

[54] SELECTIVE FIRING APPARATUS

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[58] Field of Search 175/4.55; 181/5 BE; 102/21.6; 166/177

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UNITED STATES PATENTS

3,327,791	6/1967	Harrigan	175/4.55
3,126,964	3/1964	La Rue	175/4.55
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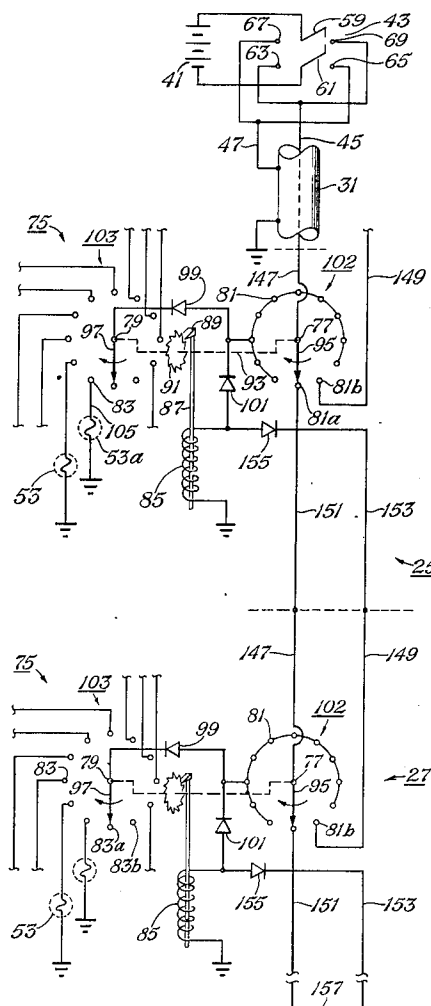
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[57]

ABSTRACT

Improved apparatus for selectively firing charges in a well penetrating subterranean formations characterized by a plurality of discrete and separable guns; each carrying, in addition to its predetermined number of charges, a multi-deck stepping switch for connecting the charges with the firing conductor in sequence within each gun, the stepping switch of each lower gun having an electrical connection with the stepping relay of the stepping switch of the next higher gun such that the next higher gun is stepped from an isolating contact onto its first charge after, and only after, all of the charges in the lower gun have been fired. Appropriate unidirectional conduction means are provided to pass current of a first polarity for firing the charges; pass current of a second polarity for stepping onto the next charge; and to isolate electrically, lower guns such that they will not cause a malfunction even if their conductors should become grounded. An electrical interconnection is provided on the bottom gun such that its stepping switch may be stepped from its isolating contact by current of the second polarity. Specific structural and preferred embodiments are also disclosed.

