FLUID SENSITIVE DETONATOR ASSEMBLY

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Ernest L. Gillingham
Jack O. Grunwald

INVENTORS

John O. Evans, Jr.
ATTORNEY
The present invention relates to a detonator assembly for an explosive device. More particularly, the invention relates to a fluid sensitive detonator assembly for firing a detonating fuse in a well perforating apparatus, and to the well perforating apparatus including such detonator.

The conventional method of detonating shaped charge units in a well perforating apparatus is to use a length of detonating fuse, such as “Primacord,” manufactured by The Ensign-Bickford Co. No electric blasting cap is used to initiate the detonating fuse. The shaped charge units are often mounted in an elongated, hollow, cylindrical, liquid-tight carrier for disposition in the well borehole. It is essential that the carrier remain free of liquids until the shaped charges are detonated. Should liquid enter the carrier and cover the shaped charges, the jets will not form properly when the charges are detonated and little or no perforation of the well casing and earth formation will occur. Also, the presence of liquid in a hollow, heavy walled, reusable type carrier will not allow sufficient expansion of the gases produced by the detonating charge units with resultant distortion damage to the carrier.

To overcome these objectionable effects, detonating devices have been developed which are rendered inactive by the presence of liquids in a hollow carrier. Such a detonating device is disclosed in U.S. Patent No. 2,691,477, issued June 23, 1959, to Merrill E. Swanson and entitled “Initiation Device Desensitized by Fluids.” The apparatus of the present invention is an improvement upon the device disclosed therein. Detonating devices, such as disclosed in the aforementioned patent, are usually located in the bottom of a hollow carrier for ready deactivation upon ingress of even a small amount of fluid from the well bore into the hollow space of the carrier.

The shaped charges and a length of detonating fuse, in detonating relationship to the shaped charges, are usually placed in the carrier before it is delivered to the well. For safety reasons, the detonating device is attached to the detonating fuse immediately before the perforating apparatus is run into the well bore. An electric blasting cap is crimped to the lower end of the detonating fuse which extends to the open lower end of the hollow carrier. Electrical connections are made which permit firing of the blasting cap from the earth’s surface. The blasting cap, with its attached detonating fuse and electrical lead wires, must be pushed back up into the end of the carrier to permit the open end to be closed with a bull nose, or other suitable closing member. This operation may cause a sharp bend to occur in the detonating fuse because of the excessive length of fuse confined in the narrow space at the end of the hollow carrier. A sharp bend in a detonating fuse will often cause the fuse to part at the point of the bend when the fuse is detonated. Thus, the fuse does not detonate over its required length and fails to fire the shaped charge perforating units. When this type of misfire occurs, the perforating apparatus must be retrieved to the earth’s surface and a spare perforating apparatus run into the well. Normally, a misfire of this nature will not leave a sufficient length of detonating fuse to permit crimping on another blasting cap, and the perforator must be returned to the loading site for reloading before it is usable. This problem occurs more frequently in the newly developed, small diameter, hollow carrier perforating apparatus which is adapted for running into a well through tubing previously set for permanent completion of the well. Chances of forming a sharp bend in the detonating fuse when the blasting cap is pushed up into the carrier is increased in this type of perforating apparatus, because of the relatively narrow diameter of the carrier.

Therefore, it is an object of this invention to provide a hollow carrier well perforating apparatus utilizing a fluid sensitive detonator assembly that can conveniently be placed in detonating relationship to a detonating fuse in the hollow carrier just prior to running the apparatus into the well.

An additional object of this invention is to provide a hollow carrier well perforating apparatus incorporating a fluid sensitive electric detonator in which one leg wire of the detonator is conventionally grounded to the carrier.

A further object of this invention is to provide a fluid sensitive detonating assembly that is adapted for use in small diameter, hollow carrier perforating apparatus.

A still further object of this invention is to provide a fluid sensitive detonating assembly that does not require the crimping of a blasting cap to the detonating fuse, yet sidably movable along a length of the detonating fuse to prevent forming sharp bends and consequent misfire of the detonating fuse.

In general, the assembly of the present invention includes a liquid desensitized electric blasting cap having an elongated tubular case. The case contains a primary charge and a secondary charge which is longitudinally separated from the primary charge by a flash chamber.

