April 28, 1959 C. A. HOUCK ET AL 2,883,931

DETONATOR

Filed Dec. 18, 1953 2 Sheets-Sheet 1

FIG. 1.

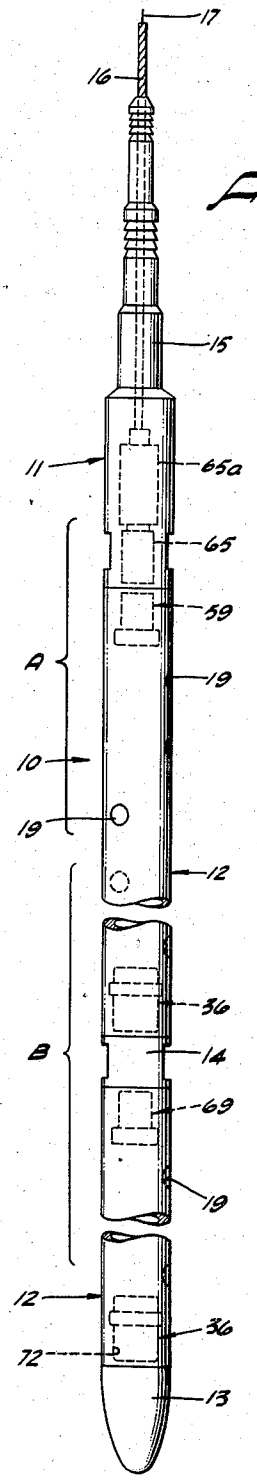


FIG. 3B.

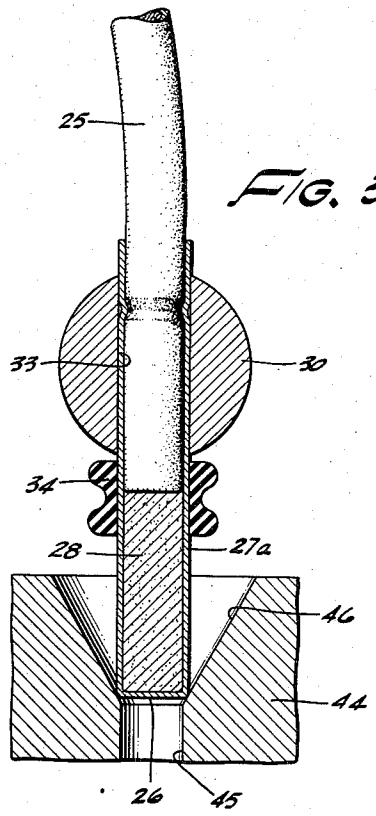
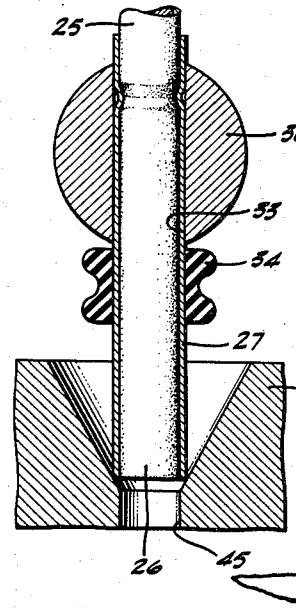


FIG. 3A.