7 Claims, 4 Drawing Figures



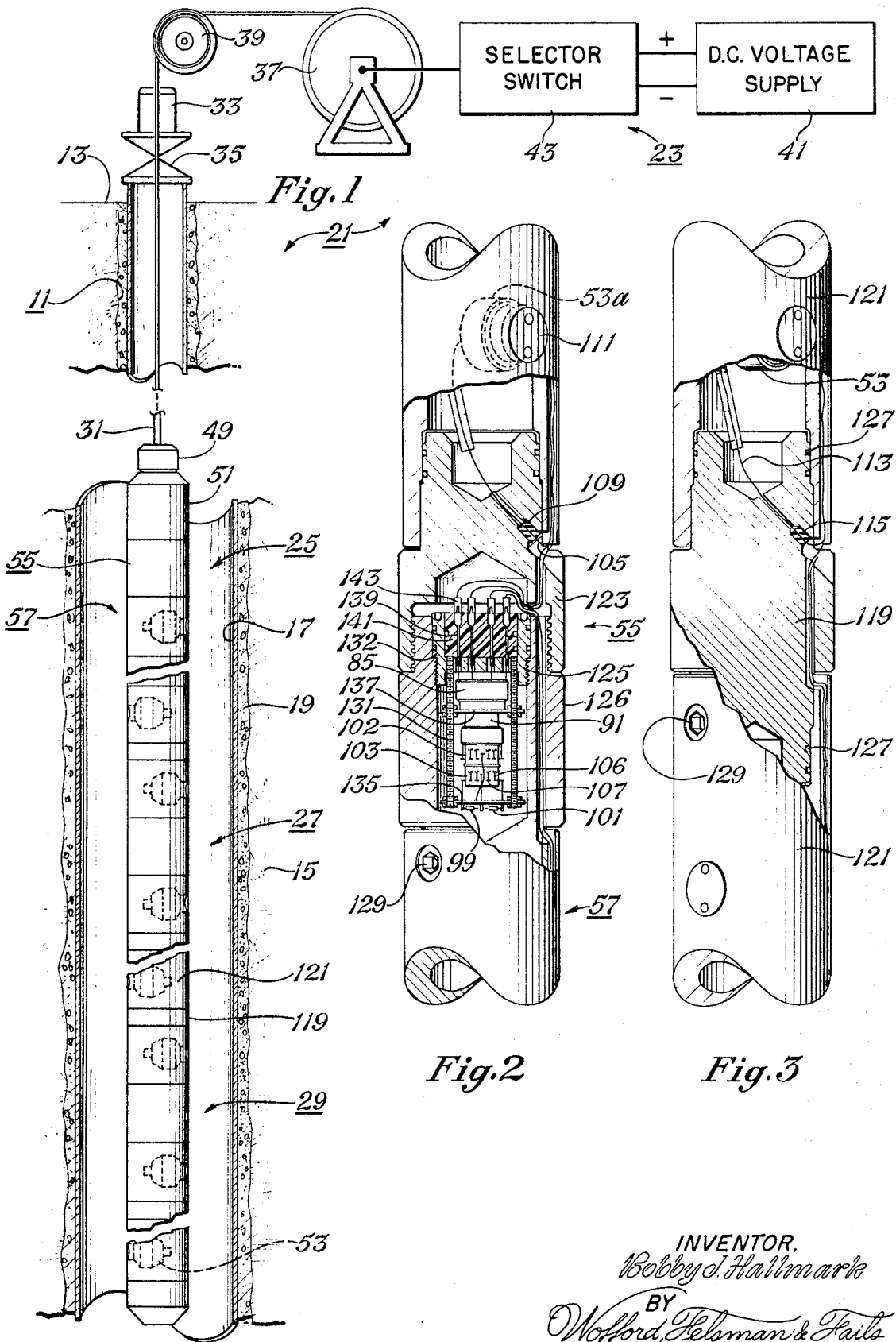
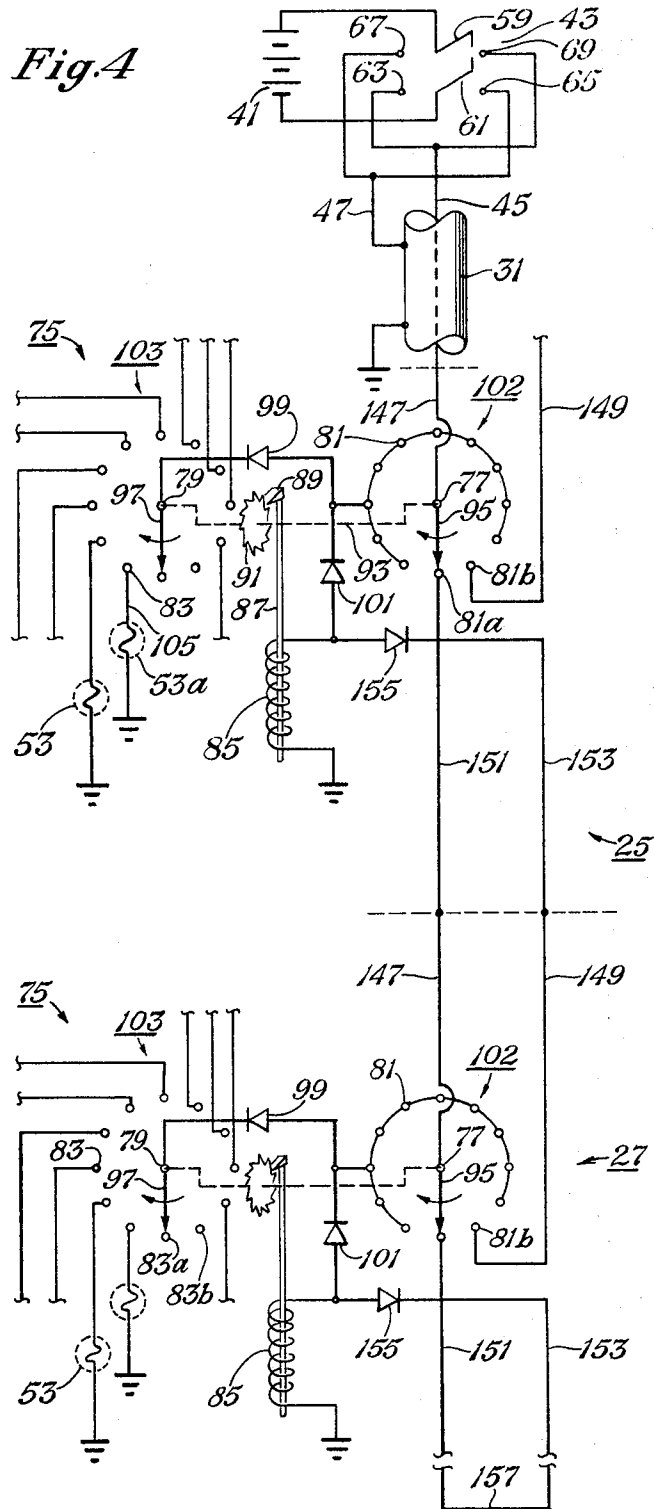


Fig. 4



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SELECTIVE FIRING APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to apparatus for detonation of explosive charges at a location remote from a control location. More particularly, it relates to well perforating apparatus for selectively firing a plurality of electrically detonable perforating means individually.

