

Dec. 1, 1936.

W. G. LANE

2,062,974

WELL CASING PERFORATOR

Filed Nov. 12, 1932

2 Sheets-Sheet 1

Fig. 1.

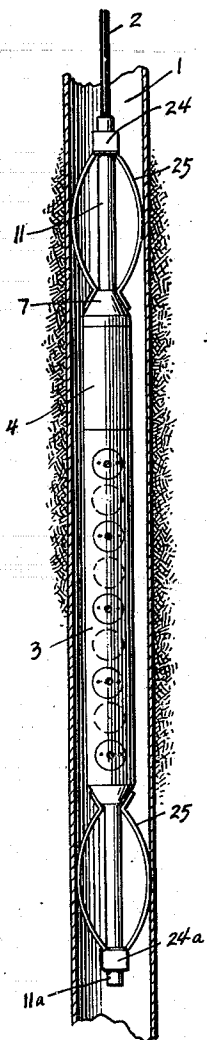


Fig. 2.

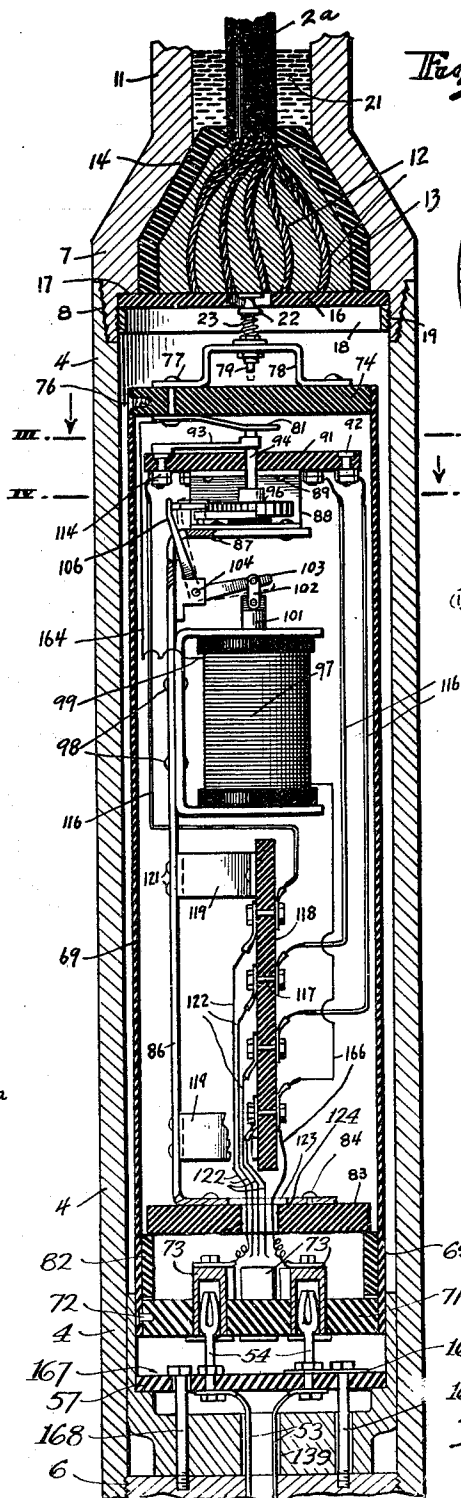
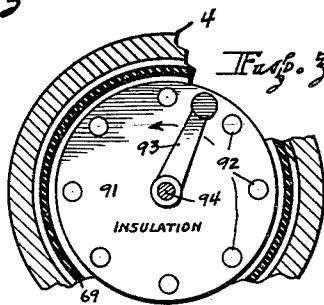
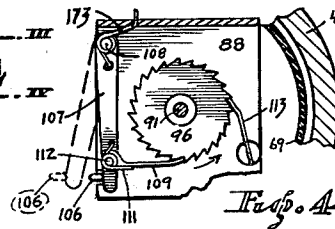
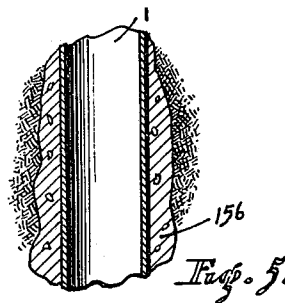
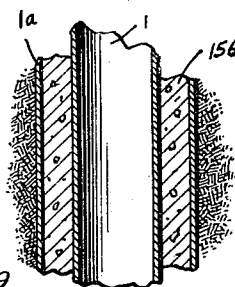


Fig. 6.