Electrical energy means are provided to initiate the primary charge. Ports are provided in the case to admit liquid from the exterior into the flash chamber. The walls of the case surrounding the flash chamber further provide a pair of diametrically opposed holes therethrough located closely adjacent to the secondary charge. The secondary charge is detonable by the primary charge when the flash chamber is dry and incapable of being detonated by the primary charge when the flash chamber contains a liquid. A body is provided having substantially the same length as the secondary charge. The body provides a longitudinal bore therethrough adapted to receive the blasting cap with a close fit. The blasting cap is received in the bore of the body with the body surrounding substantially only the portion of the case containing the secondary charge but with a small portion of the body overlying the pair of diametrically opposed holes in the case. The body provides a pair of holes therethrough registering with the pair of holes in the case. A length of flexible wire extends through the registered holes in the case and the body securing the body to the case. The ends of the length of wire extend outwardly from the body and are adapted to provide means for sidably securing the assembly in the bottom of the tubular portion of a hollow carrier shaped charge well perforating apparatus. The body further provides a fuse passage therethrough extending parallel to and intersecting the bore. The body, blasting cap and length of wire are adapted to slide along a detonating fuse inserted in the passage. The body is adapted to position the portion of the fuse received in the passage in detonating relationship to the secondary charge.

These and other objects, features and advantages of the present invention will be apparent from a consideration of the following specification taken in conjunction with the accompanying drawing.
In the drawing:

FIG. 1 is a vertical view of a hollow carrier perforating apparatus with the lower end broken away to reveal the fluid sensitive detonating assembly;

FIG. 2 is an axial sectional view taken along line 2--2 in FIG. 3 of the fluid sensitive detonating assembly;

FIG. 3 is a plan view of the fluid sensitive detonating assembly;

FIG. 4 is an axial sectional view taken along line 4--4 in FIG. 5 of the retainer sleeve of the fluid sensitive detonating assembly; and

FIG. 5 is a plan view of the retainer sleeve of the fluid sensitive detonating assembly.

Referring to FIG. 1, a perforating apparatus is indicated generally by the numeral 10, the apparatus including an elongated, hollow cylindrical carrier 11, closed by a bulb plug 12 at the lower end and a top closing member 13 at the upper end to provide a liquid-tight assembly. A cable head 14 is sealingly attached to the top closing member and retains the lower end of the suspending cable 15. An insulated electrical conductor wire 16 is provided in the core of the cable for connection to a source of electrical energy on the earth's surface. The steel sheath of the cable 15 and the metallic body of the perforating apparatus 10 furnish a return path for the electrical energy to the earth's surface.

The hollow carrier 11 is provided with a plurality of threaded port openings which are sealed by port plugs 17. A tubular metal case 22 provides two sets of opposed ports or openings 23 therein to admit liquids from the exterior of the case into the flash chamber 24. The flash chamber is defined by the closed ends of the primary or initiation charge shell 25 and the secondary or detonating charge shell 26, and a section of the metal case 22 therebetween. The tubular case is preferably made of copper alloy and the primary and secondary charge shells are preferably made of aluminum alloy. The primary charge shell 25 is formed with a concavity 27 in the base and is tightly fitted in the case 22. A crimp 28 in the case 22 prevents the primary charge shell from moving into the flash chamber 24. The base end of the primary charge shell 25 is filled with a primary explosive charge 29, such as lead azide. Adjacent to the primary charge is the ignition charge 30 which contains an igniter wire 31 therein. The igniter wire is connected to extensions of the leg wires 32 which extend through the rubber seal plug 33 that closes the opening of the primary charge shell 25. A resistor 34 is connected in series with the igniter wire 31 by one of the extensions of leg wires 32. A bridge wire 35 is connected across the extensions of leg wires 32. Protection against accidental firing of the detonating charge 37 is provided by the resistor 34 in series with the igniter wire 31, which increases the electrical energy required to fire the blasting cap. The bridge wire 35, in parallel with the series connected resistor and igniter wire, affords protection from accidental discharge of the blasting cap by electrostatic discharge. The leg wires project through a rubber seal plug 36 which is crimped in the case 22 to provide a liquid-tight seal for the lower end of the case.

The detonator charge shell 26 has a lower half-section of slightly reduced diameter which is press fitted into the upper end of the case 22. Lowermost in shell 26 is a booster charge 37 of shock sensitive explosive such as lead azide. Above the booster charge is the secondary or detonating charge 38, which may be compressed pure Cyclonite or other suitable detonable explosive. The chamber 39, immediately above the detonator charge, is closed off with a cork stopper. Slightly fitted over a portion of the outside of the case 22 is a detonating fuse retainer or sleeve 41. The sleeve is positioned substantially opposite that portion of the case 22 containing the booster charge 37 and secondary charge 38. As seen in FIGS. 4 and 5, the wall of the fuse retainer is provided with two transverse aligned openings 42 adjacent to one end. The openings 42 in the sleeve are adapted to register with the openings 23 in the case 22 which are adjacent to the secondary charge shell 26.