2. Description of the Prior Art

As noted in U.S. Pat. No. 3,126,964, it has been the usual practice to employ a perforating gun having a multiplicity of explosive charges positioned therealong and interconnected by a line explosive, such as Primacord, for the purpose of detonating the explosive charges. The Primacord is detonated by an electrically detonable squib disposed in the housing of the perforating gun. The simultaneous detonation of the line explosive and the explosive perforating charges releases a tremendous amount of energy, frequently damaging the well casing. Moreover, to have a successful perforating job with the desired number of perforations, the preparation of the gun must be planned in advance so that the proper number of charges are employed. Also, the transportation of the gun with the charges electrically connected presented a hazard since stray currents could be induced; for example, by static electricity or by electromagnetic energy emanations, such as from television broadcasting towers.

The improvement in the invention described by LaRue in U.S. Pat. No. 3,126,964 enabled firing the explosive charges individually in a downhole gun. Insofar as I am aware, however, the prior art has not provided a plurality of gun means in which the charges in each gun could be selectively and individually fired and in which the next upper gun would thereafter, and only thereafter, be armed so that it could be fired. Particularly, the prior art has not provided perforating apparatus incorporating a plurality of guns, each of the guns being readily prepared and assembled into the overall perforating apparatus at the well site, thereby providing increased flexibility without the necessity for elaborate pre-planning.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic diagram of a well installation and perforating apparatus in accordance with one embodiment of this invention.

FIG. 2 is a partial side elevational view, partly cut-away, of the modular construction of the embodiment of FIG. 1 facilitating field assembly of the guns to do a desired perforating job.

FIG. 3 is a partial side elevational view, partly cut-away, illustrating the apparatus for assembling the charge-containing subassemblies in a gun in the embodiment of FIG. 1.

FIG. 4 is an electrical schematic diagram of the perforating apparatus in accordance with one embodiment of this invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

It is an object of this invention to provide apparatus for selectively detonating from an operating location a plurality of electrically detonable explosive charge means located at a remote location by apparatus incorporating a plurality of discrete and separable guns, each gun having a plurality of charges; means for firing

the charges; and means for arming the next higher gun after, and only after, all of the charges have been fired in the lower gun. It is a specific object of the invention to also provide, singly or in combination, and in addition to the foregoing object, unidirectional conduction means to allow firing of the charges by a signal of a first polarity; stepping of the advancing means onto the respective charges by a signal of a second polarity; and electrical isolation so that a short circuit in a lower, previously fired gun will not adversely affect operation of an upper gun.

It is also an object of this invention to provide modular construction such that a plurality of guns containing the desired number of charges and their firing means can be assembled at the well site for a high degree of flexibility in effecting the desired perforating of wells, including the so-called "pin point" perforating.

Other objects will become apparent from the detailed descriptive matter hereinafter, particularly when taken in conjunction with the drawings delineated hereinbefore.

Referring to FIG. 1, borehole 11 extends from the earth's surface 13 to a productive subterranean formation 15. The borehole 11 has casing 17 bonded to the wall of the borehole by a cement sheath 19 in conventional manner. Perforating apparatus is illustrated employed in the well for selectively detonating, from the surface, a plurality of electrically detonable explosive charges located at the remote subterranean formation for establishing communication between the productive subterranean formation and the interior of the casing 17. The perforating apparatus 21 comprises conventional surface equipment 23 and a plurality of discrete and separable gun means; such as, guns 25, 27 and 29; suspended in the casing 17 via cable 31. A conventional lubricator 33 is provided for insertion and running in of the guns and cable through the conventional well head, illustrated by valve 35.

The cable 31 comprises at least two electrical conductor means, conventionally an internal conductor and a shield that serves as an electrical common, or ground. The cable 31 is shown as being connected to a winch 37 by way of pulley 39. The cable 31 is wound on a drum on the winch 37 in accordance with usual practice. The electrical conductors comprising the at least two conductor means are connected with a direct current voltage supply source 41 by way of a selector switch 43. The voltage source 41 and the selector switch 43 cooperate, as illustrated in FIG. 4, to enable impressing an electrical signal of the desired polarity onto the conductors 45 and 47 of the cable 31.