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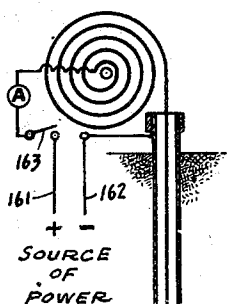
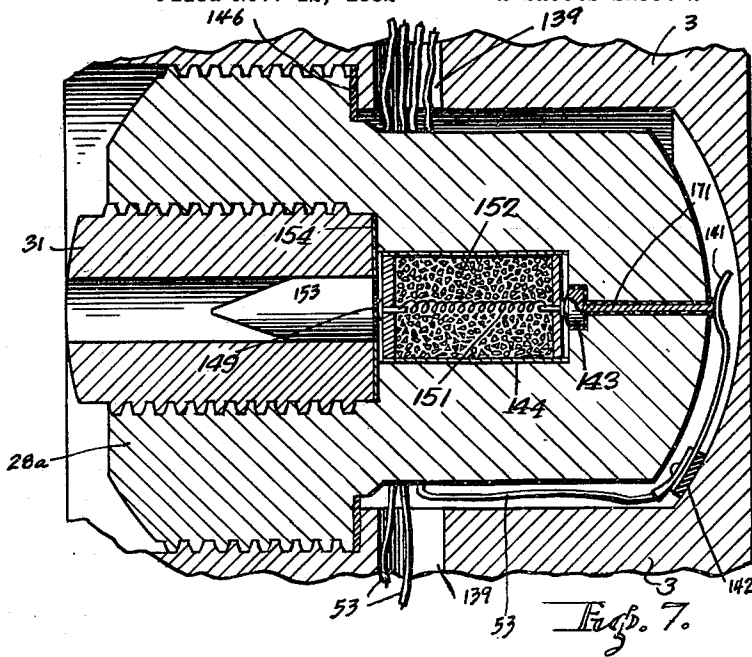
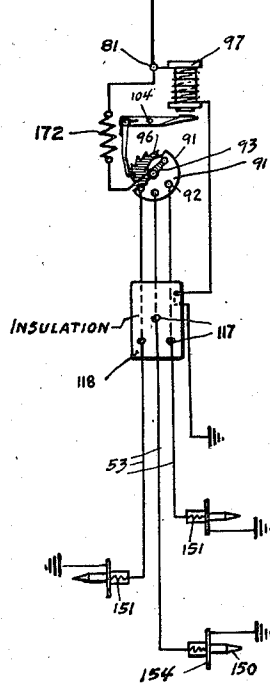
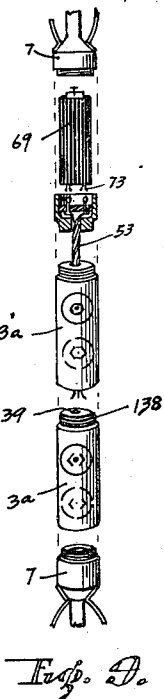


Fig. 10

Fig. 11

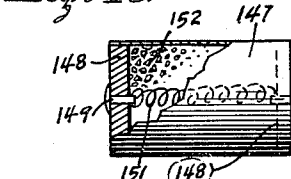
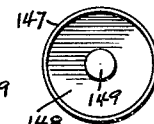


Fig. 12

Fig. 13

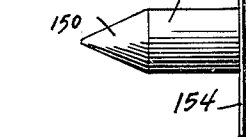
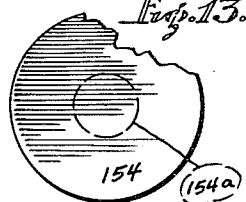


Fig. 14

Fig. 15

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WELL CASING PERFORATOR

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Application November 12, 1932, Serial No. 642,410

12 Claims. (Cl. 81—188)

The present invention is an improved casing perforator for oil wells and the like.

It is often desirable to perforate a casing, as for instance, where oil bearing sand strata have been drilled thru and cased off and the well extended to greater depth.

When production of the well has become exhausted to a degree rendering its operation unprofitable said production can be augmented by perforating the casing to admit therethru oil from sands occurring at other levels.