CLAUDE A. HOUCK
JAMES V. BRADSHAW
INVENTORS

BY

AGENT

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2 Sheets-Sheet 2

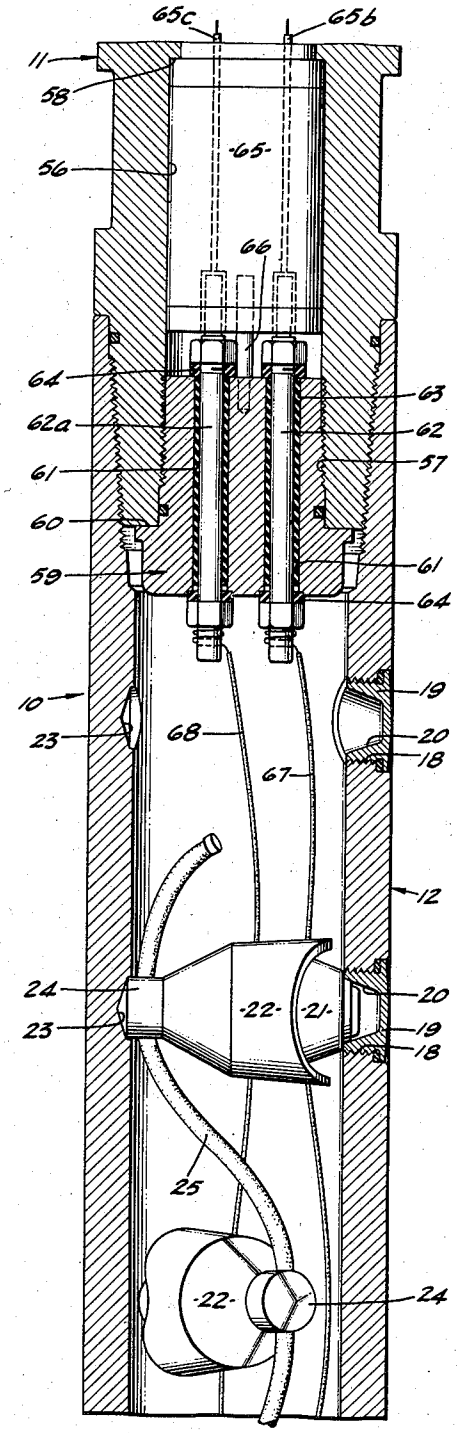
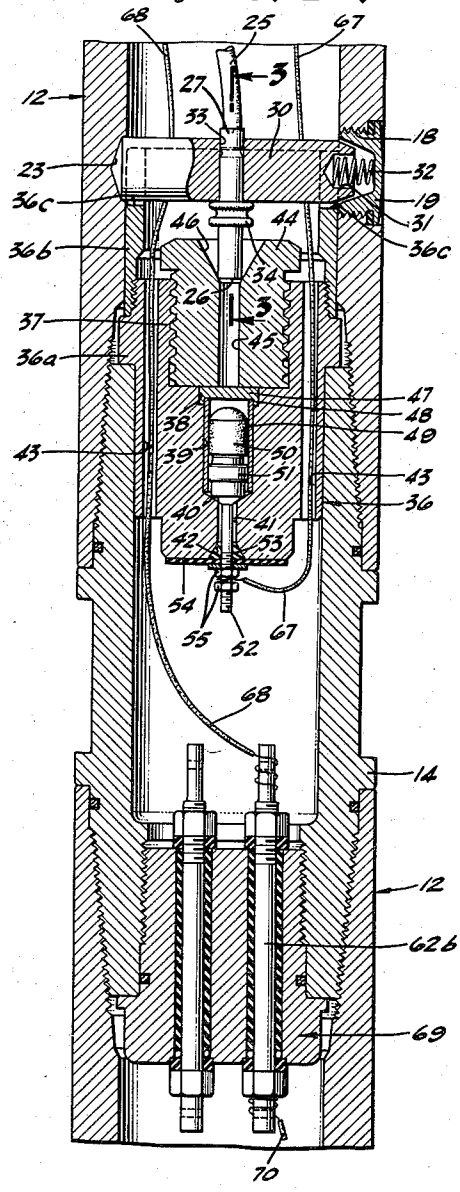


FIG. 2A.

FIG. 2B.



CLAUDE A. HOUCK
JAMES V. BRADSHAW
INVENTORS

BY

AGENT

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2,883,931

DETONATOR

Claude A. Houck, South Pasadena, and James V. Bradshaw, Los Angeles, Calif., assignors, by mesne assignments, to Borg-Warner Corporation, Vernon, Calif., a corporation of Illinois

Application December 18, 1953, Serial No. 399,032

4 Claims. (Cl. 102—20)

This invention relates to apparatus employed in perforating well casings by explosive means, and more particularly to a novel means for detonating a detonable fuse of the type employed to detonate one or more explosive units which in turn, when detonated, perform a function in casing perforation.