The respective plurality of gun means are connected with the cable 31 by adapter sub 49 and cable head 51. Conventional adapter subs and cable heads may be employed. Accordingly, there is no need for further detailed description of them herein.

Each of the gun means, such as gun 25, has a plurality of charges; a firing electrical connector means for firing the charges; isolation means for maintaining the charges electrically insulated prior to firing; actuator means for effecting stepping of the firing electrical connector means to connect the respective charges to the first conductor means; and advancing means for advancing the actuator means of a gun means. The broadly recited elements will be specifically delineated later hereinafter with respect to FIG. 4. As illustrated in FIGS. 1-3, each gun comprises first and second mod-

ules 55 and 57. First module 55 contains the firing electrical connector means, the actuator means, the isolation means and the advancing means. The second module 57 contains the charges 53. By this modular construction the desired number of guns may be readily assembled in the field for a given perforating job. The first module may be readily interchanged, replaced or repaired as necessary without having to replace an entire gun.

In the first module, the firing electrical connector means includes a unidirectional conduction means for passing current of a first polarity. The firing electrical connector means is electrically connected with the respective charges 53 and with the first conductor means, such as conductor 45 in FIG. 4, and operable to connect the conductor 45 with respective charges 53 responsive to the actuator means. The actuator means also includes a second unidirectional conduction means for passing current of a second polarity for effecting intra-gun advancing.

The advancing means of a particular gun comprises first and second portions for at least initially advancing the gun's own actuator means, or intra-gun advancing, and a third portion for initially advancing the actuator means of a next higher gun in the perforating apparatus 21. The first portion of the advancing means is electrically connected with the first conductor 45 when the isolation means is maintaining the charges electrically insulated. The second portion is drivingly connected with the actuator means. The third portion is electrically connectable with the conductor means after, and only after, the charges in its gun means have been fired in normal operation such that the firing electrical connector means of the next higher gun is moved from the isolation means and connected with the first charge in the next higher gun after, and only after, the charges in the lower or associated gun have been fired in normal operation. The term "associated gun" as used herein means the gun that is associated with a particular charge selector assembly 125. The term "lower gun" as used herein in some cases includes an "associated gun."

An electrical interconnection is electrically connected with the first and second portions of the advancing means in the bottom gun such that a signal of the second polarity will step the actuator means of the bottom gun, and only the bottom gun, so as to connect the firing electrical connector means with the first charge in the bottom gun. Thereafter, a signal of the first polarity can fire the first charge. The advancing means also contains a third unidirectional conduction means to prevent short circuiting of the signal of second polarity in the event that the advancing means in a lower gun becomes grounded.

Referring to the figures for specific construction, and particularly FIG. 4, the selector switch 43 is illustrated as a double-pole, double-throw reversing switch; the knife terminals 59 and 61 of which are respectively connected to the positive and negative terminals of the DC voltage supply source 41. The first conductor 45 of the cable 31 is connected with switch terminals 63 and 69. The conductor 47 is connected to switch terminals 67 and 65. Thus, when the switch blades are thrown to the right, as shown, first conductor 45 is positive with respect to second conductor 47. Conversely, when the switch blades 59 and 61 are thrown to the left, the conductor 45 is negative with respect to the conductor 47.

In this way, signals of the respective first and second polarities are produced.

