FIG. 4 in each bore hole.

It 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 pattern shooting system, comprising a detonator cord trunk line having a core loading of from 0.1 to 25 grains per foot (PETN or equivalent); a non-electri-

cally fired detonator assembly outside and adjacent each bore hole of said pattern; said detonator assembly comprising (1) a closed elongated shell including, as one end closure therefor, an empty primed rifle cartridge casing extending open end first into said shell through one end thereof sufficiently to dispose the primer end of said casing adjacent, and across, said shell end, (2) a base explosive charge in said shell spaced from said primer end, (3) a delay fuse composition intermediate said primer end and said base charge, ignitable in response to ignition of the primer charge in said primer end, and spaced from said primer charge, in that relationship, (4) a primer composition intermediate said delay fuse and said base charge, detonatable in response to ignition, and concomitant burning, of said delay fuse, and spaced in that relationship, and (5) said base charge detonatable in response to detonation of said primer composition and spaced in that relationship; a loop member supported at each end at opposite sides on said shell adjacent said primer end and extending around, and above, said primer end; said trunk line extending through each said loop laterally across the primer end of each detonator assembly; a body of main explosive charge in each bore hole, and a plurality of spaced apart boosters for, and disposed in, each said main charge; another said detonator assembly and associated loop structure extending base charge end first into each said booster assembly sufficiently to retain said loop outside the booster shell; and a single down line detonator cord in each said body of main charge, having a core loading of from 0.1 to 25 grains per foot (PETN or equivalent) extending to the adjacent detonator outside the bore hole, into detonating relationship therewith and through the loop of each said detonator assembly in the body of main charge.

2. An explosive assembly comprising a mass of main explosive charge; a plurality of booster charges and a separate delay type detonator for each, spaced apart in said main explosive; detonator cord means for initiating said detonators, extending in said explosive mass, and means for detonating said cord means; each said detonator comprising a closed shell containing base charge, primer, delay and impact-sensitive ignition compositions spaced from each other in that order, and operatively responsive to impact-ignition of said igni-

tion composition to detonate said base charge, and thereby detonate said booster; and said cord initiating means supported outside said shell for detonation to provide, and direct, resulting explosive energy to said ignition composition for said impact ignition.

3. In an explosive assembly of claim 2 an elongated closed shell containing said base charge, primer, delay and impact-ignition compositions spaced from one end of the shell in that order, an empty primed rifle cartridge casing extending, open end first, into said shell through the opposite end thereof, and the primer end of said cartridge casing containing the primer charge therein as said impact sensitive composition.

4. In an explosive assembly of claim 3, said detonator cord means having a core loading of from 0.1 to 25 grains per foot (PETN or equivalent).

5. An explosive assembly of claim 4 wherein said cartridge casing is rim-fired.

6. An explosive assembly of claim 4 wherein said cartridge casing is center-fired.

7. In an explosive assembly of claim 4, said detonator cord means extending as a single cord across the primer end of at least two of said booster charges.

8. An explosive assembly of claim 4 containing an ammonium nitrate-fuel oil (ANFO) main explosive charge.

9. A pattern shooting system containing a plurality of explosive assemblies of claim 3, and a detonating cord trunk line spaced from said assemblies but connecting in common with each said detonator cord means in detonating relationship therewith.

10. In a pattern shooting system of claim 9, an additional of said detonators separately connecting with each said detonator cord means in detonating relationship therewith; said detonating cord trunk line connecting, in common, with each of said separate additional detonators in detonating relationship therewith, and said trunk line, and each said detonator cord initiating means having a core loading of from 0.1 to 25 grains per foot (PETN or equivalent).

11. In a pattern system of claim 9, each said detonator cord means connecting with said trunk line, having a core loading of from 0.1 to 25 grains per foot (PETN or equivalent).

* * * * *

50

55

60

65