It is customary, in perforating well casings in situ to employ one or the other of two principal perforating modes, the first of which involves firing hard projectiles through the casing and into the surrounding cement and rock, and the second of which utilizes the unique piercing characteristics of so-called "shaped charges" of high explosive material. A variety of means are employed in both modes for detonating or firing the charges that propel the projectiles, or that by a sort of jet-like action pierce an obstacle. One common means of thus firing or detonating the charges is a length of relatively insensitive detonable fuse. The fuse may extend to one or more explosive units, and when detonated serves in turn to fire or detonate substantially simultaneously or in rapid succession the several charges to which it extends. Fuse employed for this purpose is, due to the environment of its use and for general reasons of safety to personnel and equipment, chosen from a variety of types, all of which are insensitive to ordinary, severe handling shocks of both mechanical and thermal nature; and for that reason must be detonated by an extremely severe concussive shock. Heretofore detonation of such fuse material has usually been effected by conventional electrical blasting caps containing a detonable material such as fulminate of mercury. It is well known that caps of the type mentioned are apt to be accidentally detonated by relatively light shock and are susceptible to detonation by static electricity, abrasion with hard materials such as are employed for holding the cap, with tools, and with other caps; and that, therefore, considerable care must be exercised in handling such caps. As a consequence of the danger involved in assembling apparatus of the nature of that hereinbefore mentioned and employing blasting caps as a fuse detonating means, field assembly and field renewal of the apparatus has been precluded, and such operations have been carried out in specially prepared places and only by skilled personnel.

The present invention provides means for detonating fuses of the type aforementioned without use of blasting caps or any other means or materials sensitive to ordinary handling shock, whereby assembly of the fuse and apparatus in its container or supports may be safely effected without undue care in regard to the explosives employed. Additionally the invention provides an apparatus for perforating well casings that is readily and quickly and safely assemblable by ordinary workmen, and which is such that those expendable items of the apparatus that are destroyed or consumed in the casing-perforating operation are easily renewed with an extreme measure of safety for adjacent personnel and equipment, permitting renewal of the apparatus in the field and by unskilled personnel.

Generally, the invention provides a novel detonator means which may be used in a string of interconnected perforating unit sections interconnected at easily assembled and disassambled joints including short substitute joints or "subs," the detonator means using the sections and subs as support means and employing an electrically ignited charge of deflagrable material or powder not sensitive to ordinary handling shock, to create pressure to disrupt or shear apart a piece of hard material and propel, preferably, a portion or piece or fragment of the latter along a preferably restricted path into detonating impingement with a portion, preferably an end, of a detonable fuse held and positioned in the path by a part of the means, whereby the fuse is detonated without use of any means sensitive to ordinary handling shock. The means for detonating the fuse are preferably but not necessarily formed as a principal bored and chambered plug snugly fitting in an end of a sub, into the chamber of which plug an electrically heated igniter is removably fitted, the chamber containing adjacent the igniter a deflagrable charge which in turn is restrained from exit from the chamber by a disruptable element, preferably in the form of a shear disc, which serves to tightly close the chamber, the shear disc being tightly held in posiiton by a bored member, readily yet tightly fitting in the bore of the plug as by being threaded thereinto, the bore of the member being completely covered at one end by the shear disc and preferably being arranged to provide a restricted path for a projectile formed of a fragment of the shear disc upon disruption of the latter by pressure created by deflagration of the deflagrable charge; the means also including a fuse holding and positioning device arranged to hold and position a portion, preferably an end, of a detonable fuse either in the bore of the member or outside but in axial alignment therewith, so that the fragment of the shear disc will, with a high degree of certainty, be propelled at high speed into detonating impingement or impact with the fuse and detonate the latter. The plug is preferably of a shouldered-cylinder form adapted to easily but snugly slide into position in one end of a sub with the shoulder abutting the end of the sub, and the bored member providing the restricted path for a fragment of the disc preferably such as to screw readily but tightly into the internally threaded bore of the plug to thereby tightly press the disc in place over the powder chamber of the plug; and the fuse holding means is preferably in the form of a readily removable means including a pin arranged transversely across the axis of the perforator sections, with a hole in the pin arranged in substantially axial alignment with the bore of the plug and member so that a portion, preferably an end, of a detonable fuse, either with or without an auxiliary charge, can be positioned either in the bore of the member or outside but in substantially axial alignment with said bore and in the direct path of the propelled fragment. The pin, the fuse, the shear disc, the deflagrable charge, and the igniter may all be expendable items of the apparatus, are all quite readily assembled and replaced or renewed, and are, with all other parts of the apparatus, very insensitive to ordinary handling shocks.