As illustrated in FIGS. 2 and 4, each of the guns carries a stepping switch means 75 for connecting its first and second main terminals 77 and 79 sequentially with respective contacts 81 and 83 spaced around its respective deck means; such as, first and second decks 102 and 103. Each stepping switch means 75 has an actuator means such as armature 87 of solenoid 85. The armature 87 of the solenoid 85 has thereon a pivoted dog 89 that is positioned and adapted to engage the serrations in wheel 91. Wheel 91 is connected, as indicated by dashed line 93, with movable wiper arms 95 and 97. The wiper arm 95 is electrically connected with the first main terminal 77, which is connected with the first conductor 45. The wiper arm 97 is connected with the second main terminal 79. The wheel 91 rotates unidirectionally clockwise in response to respective movement of the armature 87 of the solenoid 85, and each wiper arm moves sequentially to make electrical connection with the respective contacts 81 and 83. As illustrated, the stepping switch means has twelve contacts on each deck; ten for firing ten charges plus an ultimate and penultimate contact. Use of all of the respective contacts is not necessarily required, but is advantageous in allowing alternate advancing and firing without interruption. The contacts 81, exclusive of the ultimate contact 81a and penultimate contact 81b, of the first deck 102 are connected together; and are connected with the second main terminal 79 of the second deck 103 via a first unidirectional conduction means, such as diode 99, for passing current of a first polarity for firing the respective charges. The contacts 81 are also connected via a second unidirectional conduction means such as diode 101 with the solenoid 85 for passing current for a second polarity for stepping the stepping switch means 75. The contacts 83, exclusive of the ultimate and penultimate contacts 83a and 83b, of the second deck means 103 are connected with respective charges 53 such that the charges are fired upon the application of firing current to their respective contact. Thus, it can be seen that the firing electrical connector means comprises the respective interconnected contacts 81 and wiper arm 95 of the first deck 102 and the wiper arm 97 and respective correlative contacts 83. As illustrated in FIG. 2, the conductors 106 are connected with tabs 107 which in turn are connected respectively to those contacts 81, 83 of the first and second decks 102 and 103 which are to receive external connections, to main terminal 77, and to lead 153; and are shown discontinuous for clarity of illustration. The first module 55 comprises the charge selector assembly 125 and its housing 126. In the mechanical arrangement of the charge selector assembly 125, FIG. 2, the respective elements are supported by threaded rods 131 screwed into a housing 132 and carrying respective fiberglass circular supports 135. External connections from the charge selector assembly are made via contact pins 139 which are inserted through a sealing and insulating block 141, which may be Delrin. The lower ends of the contact pins protrude from the bottom of the block 141 and are connected, as by soldering, to the conductors 106. The block 141 is sealingly inserted with appropriate O-rings in the bore of housing 132. The housing 132 is screwed into the internal threads of the housing 126 of shot selector assembly 125. The contact pins 139 are adapted at their upper ends to re-

ceive respective conductors for external connections. The respective conductors are inserted in a transverse opening in a respective contact pin 139 and insulated and secured on the pin by means of a boot 143. The electrically operated elements and their electrical interconnections are sealingly emplaced within the charge selector assembly 125 with the illustrated appropriate machined fittings and O-rings so as to prevent the invasion of borehole fluids; such as, aqueous fluids that could cause malfunctioning. As illustrated, each charge, too, is protected against invasion of borehole fluids. For example, as illustrated in FIGS. 2 and 4, the conductor 105 from the charge selector assembly 125 of the next higher gun is connected via respective sealed contact pin 139, and fluidproof seal 109 with the first charge 53a behind charge port plug 111.

In fact, as illustrated in FIGS. 1 and 3, each charge 53 is connected through respective sealed contact pin 139 and via its respective conductor 113 by way of its seal 115 in respective tandem subs 119 that join respective charge sections 121. Each section 121 houses a charge 53; and the respective tandem subs enable making up as many charges as desired in a single gun. I have found it advantageous, for example, to employ ten charges requiring ten charge sections 121 and nine tandem subs 119, FIG. 1. The selector top 123, FIG. 2, for the shot selector assembly 125 serves for connecting the bottom charge, as illustrated in FIG. 2. The respective male ends of the tandem subs are inserted within conforming machined recesses of the adjacent sections with appropriate seals, such as O-rings 127, and retained in place by retainers, such as Allen head set screws 129. Similarly, the respective male ends of the selector top 123 and the charge selector assembly 125 are inserted within respective recesses and held by the set screws 129.

Referring to FIGS. 1 and 4, the first conductor 45 serves as a correlative conductor coming into the top gun 25. Each of the guns have a first conductor means such as conductor 147 that is serially connected with the first correlative conductor coming into the gun means and with the first main terminal 77 of the first deck 102. Each gun also has a second conductor means such as conductor 149 that is serially connected with the penultimate contact 81b on the first deck and with a second correlative conductor when there is a next higher gun. The conductor 149 serves as a third portion of the advancing means. Since there is no next higher gun after the top gun, there is no need for the third portion of the advancing means; and the conductor 149 is left floating, or electrically discontinuous, in the top gun. Each gun also has third and fourth conductor means, such as conductors 151 and 153, that define respective first and second correlative conductors for electrical interconnection between an upper gun and an adjacent lower gun. The first and second portions of the advancing means comprise the third and fourth conductors 151 and 153. The third conductor 151 is connected with the ultimate contact 81a on the first deck 102, and thus provides electrical continuity when the wiper arm 95 is on the contact 81a, serving as the isolation means. The fourth conductor 153 is connected with the solenoid 85 via a third unidirectional conduction means such as diode 155 for passing current of a second polarity for stepping the stepping switch means 75 from the penultimate contact 81a of the lower gun 27. The second portion of the advancing

means also includes diode 155. It can be seen that after, and only after, the charges in a lower gun 27, FIG. 4, have been fired in normal operation, the penultimate contact 81b and second conductor 149 of gun 27, and the fourth conductor 153 of the gun 25 connect the solenoid 85 of gun 25 with the first conductor 45 for advancing the stepping switch means 75 of gun 25. Diode 155 serves to electrically isolate the solenoid 85 in event that there is a short circuit in the conductors of the associated (gun which may occur during the firing of the charges therein) such that the solenoid 85 of the associated gun would otherwise be short circuited. Specifically, the diode 155 will not pass stepping current into the short circuited electrical conductors, and consequently, the solenoid 85 of the associated gun will operate when the signal is passed through respective second diode 101, regardless of what has transpired in the associated gun.