A spring wire 43 inserted through the aligned openings in the case 22 and sleeve 41 retains the sleeve in a position opposite the detonating charge shell 32 of the blasting caps both to position the detonating assembly in the carrier and to provide a portion of the ground return of the firing circuit. The sleeve 41 should not extend any appreciable distance over the portion of the case 22 occupied by the flash chamber 24. If the sleeve is taken over the flash chamber, it will act as a reinforcement for the thin wall section of the case 22 and may cause a concentration upon the booster charge 37 of explosive energy from the detonation of the primary charge 29 sufficient to detonate the booster charge even when the flash chamber contains liquid. The external sections of the wire 43 are bent upward at their points of emergence from the case 22 at angles of approximately 45° to the case, and the terminal ends are bent inward toward the case. Other means for attaching the sleeve 41 to the case 22 may be used, such as a cotter pin or a short length of wire which may be inserted in the aligned openings and the projecting ends bent over against the case.

It is necessary when using such other means to ground the return leg wire of the blasting cap as by connecting it electrically to the carrier.

Referring now to FIGS. 3, 4 and 5, the sleeve 41 provides a longitudinal bore 44 therethrough adapted to receive the case 22 in relatively close fit. A fuse passage 45 is provided in the sleeve, parallel to and intersecting the bore 44 of the sleeve. The diameter of the fuse passage is such that the sleeve 41 will also freely over a length of Primacord received in the fuse passage yet retain the Primacord in detonating relationship to the secondary charge 38. The sleeve 41 can be formed by crimping a strip of aluminum or copper tubing into the sleeve mandrels to produce openings 44 and 45. An alternative method of forming the sleeve is to crimp a proper length of aluminum or copper tubing around suitable mandrels to provide openings 44 and 45.

The fluid sensitive detonating assembly 20, as shown in FIG. 2, is conveniently assembled in the shop for distribution to the field. The leg wires 32 of the blasting cap provide shunting of the igniter wire 31, the bare ends of the leg wires being wrapped around the spring wire 43 to provide this result.

In operation, the fluid sensitive detonating assembly 20 is inserted in a previously loaded perforating apparatus 10, as shown in FIG. 1, just prior to running the apparatus into a well bore. The bull plug 12 is removed and either one of the leg wires 32 is unwrapped from the spring wire 43 and attached to the extension conductor wire 16a, which extends to the lower end of the carrier 11. The other leg wire 32 remains wrapped to spring wire 43 to provide a path for the ground return circuit for the blasting cap. Contact between spring wire 43, carrier 11 and the steel sheath of the conductor cable 15 provides...
the ground return circuit to a source of electrical energy on
the earth's surface. The end of detonating fuse 19 is
inserted in the fuse passage in the sleeve of the detonating
assembly 20. The ends of the spring wire 43 are flexed
inwardly by hand and the assembly is slid along the
detonating fuse past the internally threaded lower portion
of the carrier, then released to engage the inside wall of
the carrier. The detonator assembly is maintained centrally
within the carrier by the spring wire and, in turn, retains
the lower end of detonating fuse 19 centrally in the
carrier. The bull plug 12 is screwed into the lower end
of the carrier, receiving the detonating assembly 20 and
the lower extremity of the detonating fuse 19 in the recess 21.
Since no rigid attachment exists between the detonating
assembly 20 and the detonating fuse 19, no kinks or
sharp bends are formed in the detonating fuse as the detonating
assembly is pushed up into the carrier.

The assembly of the present invention is also advanta-
gerously used in perforating apparatus that does not pro-
vide a recess in the bull plug to receive the detonating
assembly. Screwing in the bull plug will force the
detonating assembly to slide further up the Primacord
with any sharp bends that may be forming being located below
the point at which the Primacord is initiated by the deto-
nating assembly.