With the aforementioned and other obvious disadvantages and dangers of the prior art devices and apparatus in view, it is accordingly, a principal object of the present invention to provide a detonator for a detonable fuse which is effective to detonate such a fuse without means or materials sensitive to ordinary handling shock.

A further object of the invention is the provision of a readily and safely renewable detonator for a detonable fuse, the detonator being simple in construction and highly effective to detonate the fuse in the complete absence of means sensitive to ordinary handling shock.

An additional object of the invention is the provision of a fuse detonator comprising a disruptable element, shock insensitive means to disrupt the element and propel at least a portion of the element along a path, and means to hold a detonable fuse with a portion thereof in the path so the propelled portion of the element will make detonating impingement with the portion of the fuse disposed in its path.

Another object of the invention is to provide in a well casing perforator apparatus using explosive charges in the perforating operation and a detonable fuses to detonate the charges, a simple and safe detonator for detonating the fuse, the apparatus including the detonator comprising only parts and materials not sensitive to ordinary handling shock, whereby the apparatus may be safely renewed in the field by ordinary and unskilled workmen.

The above-mentioned objects, and other objects obvious or hereinafter made apparent, are accomplished by the invention, a preferred physical embodiment of which is described and explained in the disclosure of this specification and accompanying drawings, in which like reference ordinals in the several views have reference to the same or substantially identical parts. In the drawings:

Fig. 1 is a view, with parts broken away, of a well casing perforator device comprising the several components of the invention and indicating the general relative disposition of the support means and of auxiliary means including a suspending and electric power transmitting cable;

Fig. 2A is a longitudinal sectional view of a portion of the structure more generally depicted in Fig. 1 and there indicated by the bracketed portion A, and showing certain details pertinent to the subject matter of the invention;

Fig. 2B is a longitudinal sectional view similar to Fig. 2A and showing details of structure included in that bracketed at B in Fig. 1;

Fig. 3A is a fragmentary detail view on a plane indicated by line 3—3 of Fig. 2B, principally in section, and illustrating the means for holding and positioning a portion of one kind of detonable fuse in the path of a propelled fragment; and

Fig. 3B is a view similar to Fig. 3A but depicting the holding means positioning another kind of detonable fuse in the path of a propelled fragment.

Referring to the drawings, and to Fig. 1 thereof in particular, a well casing perforating apparatus assembly is indicated generally by ordinal **10**, the apparatus comprising an upper cylindrical body section **11**, a series of interconnected perforator sections indicated generally at **12**, the lowermost one of which is terminated by a bull plug **13**. While but two sections **12** are shown, it will be understood that only one such section may be employed, or two or more, as conditions and requirements of the perforating operation dictate. Each of sections **12** above the lowermost thereof includes a substitute joint or sub **14** at its lower end, the bull plug **13** serving in lieu of a sub for the lowermost of the sections. The upper part of body section **11** is provided with an upstanding cable head **15** in which is secured and sealed in conventional manner a suspending cable **16** which comprises an insulated electrical conductor **17** whose purpose is to supply the suspended apparatus with electric current, the grounded exterior of the metallic body of the apparatus and the earth serving as a return path for the current.

Each perforator section **12** is provided with a plurality of threaded apertures **18** (see Fig. 2A), each equipped with a gasketed centering plug **19** readily removable therefrom in an evident manner. The apertures **18** may be distributed around the periphery and along the length of the perforator section in any desired pattern. Each centering plug **19** is provided with an internal tapered recess **20** arranged to receive and seat alternatively the

frusto-conical end of a charge-aligner **21** forming part of an explosive-containing shaped-charge unit **22**, or a means hereinafter described in detail. Diametrically opposite each aperture **18** is a respective recess **23** formed in the interior wall of the perforator section, and the recess being adapted to alternatively receive a pin, hereinafter described, or the cylindrical base **24** of a shaped-charge unit **22**. Units **22** are of conventional commercial form and may be such as are disclosed in the application for patent of Lindsay et al., Serial No. 106,567, filed July 25, 1949, now U.S. Patent No. 2,707,917, issued May 10, 1955.