An electrical interconnection 157 is connected with the third and fourth conductors 151 and 153, preferably at the well site. Thus, the first and second portions of the advancing means are connected by the electrical interconnection 157 in the bottom gun. The electrical interconnection 157 thus electrically connects the correlative conductors on the bottom gun such that a signal of the second polarity will step the actuator means and, consequently, the stepping switch means of the bottom gun only; and connect the respective first contacts on the respective decks 102 and 103 with respective first and second main terminals 77 and 79. Thereafter, a signal of the first polarity can fire the charge connected with the first contact on the second deck 103.

In operation, the perforating apparatus 21 is connected as described hereinbefore and the plurality of discrete and separable gun means are lowered, via cable 31, into the borehole 11 for perforating the casing 17 opposite the productive formation 15. As illustrated, there are ten charges 53 connected into each respective gun means and electrically connected with respective contacts 83 on the second deck 103 of the respective stepping switch means 75. The charges are maintained electrically isolated by the respective wiper arms 95 being disposed on contact 81a. Thus, the ultimate contacts 81a and 83a serve as initial isolation contacts. Moreover, the contact 81a and the respective conductors 151 and 147 effect electrical continuity of the first conductor 45 throughout the serially connected guns. The mechanical joiner of the respective subs and housing of the guns effect electrical continuity of second conductor 47, illustrated by the ground symbol. The charges are grounded to the gun casings for firing, without requiring a separate electrical return.

The modular construction illustrated and described hereinbefore facilitates assembly of as many guns as desired at the well site and alleviates the necessity for careful preparing of individualized custom perforating apparatus at a central location. Moreover, greater safety is effected since the respective elements may be carried to the well site separately and interconnected at the well site. The modular construction also facilitates replacement of faulty selector assemblies without requiring discarding an entire gun.

Once the guns are emplaced in the well, movement of the selector switch 43 to produce a signal of the desired polarity will effect, by way of electrical interconnector 157, advancing of the bottom relay 85 to advance the wiper arms 95 and 97 onto their respective

first contacts. Specifically, the movement of the wiper arm 95 effects removal of the isolation means and electrically connects the first charge with the first conductor 45, by way of diode 99 and wiper arm 97. Thereafter, the selector switch 43 is moved in the opposite direction to provide the firing signal of the desired first polarity which is passed by diode 99 to fire the first charge. After the first charge is fired, the selector switch is moved in the opposite direction to provide a signal of the second polarity. Diode 99 blocks the signal of the second polarity. The signal of second polarity is conducted via diode 101 to solenoid 85 to advance the stepping which to the second contact. Thereafter, the selector switch 43 is moved in the opposite direction to provide a signal of the first polarity to fire the second charge 53. The alternate movement of the stepping switch effects respective firing and advancing of the stepping switch means 75 until all of the charges have been fired in normal operation. After the tenth charge has been fired, the next signal of the second polarity will advance the wiper arm 95 to the penultimate contact 81b which serves as a final isolation contact with respect to the effects electrical interconnection via conductors 149 and 153 and diode 155 with the solenoid 85 to effect advancement of the stepping switch means 75 of the upper gun 25. Consequently, the wiper arms 95 and 97 of the upper gun 25 are advanced to their first contacts. Movement of the selector switch in the opposite direction to produce a signal of the first polarity will fire the first charge 53a of the upper gun 25. Similar sequential and alternate stepping and firing of charges will fire all of the charges in the upper gun 25; and then effect advancement of the stepping switch means of any higher gun, as described hereinbefore.

Although the stepping switch means 75 has been illustrated as a mechanical stepping switch employing solenoid 85 for its actuator means to advance wiper arms 95 and 97, any other stepping switch or switching device that can be programmed to switch in a sequential manner may be employed. For example, cross bar switches; other random access switching devices; solid state switching devices; logic elements; ring counters; or any combination thereof can be employed as the stepping switch means as long as they can be programmed to switch in the described sequential manner and provide the described functions.