My invention contemplates a gun structure, adapted to be lowered into a well casing on a wire cable, and so constructed that it can be safely and effectively operated and controlled from the mouth of the well, and whereby a number of projectiles can be fired, consecutively, either singly or in groups simultaneously, to perforate a surrounding casing and penetrate the formation behind it.

As oil is usually encountered at great depths, and as the casings in deep wells often contain liquid, certain problems are presented which are not met with in ordinary gun fire practice. Again the diameter of tools capable of being run into well casings is of such small dimension as to limit the length of the barrel, thru which a projectile is fired, to a minimum.

Means must be provided to increase the degree of penetration of a projectile discharged from a barrel of such relatively short dimension and the explosive charge behind said projectile must be protected against hydrostatic pressure from without.

Solution of these problems constitutes the primary object of my invention.

Another object is the provision of a gun, of the nature disclosed, which it is impossible to discharge prematurely, or accidentally, when operated in conjunction with conventional well equipment, and one which will be serviceable for repeated use.

Other objects and advantages will become apparent as this description proceeds.

In the accompanying drawings Figure 1 represents a fragment of well casing shown in vertical central cross section and shows my improved perforating gun as it would appear while being lowered through said casing.

Figure 2 is a central vertical cross section of one tubular section of my gun and illustrates the removable connection therewith of an electrically operated control unit for firing of explosive charges contained in adjacent sections of the gun.

Figure 3 is a fragmentary section of Figure 2, taken on the line III—III.

Figure 4 is a fragmentary section of Figure 2, taken on the line IV—IV.

Figure 5 is a central vertical cross section of a fragment of casing and shows a body of cement as having been set around the casing to fill the space between it and the surrounding formation.

Figure 6 is a view, similar to Figure 5, showing another condition demanding perforation, where in two concentric strings of tubing are employed, with cement interposed between the two.

Figure 7 is a fragmentary vertical section of the body portion of the gun showing the removable barrel structure and wiring arrangement.

Figure 8 is a diagrammatic view illustrating the wiring and electrical equipment and remote control used in firing my device.

Figure 9 is a detached view of a form of the gun assembly.

Figures 10 and 11 are, respectively, a side elevation, (partly in section) and an end view of a cartridge for containing an explosive charge.

Figures 12 and 13 are, respectively, side and rear end views of a projectile and a retarding element associated therewith.

Figure 14 is a side view (partly in section) of the projectile shown in Figures 12 and 13, as it would appear after having been fired, illustrating the effect of shearing said retarding element and

Figure 15 is a vertical cross-sectional view of said retarding element after shearing has been effected.

Referring to the drawings, the numeral 1 indicates a wall casing to be perforated. My improved perforating device is lowered into the casing 1, as indicated in Figure 1, on a cable 2 unwound from a reel (not shown) at the mouth of the well.

The assembled device is comprised of a major body portion 3, a hollow cylindrical sleeve member 4, connected thereto, as by threads 6, and a head 7.

Threads 8 connect the sleeve 4 to head 7 which is reduced to form a cylindrical extension 11 integral therewith, thru which extends the cable 2.

The cable 2 serves a dual purpose. It supports the weight of my device as it is run in and out of the casing 1 and also transmits electrical energy from a source at the mouth of the well to the gun body 3. Said cable is insulated exteriorly as indicated at 2a, Figure 2, and the strands 12 of which the cable is formed are frayed and em-

bedded within a moulded or cast body of babbitt or the like indicated at 13.

As the wiring and moving parts of my device may be submerged in liquid it is necessary to seal against the intrusion of said liquid.

A frusto-conic bushing 14 of insulating material is formed exteriorly to fit the cavity in head 7 and interiorly to fit the cast body of babbitt 13. Said bushing is held in place within head 7 by a disc 16 which is held against a seat 17 by a ring 18 threaded at 19 into the open end of head 7.

When so assembled head 7 becomes an integral part or terminal for cable 2, which is securely held in the cylindrical extension 11, being embedded in a waterproof compound 21.