A length of detonable fuse **25** such as "Primacord 50 grain PETN," manufactured by Ensign-Bickford Company, for example, is arranged in each perforator section **12** for detonating the shaped charge units **22** in the respective section, the fuse extending through holes formed in the bases **24** of units **22**, one hole to each of the units, and extending downwardly below the lowermost unit **22** in the section. This downwardly extending end portion **26** of fuse **25** is preferably but not necessarily encased in a stiff tubular case **27** (see Fig. 3A) formed of fiber or other stiff material, or may be provided with a closed-end case **27***a* (see Fig. 3B), formed of fiber or metal and partly filled with detonable material **28** of the same composition as that employed in fuse **25**, selection of the type of case depending upon the relative insensitivity to shock of the type of detonable fuse employed. For types of fuses extremely difficult to detonate, and with other considerations set out hereinafter in mind, the closed-end case is preferred; whereas for other types of detonable fuses a tubular case, as case **27**, or no case at all, is sufficient. Detonable material **28**, being of the same type or composition as that employed in fuse **25**, is not sensitive to ordinary handling shocks, hence either arrangement of fuse end may readily be assembled in the apparatus of the invention by unskilled personnel without danger of accidental detonation.

A portion of the fuse, such as end **26**, is held in position for detonation by means including a pin **30** suitably shaped as indicated from metal, thermo-setting resin or other suitable material, the pin being formed at one end to snugly fit in one of the recesses **23** and at its other end with an exterior taper complementary to the taper of a plug **19** and further with an internal bore **31** arranged to receive a compression spring **32** adapted to be compressed by plug **19** when the latter is screwed home in recess **18**. Pin **30** is provided with a transverse hole or bore **33** through which the end **26** of the fuse **25** is threaded, the fuse being held therein by suitable means such as the force of gravity, a friction fit, wedge means, or, preferably and as illustrated, by an elastic grommet **34** applied over the end of the fuse and forced into position along the fuse and into contact with pin **30**. A suitable length of the fuse is left protruding from the lower side or face of the grommet, as will hereinafter be explained in more detail.

Situated below each pin **30**, and supported by the sub **14** (or bull nose **13**) secured to the lower end of a section **12** is a detonator indicated generally in Fig. 1 by ordinal **36** and comprising a chamber-forming means preferably in the form of a bored plug **36***a* (Fig. 2B) dimensioned to fit snugly in the upper cylindrical part of the respective sub **14** or nose **13**, as indicated. Plug **36***a* is preferably formed with an internally threaded bore **37**, a smaller step-bore **38** and a still smaller and preferably slightly tapered chamber-forming bore **39** having a generally conical base **40** terminating in an igniter-pin receiving aperture or bore **41**, which in turn is provided with a flared lower opening **42**. Plug **36***a* also is provided with a circumferentially disposed series of longitudinally extending bores **43**, two of which are shown in Fig. 2B, each positioned close to the outside of the plug as indicated and serving to pass electric conductors through the plug as will hereinafter be explained in detail.

Also comprised in the detonator **36** is a means in the form of a preferably bored plug member **44** formed to be mounted tightly and securely in bore **37**, as by means of complementary threads as illustrated, for example; the plug having a preferably straight bore or passage **45** so dimensioned and positioned that when plug **44** is tightly engaged with the bottom of bore **37**, bore or passage **45** is in substantially axial alignment with both hole **33** of pin **30** and chamber-forming bore **39** of plug **36***a*, and such that the diameter or principal dimension of bore or passage **45** is somewhat less than that of bore **38** and of bore **39**. Bore or passage **45** is preferably terminated at its upper or outer end by a conical recess **46** which is adapted to guide and receive the end **26** of a fuse **25** when the apparatus is assembled. Also, the length of the straight part of bore **45** is preferably of the order of one inch, although considerable variation in this dimension is permissible, depending upon other design factors.