The details of the physical interconnection of the respective elements herein have been treated only briefly since they are within the purview of those skilled in the art and do not require elaborate and detailed description. Likewise, the emplacement of the respective charges, and their alignment and protection by alignment washers and port plugs have been treated summarily, since they are within the skill of those conversant with this art.

From the foregoing descriptive matter it can be seen that this invention provides the objects delineated hereinbefore. Specifically, it provides the following desirable features: (1) the guns are fired, beginning with the lowest or bottom charge and progressing upwardly, in accordance with the accepted desirable technique; (2) the risk of damaging necessary electrical conductors due to guns being fired adjacent such conductors is eliminated by the unique disconnect system embodied in the series connection of the individual selector assemblies; that is, the short circuiting caused by damage in a lower gun is made inconsequential by the isolation

effected by the third diode 155; (3) each set of selectively fired charges can be fired by a single charge selector assembly; each gun comprises first and second modules such that the second module containing the charges can be preassembled at a convenient place, such as a loading shop, and the first module containing the charge selector assembly readily joined thereto; these sets of guns can then be easily transported to the well site where any number of guns can be connected in series by splicing two electrical conductors between each set and mechanically connecting the sets as described; (4) the charge selector assembly is constructed as a modular unit and requires no permanent electrical connections and can be quickly removed for replacement in the field; (5) the system is operable with conventional single conductor wire line cable; (6) any number of selector assemblies can be connected in series and operated without additional power requirements; and (7) the isolation means of the respective guns retain the charges electrically isolated until the charges in a given gun are desired to be fired; this latter feature providing greater safety.

Although the invention has been described with a certain degree of particularity, it is understood that the present disclosure is made only by way of example and that numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and the scope of the invention. For example, many equivalents will occur to those skilled in the art once Applicant's invention has been delineated.

What is claimed is:

1. In apparatus for selectively detonating from an operating location a plurality of electrically detonatable explosive charge means located at a remote location and having:

- a. first and second conductor means for conducting electrical signals extending from the operating location to the remote location, and defining a first correlative conductor and electrical common at the remote location;
- b. means at said operationing location connected to said first and second conductor means for applying electrical signals of the desired polarities to said first and second conductor means;

the improvement comprising:

- c. a plurality of discrete and separable gun means for carrying and detonating a predetermined number of said charges, said gun means being disposed at the remote location, each said gun means carrying, in addition to the charges, a charge selector assembly comprising:
 - i. a stepping switch means for connecting first and second main terminals sequentially with respective contacts spaced around respective first and second deck means of the stepping switch means, said stepping switch means having actuator means for advancing and effecting respective connections in response to an electrical signal; said stepping switch means having respective first and second main terminals of said first and second deck means connected with respective ultimate contacts before firing; said ultimate contacts being electrically isolated from contacts that are connected with respective charges; said first and second deck means having respective first and second penultimate contacts that are

also electrically isolated from the contacts connected with said charges; said first penultimate contact of said first deck means being connected with a second conductor means, as recited in element (c), (ii), hereinafter, for advancing a next upper gun's stepping switch means only after said first penultimate contact is connected with said first main terminal; a plurality of said contacts, exclusive of the ultimate and penultimate contacts, of the second deck means being electrically connected with respective charges such that said charges are fired upon the occurrence of firing current on their respective contact; a plurality of the same number of contacts, exclusive of the ultimate and penultimate contacts, of the first deck means being connected together, being electrically serially connected with the second main terminal of the second deck means and thence via respective said contacts of said second deck means and charges with said electrical common; the electrical connection with said second main terminal being via a first unidirectional conduction means that is connected for conduction in the forward direction for passing current of a first polarity through respective said charges to electrical common for firing said respective charges, said plurality of said connected together contacts of said first deck means also being connected with said actuator means via a second unidirectional conduction means that is connected for conduction in the forward direction for passing current of a second polarity for energizing said actuator means to advance said stepping switch means;

ii. a first conductor means being serially connected with a first correlative conductor coming into said gun means and with said first main terminal of said first deck means; and a second conductor means being serially connected with said penultimate contact on said first deck and with a second correlative conductor on any higher guns means;

iii. third and fourth conductor means defining first and second correlative conductors for electrical interconnection; said third conductor means being connected also with said ultimate contact on said first deck means; and said fourth conductor means being connected also with said actuator means via a third unidirectional conduction means that is connected for conduction in the forward direction for passing current of the second polarity for energizing said actuator means; and

d. an electrical interconnection electrically connecting the first and second correlative conductors on the bottom gun means so that a signal of the second polarity will energize said actuator means and consequently step said stepping switch means of the bottom gun only, and connect the respective first contacts on the respective first and second deck means with the respective first and second main terminals so that, thereafter, a signal of the first polarity will fire the charge connected with said first contact; whereby sequential signals of alternate polarity will effect advancing of said stepping switch means to and firing of all of said charges in a lower gun means and then advance the stepping switch means of the next higher

gun after, and only after, the stepping switch means of the said lower gun means has been advanced beyond the last charge thereof and to its penultimate contact position.