Electrical energy conducted thru cable 2 is transmitted to a button 22, extending thru a hole in the center of insulating disc 16. Said button is urged to contact the cast babbitt body 13 in which the strands 12 of the cable 2 are embedded, by a spring 23. My device is maintained in concentric relation to the casing 1 by means of spring cages at both ends. Bow springs 25 are attached at one end to head 7 and at the opposite end to a ring 24 slidable on the tubular extension 11. Since these springs constantly contact the casing with a firm pressure, they serve the further purpose of providing suitable electrical connection between gun body and casing when the casing is used as the ground or return lead for establishing an electrical circuit.

The bottom end of body 3 is provided with a similar centering device, a ring 24a sliding on an extension 11a of said body.

The body 3 is provided with a plurality of transverse sockets or recesses to receive separate preloaded electrically fired gun units to be hereinafter more fully described. These sockets may occur alternately on opposite sides of the body, as shown in Figures 1 and 9. A means for conducting current to said units for firing the same includes a plurality of distributor wires 53, extending through a longitudinal bore 139 in the body, there being a wire provided for each unit. The end of each wire remote from the unit is connected to a terminal post 54. These terminal posts are mounted in spaced relation around and through a platform 57 of insulative material supported in the space between the body and control unit as clearly shown in Figures 2 and 9.

I will now describe a control unit, interposed between body 3 and head 7, within the sleeve 4, and removable as a unit therefrom, adapted to conduct electrical energy, in successive impulses, for sequential firing of the device.

A cylindrical tube 69, of bakelite or suitable insulative material, is closed at the bottom by a disc 71, of insulative material, secured, as by screws 72, to said tube. Extending through said disc 71, in spaced-apart relation are sockets 73 of slip-joint terminals, said members coinciding in number with the terminal posts 54 and positioned to register therewith, so that tube 69 can be inserted and removed from sleeve member 4 and contact established and broken between all of terminal posts 54 and corresponding sockets 73, simultaneously.

Tube 69 is closed at the end remote from said terminals by a cap 74, secured within said tube, as by screws 76. Secured to said cap by rivets 77 is a U-shaped finger-pull 78, through which slides a pin 79 secured to the contact button 22.

Electrical energy from cable 2 is conducted through button 22, pin 79 and rivet 77 to a spring contact member 81 depending from the cap 74.

At 82, Fig. 2, within the bottom of tube 69, I show a split ring, preferably of insulative material, adapted to spread when inserted in said tube and frictionally engage the inner wall thereof and, when so engaged, to form a support for a circular platform member 83, and further act as a spacer between said platform member 83 and terminal disc 71 to provide a compartment to receive the electrical control wiring connected to the terminals on disc 71.

Secured, as by screws 84, to platform 83 is one end of a U shaped bracket member 86, to the opposite end of which is secured as by screws 87, a similar but shorter bracket 88, secured at the top, by screws 89, to a disc 91, Figs. 2 and 3.

Extending through disc 91 are electrical contacts 92, corresponding in number with contact members 54 in base member 71 of tube 69.

Contacts 92 are spaced apart and are equidistant from the center of disc 91 to lie in the path of travel of, and be successively energized by, a contact arm 93, secured to a shaft 94 which has its bearing through the center of disc 91.

Secured to shaft 94 is a ratchet wheel 96. Step-by-step movement of ratchet-wheel 96 is imparted by a solenoid 97, secured to bracket 86 by rivets 98. One end 99 of the magnet coil is connected to spring contact 81 and the other end of said coil is grounded on the body 3 of the gun.

The movable core 101 of solenoid 97 is pivotally connected by a link 102, to one end 103 of an elbow lever pivoted at 104 in bearings secured to bracket 86. When solenoid 97 is energized, core 101 moves lever 103 to its dotted-line position and the end 106 of said lever actuates a finger 107, Fig. 4, pivoted at 108 to bracket 88, moving said finger from the dotted-line position, Fig. 4, advancing a pawl 109 which is pressed into engagement with the teeth of ratchet wheel 96 by a spring 111 coiled around the pivot pin 112 of 40 said pawl.

A spring detent 113 prevents return movement of ratchet wheel 96.

The step-by-step advance of ratchet wheel 96 moves contact arm 93, successively, into contact with contact members 92 in cap 91.

To said members 92 are secured as by nuts 114, ends of wires 116, the remote ends of which are similarly secured to contact pins 117 extending through a terminal board or panel 118 of insulative material supported on brackets 119 riveted at 121 to bracket 86.