Tightly pressed into place in short step-bore **38** by plug member **44** is a preferably recessed disruptable element **47** preferably of the character of a shear-disc of mild cold-rolled steel or similar material. Element **47** retains in place in slightly tapered bore **39** a cylinder **49** of fiber or similar suitable material, which rests on the conical base **40** and in turn serves to aid in sealing in bore **39** a deflagrable charge **50** of a common propellant powder and an electrically operable igniter **51** having an electrically insulated pin **52** extending through a conical sealing plug **53** and insulating washer **54** as indicated, the pin being threaded at its end to receive suitable nuts **55** to secure the igniter in position and to receive a suitable electric conductor as will hereinafter be explained. Charge **50** is insensitive to ordinary handling shock and may, by way of example, be a pellet containing 30 grains of "Hercules H.E.S. 5002.180" propellant powder; and igniter **51** may be of a type using a fusible electric filament embedded in black powder, or such as is fully disclosed in the patent to Phillips, No. 2,649,736 issued August 25, 1953. The arrangement and proportions of the structures just described are such that when electric current is supplied to igniter pin **52** and returned through the interconnected metallic bodies of the several structures to the source, deflagrable charge **50** is ignited or deflagrated and produces a high pressure in the chamber formed by bore **39**. As this pressure increases to near its peak value, a fragment or portion of disruptable element **47** is broken or sheared out, usually in the form of a round slug or fragment, the latter is propelled at high speed along a more or less confined path provided in bore or passage **45**, and into detonating impingement with that portion of fuse **25** which is disposed in its path. While bore or passage **45** is illustrated as a cylindrical bore since that shape is perhaps easiest and simplest to form, the passage could well be of other shape, and could be of dimensions different from those of the end portion of fuse **25**. Also, while element **47** has been illustrated as a simply coined disc, it could be of frangible material of other type and shape, it being necessary for the purposes of the invention only that the pressure provided in chamber or bore **39** be sufficient to disrupt and propel a portion, either all or a part, of element **47** into detonating impingement with or upon a portion of fuse **25**. Further, while for the sake of simplicity and ease of assembly the end face of the fuse, in the disclosed embodiment of the apparatus, forms a target for the propelled portion of element **47**, it is evident that a loop of fuse **25** could also be used at the target. Thus, for example, the chamber could be of spherical shape with the fuse arrayed on the interior wall with a disruptable element in the form of a frangible sphere inside and containing the igniter at its center surrounded by the deflagrable charge, whereby at least one portion of the frangible sphere would be propelled into detonating impingement with the detonable fuse.

Plug **36***a* is formed with means to hold it in position

against undue downward descent in the bore of a sub **14** or nose **13**, the means preferably being in the form of an annular shoulder resting on the end of the sub or nose, as indicated; and the plug is held from upward dislodgement in the assembled apparatus by a transversely notched internally-threaded sleeve **36***b* which is attached to the upper end of plug **36***a* as by means of a threaded joint as illustrated, the sleeve having opposed holding notches **36***c* complementary to pin **30** as indicated in Fig 2B.

Referring now to Fig. 2A, body section **11** is provided with a bore **56** having internal threads for a threaded joint **57**, and an internal upper shoulder **58**. An adapter plug **59**, provided with an external upwardly facing shoulder **60** and a threaded upper central periphery is screwed into the lower end of bore **56**. This plug is provided with a circumferentially arranged series of longitudinally extending through-holes **61** for reception of a plurality of connector bolts such as **62**, **62***a*, which latter are each encircled by a respective tubular insulator sleeve **63** and a pair of end insulating washers **64**, **64**, the insulator devices serving the obvious function of electrically isolating the through-bolts from the metal of adapter plug **59**. Nuts, as shown, are provided to retain the bolts in place.

Positioned in bore **56** immediately above the connector bolts and plug **59** is a terminal block **65** having sockets in its lower end and making contact with respective connector bolts, and having conductors such as **65***b*, **65***c*, one for each socket, leading upwardly through the block, the latter being properly oriented in bore **56** with respect to the several bolts by any suitable means, as, for example, a pin **66** mounted in plug **59** and engaging in a complementary hole in the terminal block. Positioned above terminal block **65** in body section **11** is a circuit controller **65***a* (see Fig. 1) which may be of any suitable type and, for example, may be like or similar to that fully described in the patent to Johnston, No. 2,048,451. The purpose of controller **65***a*, to which the conductors such as **65***b*, **65***c* lead, is to provide electric current to each of the conductors in a prearranged sequence, as is explained in the patent.

The connector bolts such as **62**, **62***a*, have secured to their lower ends, as by soldering, respective insulated conductors such as **67**, **68** which are provided in excess length and which extend loosely downwardly past units **22** and through one or another of bores **43** in plug **36***a*, from which one conductor, such as **67**, extends to and terminates at, an igniter pin **52** as shown in Fig. 2B. Others of the conductors, such as **68**, extend downwardly and are secured to respective ones of connector bolts such as **62***b*, similar to bolts **62**, **62***a*. Connector bolts such as **62***b* are arranged in an adapter plug **69** which in all material respects may be similar to plug **59** and which is secured in place in similar fashion, in the lower end of the bore of sub **14**. Conductors such as **70** are secured to respective connector bolts such as **62***b* and extend downwardly therefrom to other of igniter pins such as **52**, there being an igniter pin in a detonator for each of the perforator unit sections such as **12**. Conductor **70** may, for example, lead to the lowermost detonator **36**, which is located in the upper end of bull nose **13** and the lower end of the lowermost perforator section **12**, as indicated in Fig. 1.