2. The apparatus of claim 1 wherein each said gun means comprises first and second modules, said first module containing said charge selector assembly, and said second module contains said charges, whereby the desired number of gun means may be readily joined in the field to make up the requisite assembly for a given perforating job, and said first module may be readily replaced if defective without having to replace an entire gun means.

3. The apparatus of claim 1 wherein each said third and fourth conductor means and said ultimate contact of a lower gun means are necessary only for advancing its stepping switch means to connect its first charge with the first conductor means, and a fault in the circuit of its third and fourth conductor means thereafter is inconsequential to normal operation of said gun means and any higher gun means.

4. Apparatus for selectively detonating from an operating location a plurality of electrically detonatable explosive charges located at a remote location comprising:

- a. first and second conductor means extending from the operation location to the remote location;
- b. a plurality of discrete and separable gun means for carrying and detonating a predetermined number of said charges, said gun means being disposed at the remote location; each said gun means having:
 - i. a plurality of charges;
 - ii. a firing electrical connector means for firing the charges, said firing electrical connector means including respective first and second deck means, input terminals, and output contacts, with output contacts on said first deck means being serially connected with the input terminal of said second deck means via a unidirectional conduction means that is connected for conduction in the forward direction for passing as a first signal current of a first polarity; said firing electrical connector means being connected with said first conductor means and operable to connect it to respective said output contacts on said second deck means and thence via respective said charges to electrical common, said output contacts being connected with respective said charges for firing;
 - iii. isolation means that includes initial and final isolation contacts that are electrically isolated from said contacts of said firing electrical connector means for maintaining said charges electrically isolated prior to firing said charges regardless of the magnitude of the voltage effecting said first signal and that are connected respectively with said first and third portions of said advancing means, as recited in b.v. hereinafter, for advancing its own actuator means initially and advancing the actuator means of the next higher gun means only after said firing electrical connector means has been advanced through all of its contacts that are connected with respective charges in its gun means;
 - iv. actuator means for effecting stepping of said firing electrical connector means;

v. advancing means for advancing the actuator means of a gun means; said advancing means electrically connecting said actuator means with said firing electrical connector means via a second unidirectional conduction means that is connected for conduction in the forward direction for passing as a second signal current of a second polarity and not passing said first signal; said advancing means also comprising first and second portions for initially advancing its own actuator means and a third portion for initially advancing the actuator means of the next higher gun; said first portion of said advancing means being electrically connected with said first conductor means via said initial isolation contact when said isolation means is maintaining said charges electrically isolated; said second portion being drivingly connected with said actuator means; and said third portion being connected with said final isolation contact of said first deck means of said firing electrical connector means so as to be electrically connected with said first conductor means after, and only after, the actuator means in its gun means has advanced said firing electrical connector means beyond the last charge connected thereto such that the firing electrical connector means of the next higher gun is moved from its isolation means and connected with its first charge;

c. an electrical interconnection electrically connected with the first and second portions of the advancing means in the bottom gun such taht a second signal of said second polarity will step said actuator means of the bottom gun, and only the bottom gun, so as to connect the firing electrical connector means with the first charge therein; and, thereafter, a first signal of said first polarity will fire the first charge; and

d. means at said operating location connected to said first and second conductor means for applying the first and second signals to said first and second conductor means;

whereby sequential first and second signals of alternate polarity will effect advancing of said actuator means to and firing of all of said charges in a lower gun means and then advance the actuator means of the next higher gun means after, and only after, the actuator means and said firing electrical connector means of said lower gun means has been advanced beyond the last charge thereof.

5. The apparatus of claim 4 wherein said first and second portions of said advancing means are necessary only for moving said firing electrical connector means from the isolation means and onto the contact connected with the first charge and failure of said first and second portions thereafter is inconsequential to normal operation of the gun means and respective other higher gun means.

6. The apparatus of claim 5 wherein said third portion of said advancing means contains a third unidirectional conduction means connected for conduction in the forward direction to prevent short circuiting said second signal of said second polarity in the event the advancing means in the lower gun means is grounded.

7. The apparatus of claim 4 wherein each said gun means comprises first and second modules, said first module containing said firing electrical connector means, said actuator means, said isolation means and said advancing means; and said second module containing said charges; whereby the desired number of gun means may be readily joined in the field to make up the requisite assmby for a given perforating job and said first module may be readily replaced if defective without having to replace an entire gun means.

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