Wires 122 connect the contacts 117 in the panel 118 with the female members 73 of the slip joint between tube 69 and body 3, said wires passing through centrally disposed apertures 123 in bracket 86 and 124 in platform 83.

Having thus described the means for conducting electrical energy from cable 2 to the distributor wires 53 each of which fires a projectile from a gun unit, I will now describe my electrically fired gun units.

One of the principal features of novelty in my invention is an electrically-operated remote control utilizing thermal elements instead of percussion or detonating caps, a provision which obviates necessity for mechanical cocking, and makes the tool perfectly safe to operate.

The gun units can be fired only by the closing at the mouth of the well of an electrical circuit which includes said thermal elements. Accidental or premature discharge becomes impossible and means are also provided in said circuit which serve as a tell-tale affording visual proof when said thermal elements are energized.

Each gun unit comprises a housing or barrel 28a, threaded throughout a portion of its length into a socket of the body 3, and having a portion extending across the bore 139. Sufficient clearance is provided between the inner portion of the housing or barrel and socket to define a connecting passage for the bore through which wires 53 may pass to other units. A sealing gasket 146 is interposed between the flanges formed on the housing and in the socket as clearly shown in Figure 7. Each wire 53 is secured to a resilient contact finger 141 mounted in the socket and insulated therefrom at 142.

Contact finger 141 is of spring material and presses against the reduced end of a firing contact pin 143 the enlarged head of which extends into a correspondingly recessed cartridge receiving explosive chamber 144.

Before the device is lowered in a casing each of the housings 28a is preloaded in the following manner:—

Firing contact insulated as shown in Fig. 7 143 is inserted through the cartridge chamber, a cartridge of explosive, of the type shown in Figs. 10 and 11, is inserted in chamber 144, a flanged projectile of the type shown in Figs. 12 and 13 is placed in an inner removable barrel 31 which is screwed into housing 28a.

The preloaded unit is screwed into body 3 compressing the gasket 146 for water seal.

The cartridge consists of a shell 147 closed at each end by wads 148 through which extend contacts 149, connected, one with the other, by a thermal coil 151 adapted when energized to ignite powder or other explosive 152 in said shell. Obviously if shell 147 is of electrically conductive material said shell could serve as ground terminal for said coil.

The projectile consists of a cylindrical body 153 of hard steel conically pointed at one end as indicated at 154 and flat at the opposite end.

A disc 154 is spot-welded to the flat end of projectile 153 in concentric relation thereto. Said disc serves as a gasket seal against water and as a retard in firing, greatly increasing the effectiveness of projectile 153 so far as penetration is concerned.

In the form shown in Figure 9, the body 3 of the gun is made in sections 3a, said sections comprising one or more gun unit assemblies and each section provided with means for detachable engagement with an adjacent section whereby an assembly can be made of any desired length and weight. In very deep wells the load imposed upon cable 2 would be excessive if a long gun barrel were employed. Another advantage of this sectional structure lies in the fact that the units can be more easily machined. Each unit 3a is reduced and threaded as at 138 at one end and counterbored and tapped at the opposite end in corresponding manner.

In perforating well casing the projectile must have more than sufficient force to penetrate casing 1. In Figure 5 I show a body of cement 156 surrounding said casing. Obviously, unless said cement be perforated no benefit would result from perforating the casing.

In Fig. 6 I show concentric tubing strings 1 and 1a with the cement 156 interposed. This requires even greater penetrative power to perforate.

As a concrete example of the utility of my device to perforate casing in a commercially profitable manner I wish to state that I have fired the assembly shown in Fig. 7 and have caused pro-

jectiles to perforate three concentric sections of casing and the formation behind sufficiently to cause fluid from said formation to accumulate in the innermost tubing.

The firing was done when the gun was submerged in water and the diameters and thicknesses of the several tubing strings were as follows:— Inner string 6 $\frac{3}{8}$ " outside diameter, A. P. I. oil well casing, wall thickness $\frac{3}{8}$ inches; intermediate string 8 $\frac{3}{8}$ " outside diameter, A. P. I. oil well casing, wall thickness .40"; outer string 10 $\frac{3}{4}$ " outside diameter A. P. I. oil well casing, wall thickness .45".