As employed herein, the term "deflagrable charge" is intended to denote a charge of combustible material capable when ignited of burning rapidly or deflagrating with release of considerable energy, but yet insensitive to ordinary handling shock. Typical of such charge is a charge of "Hercules H.E.S. 5002.180" powder; and in contrast thereto is a charge of fulminate of mercury, which is normally a detonable substance sensitive to ordinary thermal and mechanical shocks such as slight abrasion, and which violently explodes when ignited or subjected to mechanical shock. By "detonating" is usually meant combustion at such a rapid rate that a sudden and violent explosion results. By the expression "ordi-

nary handling shock" is meant that type of shock, whether thermal or mechanical or of other nature, to which the combustible or detonable materials or devices of the nature of those disclosed are in any way likely to be subjected in normal handling, assembly, and usage procedures, and that type of shock being of such characteristics that subjection thereto of such sensitive devices as blasting caps would at least occasionally result in explosion of the sensitive device. Further, as employed herein, the term "detonating impingement" is intended to mean the engagement of a moving body or element with a detonable material with such speed and energy of impact that the detonable material detonates. By the expression "sensitive to ordinary handling shock" is meant such sensitivity to thermal or mechanical shock or static electricity that explosion of the substance is likely to at least occasionally occur when the material or portions thereof are subjected to such shocks as could normally be encountered in ordinary handling of the material, such as occur, for example, in handling, assembling, dropping, and the like.

While wide variations in design, loading, and assembly of apparatus according to the invention are possible, one commercially acceptable design will be characterized as an example. Using the aforementioned "Primacord 50 grain PETN" fuse, the end being arranged as shown in Fig. 2B of the drawings and spaced one and one-sixteenth inches from the nearest face of a shear disc or element **47** of mild cold-rolled steel one-tenth inch thick at the bore, a bore **45** of seven thirty-seconds of an inch in diameter, a propellant charge loading density of 260 grains per cubic inch of free space in chamber or bore **39** (26 grains in a chamber free space of approximately one-tenth cubic inch volume), the propellant being "Hercules H.E.S. 5002.180," and plug member **44** and plug **36***a* being of hardened steel, commercially acceptable detonation of the fuse is effected upon ignition of deflagrable charge **50** by igniter **51**.

Several possible modes of assembly of the illustrated apparatus are apparent. With respect to the detonator proper, a cylinder **49** and an igniter are dropped into the chamber of plug **36***a*, seal plug **53**, washer **54** and a nut **55** applied and tightened, a deflagrable charge **50** dropped in the chamber and an element **47** set in place in stepped bore **38**. Plug **44** is then tightly wrenched into firm seating engagement with element **47**, sleeve **36***c* screwed onto plug **36***a*, wires such as **67**, **68** are threaded through holes **43**, a length of fuse passed down through units **22** and a pin **30**, a grommet **34** applied and pin **30** inserted in recess **23** and plug **19**, wire **67** secured to pin **52** with a nut **55**, plug **36***a* dropped into sub **14** and the latter screwed onto section **12** (the excess of wire such as **67**, **68** permitting any necessary or accidental twisting); wires such as **68** then being secured to bolt such as **62***b*, plug **69** screwed into sub **14** (with excess wire again permitting twisting), and the procedure continued until the perforator "string" is completed. Wires and electric conductors are preferably suitably coded to facilitate termination of the correct wire at each igniter pin. Disassembly is obvious and is simpler and easier due to the destruction in use of the expendable items such as igniter, deflagrating charge, shear disc, fuse, grommet, and wires.