The perforating apparatus is run into the well bore and
positioned adjacent to the earth formation (not shown) to
be perforated. Referring now to FIG. 2, upon applica-
tion of electrical energy to the leg wires 32, the bridge wire
35 fuses, current flows through the igniter wire 33 which
becomes incandescent, ignition charge 30 is initiated and,
in turn, detonates primary charge 29. This detonation
fragments the primary charge shell 25, with the concavity
27 producing a focusing effect to direct metal particles
from the shell 25 into the base of shell 26. If no leaks
have developed in the hollow carrier, the flash chamber
24 will not contain any liquids, and the particles of metal
from shell 25 will strike the base of shell 26 with sufficient
force to detonate the booster charge 37 and the secondary
charge 36. If a leak does develop in the hollow carrier,
the liquids collecting in the lower end of the carrier will
enter through openings 23 in the detonating assembly and
fill the flash chamber 24 with liquids. When the flash
chamber contains liquids, the particles of metal from the
shell 25 expand the greater part of their energy in travel-
ing through the liquids and do not strike the base of shell
26 with sufficient force to detonate the booster charge and
secondary charge. The unfired perforating apparatus
must then be retrieved to the earth's surface, the source of
leak and the detonator assembly 20 replaced in the carrier.
In the absence of liquid in the flash chamber,
the booster charge 37 will detonate which detonates the
secondary charge 36, in turn detonating the adjacent
detonating fuse 19. The detonating fuse will then deto-
nate the plurality of shaped charges 18, perforating the
porous plugs 17 and the earth formation.

While there has been described what is at present con-
cidered a preferred embodiment of the present invention,
it will be apparent to those skilled in the art that various
modifications and changes may be made without depart-
ing from the spirit and scope of the present invention.
In particular, it is contemplated that other types of fluid
sensitive blasting caps may be used in the apparatus of
the present invention. Therefore, the present invention
is to be limited only by the scope and spirit of the
 appended claims.

We claim:
1. An assembly for firing a detonating fuse comprising:
a liquid desensitized electric blasting cap having an elon-
gated tubular case, a primary charge in said case, elec-
trically energized means for initiating said primary
charge, said electrically energized means and said case
longitudinally separated from said primary charge by a
flash chamber, said case providing ports for the admission of liquid from the exterior of said case into said flash chamber, the walls
of said case surrounding said flash chamber further pro-
viding a pair of diametrically opposed holes therethrough
located closely adjacent to said secondary charge, said
secondary charge being detonable by said primary charge
when said flash chamber is dry and incapable of being
detonated by said primary charge when said flash cham-
ber contains liquid; a body having substantially the same
length as said secondary charge, said body providing a
longitudinal bore therethrough adapted to receive said
blasting cap with a close fit, said blasting cap being re-
ceived in the bore of said body with said body surround-
ing substantially only the portion of said case containing
said secondary charge but with a small portion of said
body overlying said pair of diametrically opposed holes
in said case, said body providing a pair of holes there-
through registering with said pair of holes in said case;
a length of flexible wire extending through the registered
holes in said case and said body securing said body to
said case, the ends of said length of wire extending out-
wardly from said body and adapted to provide means for
slidably securing the assembly in the bottom of the tubu-
lar portion of a hollow carrier shaped charge well per-
forating apparatus; said body further providing a fuse
passage therethrough extending parallel to and intersect-
ing said bore, said body, blasting cap and body being adapted to slide along a detonating fuse inserted in said passage, and said body being adapted to position the portion of the fuse received in the passage in detonat-
"in relation to said secondary charge.
2. A well perforating apparatus comprising: an elon-
gated, hollow, generally cylindrical, pressure resistant,
sealed carrier adapted to be lowered into a well, said
carrier providing an opening at the lower end thereof;
removable means closing and sealing the opening in the
lower end of said carrier; at least one shaped charge unit
positioned in the hollow of said carrier to direct the jet of
formed upon detonation through the side wall of said carrier;
a cylindrical detonating fuse in the hollow of said
carrier in detonating relationship to said shaped charge
unit, the lower end of said fuse terminating within said
carrier adjacent to the opening provided in the lower end
of said carrier; an assembly for firing said detonating fuse,
said assembly being adapted to pass through the opening
at the lower end of said carrier, said assembly including a
liquid desensitized electric blasting cap having an elon-
gated tubular case, a primary charge in said case, elec-
trically energized means for initiating said primary
charge, said electrically energized means and said body
longitudinally separated from said primary charge by a
flash chamber, said case providing ports for admission of liquid from the exterior of said case into said flash chamber, said sec-
ondary charge being detonable by said primary charge
when said flash chamber is dry and incapable of being
detonated by said primary charge when said flash chamber
contains liquid, a detonating fuse retainer outside of and
adjacent to said case, and means securing said retainer
to said case, said retainer being positioned adjacent
said case solely within a zone on said case extending from a
location substantially opposite that end of said secondary
charge which faces said flash chamber in a direction lon-
gitudinally away from said flash chamber, the thin wall
section of said case defining said flash chamber being
free from any reinforcement capable of causing sufficient
crushing of explosive energy from the detonation of said
primary charge to initiate detonation of said secondary
charge when said flash chamber contains liquid, said
retainer providing a longitudinal, cylindrical fuse
passage therethrough parallel to and adjacent to said
case and opposite said secondary charge, said fuse pas-
 sage having a diameter which is greater than the diameter
of said cylindrical detonating fuse wherein said fuse is
end of said detonating fuse is loosely received in said
passage to permit said retainer and blasting cap to slide
freely over the full length of said lower end of said deto-
nating fuse to a position inside said lower end of said carrier while maintaining said lower end of said fuse in a substantially straight condition, and a portion of said detonating fuse within said fuse passage being in detonating relation to said secondary charge.