Operation

My invention is operated preferably from an automotive truck. Perforation service requires, in addition to transportation, a source of electrical energy, a reel for the cable 2 and a means for rotating said reel to lower and raise several thousand feet of cable and the weight of the gun.

Assuming this equipment to be positioned near the mouth of a well and that casing 1, Fig. 1, is to be perforated, the device is lowered through the casing to a point where perforation is to be done. Spring cages 25 serve as a centering means and as an electrical contact for grounding the body 3.

Before lowering said body all of gun units 28 have been preloaded, and all of wires 53 have been connected to terminal posts 54 and through control unit 69 to cable 2 in head 7.

Referring to the wiring diagram, Fig. 8, cable 2 is connected at the end remote from the gun body 3 with a source of electrical energy (preferably a direct current generator driven by truck not shown) by positive and negative wires 161 and 162, the positive leading through the reeled cable 2 to the button 22 in the head 7 of the gun, and the negative being grounded to the casing 1.

The circuit thus established is broken by a switch 163, and the positive side includes an ammeter A.

If switch 163 be closed, contact 81, Fig. 2, of the control unit is energized, and current passes thru contact arm 81, energizing, through a wire 164, solenoid 97, grounded by a wire 166 connected through one slip joint connections 73 and 54 with a plate 167 through which extends a screw 168 serving to ground the solenoid 97 and to secure platform 57 to its support and body 3.

When so energized, the coil of magnet 97 moves the core 101, actuating elbow lever 103, and moving, through arm 106, the lever 107, causing pawl 109 to advance ratchet wheel 96 and contact arm 93 into engagement with one of contacts 92, current passing therethrough, and through wires 116 to panel 118, thence through wires 122, slip joint terminals 54 and 73, and wires 53. The current then passes to the thermal elements in the gun units and is grounded to the body through the sealing and fire retarding discs.

This fires the charge in the explosive chamber destroying the thermal coil, and breaking the electrical circuit.

This operation can be repeated to fire successively the remaining charges, by repeated operation of switch 163.

Any number of said charges may be fired, in groups, simultaneously, if desired, by pre-arrangement, by connecting two or more of the terminal contacts 117 on the panel 118.

Firing contact 143 is insulated throughout its length from housing 28a, as shown at 171.

At 172, Fig. 8, I show, interposed between contact finger 91 and arm 93, current limiting resistance for the purpose of preventing the contacts 92 from becoming burned by overload.

The function of ammeter A is to provide visual proof of the rupturing of each of the thermal elements 151 and consequent firing of each explosive charge thereby. When switch 163 is closed the ammeter indicates the entire amount of current consumed by the device, which total amount is decreased to the known value consumed by the solenoid 97 alone when that circuit in which the thermal element is connected is open-circuited by the rupture of said element.

When switch 163 is opened, and solenoid 97 thus de-energized, a spring 173, Fig. 4, returns arm 107 to its initial dotted-line position for repeated operation.

I wish to call particular attention to that phase of my invention illustrated in Figs. 12, 13, 14 and 15. I have found that spot-weld connection of disc 154 is a decided factor in increasing the velocity and hence the penetration of projectile 153.

When the charge behind the disc is fired a portion of said disc, designated at 154a, is sheared from the disc by gas pressure, adhering to projectile 153, and is carried away thereby.

This portion, 154a, is larger in diameter than the projectile. The bore acts as a forming die and said portion exactly fills said bore and forms as nearly a perfect seal against the dissipation of expansive gases as it is possible to make. The welded portion 154a parts from disc 154 and assumes the shape of a cup leather behind a piston, as indicated in Fig. 14, the skirt or trailing edge being exactly coincident with the bore diameter (B D) and necessarily larger than projectile 153 and therefore a more perfect seal.

I claim:—

1. A well casing perforator including a body having a lateral recess therein, a conductor adapted to be connected with a source of electric energy and terminating within said recess, and a separate preloaded electrically fired gun unit removably positioned in said recess and electrically connected with the conductor by insertion therein.

2. A well casing perforator including a body having a lateral recess therein, a conductor adapted to be connected with a source of electric energy and terminating within said recess, a separate preloaded electrically fired gun unit removably positioned in said recess, and resilient contact means electrically connecting the conductor and gun unit upon insertion of the gun unit in said recess.