From the above description of a preferred embodiment of the invention it will be noted that there is provided a simple detonator for a detonable fuse, comprising only means which are quite insensitive to ordinary handling shock; the detonator and associated apparatus being easily and quickly assemblable without danger of accidental detonation or explosion, and the apparatus being readily disassemblable after usage whereby the expendable parts may be easily and quickly replaced. The invention thus permits safe and rapid assembly of well casing perforators and like equipment by relatively inexperienced or unskilled workmen, and in the field, accordingly, greatly reducing the cost and danger of such work and the time required for equipment servicing.

It is apparent to those skilled in the art to which the invention pertains that many modifications of the apparatus and its components may readily be effected; hence to be limited to the specific details of the described preferred embodiment of the invention is not desired, but what is claimed is:

1. A readily and safely renewable detonator for a detonable fuse comprising: readily demountable cylindrical upper and lower support members in substantially axial alignment; an axially bored and chambered plug snugly mounted in the upper end of said lower support member; a deflagrating charge and an igniter therefor slidably insertable into the chamber of said plug; a disruptable element closing said chamber; a bored member removably secured in the bore of said plug, with the bore thereof covered at one end by said disruptable element; and readily assembled means for holding said plug in said supports and serving to hold and position an end of a detonable fuse insensitive to ordinary handling shock in substantially axial alignment with said bore; whereby upon ignition of said charge by said igniter said disruptable element is disrupted and at least a portion thereof propelled along said bore and into detonating impingement with said end of said fuse, and whereby the fuse is detonated without any material sensitive to ordinary handling shock.

2. A readily and safely renewable detonator for a detonable fuse comprising: readily demountable cylindrical upper and lower support members in substantially axial alignment; an axially bored and chambered plug snugly mounted in the upper end of said lower support member; a deflagrating charge and an igniter therefor slidably insertable into the chamber of said plug; a disruptable element closing said chamber; a bored member removably secured in the bore of said plug, with the bore thereof covered at one end by said disruptable element; and a pin extending transversely in one of said support members for holding said plug in said supports, said pin providing an aperture therethrough serving to hold and position an end of a detonable fuse insensitive to ordinary handling shock in substantially axial alignment with said bore; whereby upon ignition of said charge by said igniter said disruptable element is disrupted and at least a portion thereof propelled along said bore and into detonating impingement with said end of said fuse, and whereby the fuse is detonated without any material sensitive to ordinary handling shock.

3. In a well casing perforating apparatus in which a series of detonable charges of material insensitive to ordinary handling shock are arranged to be detonated in rapid succession by a detonable cord fuse likewise insensitive to ordinary handling shock and extending to said detonable charges, a detonator arranged to detonate said fuse and comprising: readily demountable cylindrical upper and lower housing members for said charges, in substantially axial alignment, said housing members providing respectively upper and lower support members; an axially bored and chambered plug snugly mounted in the upper end of said lower support member; a deflagrating charge and an igniter therefor slidably insertable into the chamber of said plug; a disruptable element closing said chamber; a bored member removably secured in the bore of said plug, with the bore thereof covered at one end by said disruptable element; and readily assembled means for holding said plug in said supports and serving to hold and position an end of a detonable fuse insensitive to ordinary handling shock in substantially axial alignment with said bore; whereby upon ignition of said charge by said igniter said disruptable element is disrupted and at least a portion thereof propelled along said bore and into detonating impingement with said end of said fuse, and whereby the fuse is detonated without any material sensitive to ordinary handling shock.

4. In well perforating apparatus including a sealed car-

rier providing an elongated hollow spaced therein, shaped charge perforating units mounted in the hollow space of said carrier and adapted to fire outwardly through the walls of said carrier, and a detonable cord fuse insensitive to ordinary handling shock extending in detonating relation to said shaped charge perforating units, the combination therewith of a detonator for said fuse comprising: an axially bored and chambered plug readily removably mounted in the hollow space of said carrier; a deflagrating charge and an igniter therefor slidably insertable into the chamber of said plug; a disruptable element closing said chamber; a bored member removably secured in the bore of said plug, with the bore thereof covered at one end by said disruptable element; readily assembled means for holding said plug in the hollow space of said carrier and serving to hold and position an end of said fuse in substantially axial alignment with the bore of said bored member; whereby upon iginition of said charge by said igniter said disruptable element is disrupted and at least

a portion thereof propelled along said bore and into detonating impingement with said end of said fuse, and whereby the fuse is detonated without any material sensitive to ordinary handling shock.

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2,705,920	Kanady	Apr. 12, 1955