3. A well perforating apparatus comprising: an elongated, hollow, generally cylindrical, pressure resistant, sealed carrier adapted to be lowered into a well, said carrier providing an opening at the lower end thereof; removable means closing and sealing the opening in the lower end of said carrier; at least one shaped charge unit positioned in the hollow of said carrier to direct the jet formed upon detonation through the side wall of said carrier; a detonating fuse in the hollow of said carrier in detonating relationship to said shaped charge unit; an assembly for firing said detonating fuse, said assembly being adapted to pass through the opening at the lower end of said carrier, said assembly including a liquid densitized electric blasting cap having an elongated tubular case, a primary charge in said case, electrically energized means for initiating said primary charge, and a secondary charge in said case longitudinally separated from said primary charge by a flash chamber; said primary charge being detonated by said primary charge generated by said flash chamber, said flash chamber being dry and incapable of being detonated by said primary charge when said flash chamber contains liquid, a body having substantially the same length as said secondary charge, said body providing a longitudinal bore therethrough located closely adjacent to said secondary charge, said secondary charge being detonated by said primary charge generated by said flash chamber as said flash chamber is dry and incapable of being detonated by said primary charge when said flash chamber contains liquid, said primary charge being detonated by said primary charge when said flash chamber contains liquid, and being grounded, and said length of flexible wire being electrically conductive and having its ends in electrical contact with the inner wall of said carrier at their points of sidable contact therewith.

5. A well perforating apparatus comprising: an elongated, hollow, generally cylindrical, pressure resistant, sealed carrier adapted to be lowered into a well, said carrier providing an opening at the lower end thereof; removable means closing and sealing the opening in the lower end of said carrier; at least one shaped charge unit positioned in the hollow of said carrier to direct the jet formed upon detonation through the side wall of said carrier; a detonating fuse in the hollow of said carrier in detonating relationship to said shaped charge unit, the lower end of said fuse terminating within said carrier adjacent to the opening provided in the lower end of said carrier; an assembly for firing said detonating fuse, said assembly being adapted to pass through the opening at the lower end of said carrier, said assembly including a liquid densitized electric blasting cap having an elongated tubular case, a primary charge in said case, electrically energized means for initiating said primary charge, and a secondary charge in said case longitudinally separated from said primary charge by a flash chamber, said case providing ports for admission of liquid from the exterior of said case into said flash chamber, the walls of said case surrounding said flash chamber further providing a pair of diametrically opposed holes therethrough located closely adjacent to said secondary charge, said secondary charge being detonated by said primary charge generated by said flash chamber, said flash chamber being dry and incapable of being detonated by said primary charge when said flash chamber contains liquid, a detonating fuse retainer outside of and adjacent to said case, and means securing said retainer to said case solely within a zone on said case extending from a location substantially opposite that end of said secondary charge which faces said flash chamber in a direction longitudinally away from said flash chamber, said retainer providing a longitudinal fuse passage therethrough parallel to and adjacent to said case and opposite said secondary charge, said detonating fuse being slidably received in the fuse passage of said retainer with a portion of said fuse positioned in detonating relation to said secondary charge, oppositely disposed lengths of flexible wire fixed to said assembly and extending outwardly therefrom and sidably contacting the inner wall of said carrier, said means for initiating said primary charge having a source of electrical energy with a grounded terminal, an igniter wire in said primary charge, a pair of leg wires connected to said igniter wire and extending externally of said tubular case, means electrically connecting one of said leg wires to said source of electrical energy, means electrically connecting the other of said leg wires to said flexible length of wire; said hollow carrier being electrically conductive and being grounded.

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