3. A well casing perforator including a body having a lateral recess, a contact within said recess adapted to be connected with a source of electric energy, a separate preloaded electrically fired gun unit comprising a housing removably positioned in said recess having an inner explosive chamber and an outer removable barrel carrying a projectile, and a firing conductor extending through a wall of said housing from the explosive chamber and engaging the recess contact when the housing is positioned therein.

4. A well casing perforator including a body having a plurality of lateral recesses therein, a plurality of conductors each terminating in a separate recess, means for sequentially connecting each conductor with a source of electric energy, a separate preloaded electrically fired gun unit removably positioned in each recess, and contact

means on each gun unit engaging the conductor terminal in the recess upon positioning therein.

5. An electrically fired well perforator including a body having a plurality of gun units therein, conductors for each unit extending therefrom and terminating each in an individual terminal post at the top of said body, a sequential fire control unit arranged above said body, a plurality of connecting sockets in the bottom thereof each adapted to receive a body carried conductor post upon assembly, and a combined supporting and conducting cable for the assembly in contact with the firing control unit.

6. An electrically fired well perforator including a body having a plurality of gun units therein, conductors for each unit terminating adjacent the top of said body, a separate sequential fire control unit above said body, conductors therein terminating adjacent the bottom thereof, slip joint contacts connecting the gun unit and control unit conductors, a combined supporting and conducting cable having a head in electrical contact with the upper end of the control unit, and a protecting sleeve for the control unit connecting the body with said head.

7. The combination with a gun type perforator including a gun body having laterally directed sockets, a plurality of laterally directed gun units mounted therein, said sockets being at least in part diametrically larger than said gun units to define passages therearound, and said body having an axially centered bore connecting said passages; of a wiring arrangement including distributor wires threaded through said bore and passages around the several gun units and branching one at a time to the rear ends of the gun units; and contact means associated with each gun unit and branch of a distributor wire to connect electrically said gun unit therewith.

8. In a gun type well casing perforator; a gun body including laterally directed sockets and axially disposed apertures connecting said sockets; gun units fitting said sockets and having portions spaced from the walls thereof to define therebetween annular passages interposed between said apertures; each of said gun units having a cartridge chamber and an aperture extending from the inner end of the gun unit into said chamber and there enlarged; a contact means including an insulated contact pin fitting said aperture, a contact head fitting said enlargement and insulated therefrom, said contact head adapted to seat against the base of said enlargement to seal against pressures within said chamber, the opposite end of said pin projecting beyond the inner end of the gun unit; distributor wires threaded through said apertures and passages, and a contact element disposed at the base end of each socket and engageable with the projecting end of said contact pin, there being a wire for each contact element.

9. In a gun type well casing perforator; a gun body having an axially directed bore and laterally directed sockets intersecting said bore; distributor wires threaded through said bore and positioned contiguously to the walls of said sockets; gun units fitting said sockets and being sufficiently smaller to clear the wires therein; and contact means connecting said gun units with the respective distributor wires.

10. In a gun type well casing perforator; a gun body having an axially directed bore and laterally directed sockets intersecting said bore; distributor wires threaded through said bore and

positioned contiguously to the walls of said sockets, each of said sockets being threaded at its outer end and having a sealing flange inwardly of said threaded portion; a gun unit for each
5 socket, each gun unit having a corresponding threaded portion and a sealing flange, said gun unit beyond said flange being smaller than but conforming to the inner portion of said socket
10 to define therewith a sealed chamber for accommodating said wires; and contact means connecting said gun units with the respective distributor wires.

11. In an electrically fired gun type well casing perforator, a body having an axially directed bore
15 and a plurality of lateral sockets intersecting said bore, gun units in said sockets each including a barrel extending across said bore and having its periphery defining with the socket a connecting

passage for the bore, and fire controlling means utilizing the bore and passages to connect the units to a source of electric energy to permit successive firing of said units.

12. In an electrically fired gun type well casing
5 perforator, a body having an axially directed bore and a plurality of lateral sockets intersecting said bore, gun units in said sockets each including a barrel extending across said bore and having its
10 periphery defining with the socket a connecting passage for the bore, fire controlling means utilizing the bore and passages to connect the units to a source of electric energy to permit successive
15 firing of said units, and coacting securing and sealing means incorporating the outer end of each socket and its gun barrel.

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