

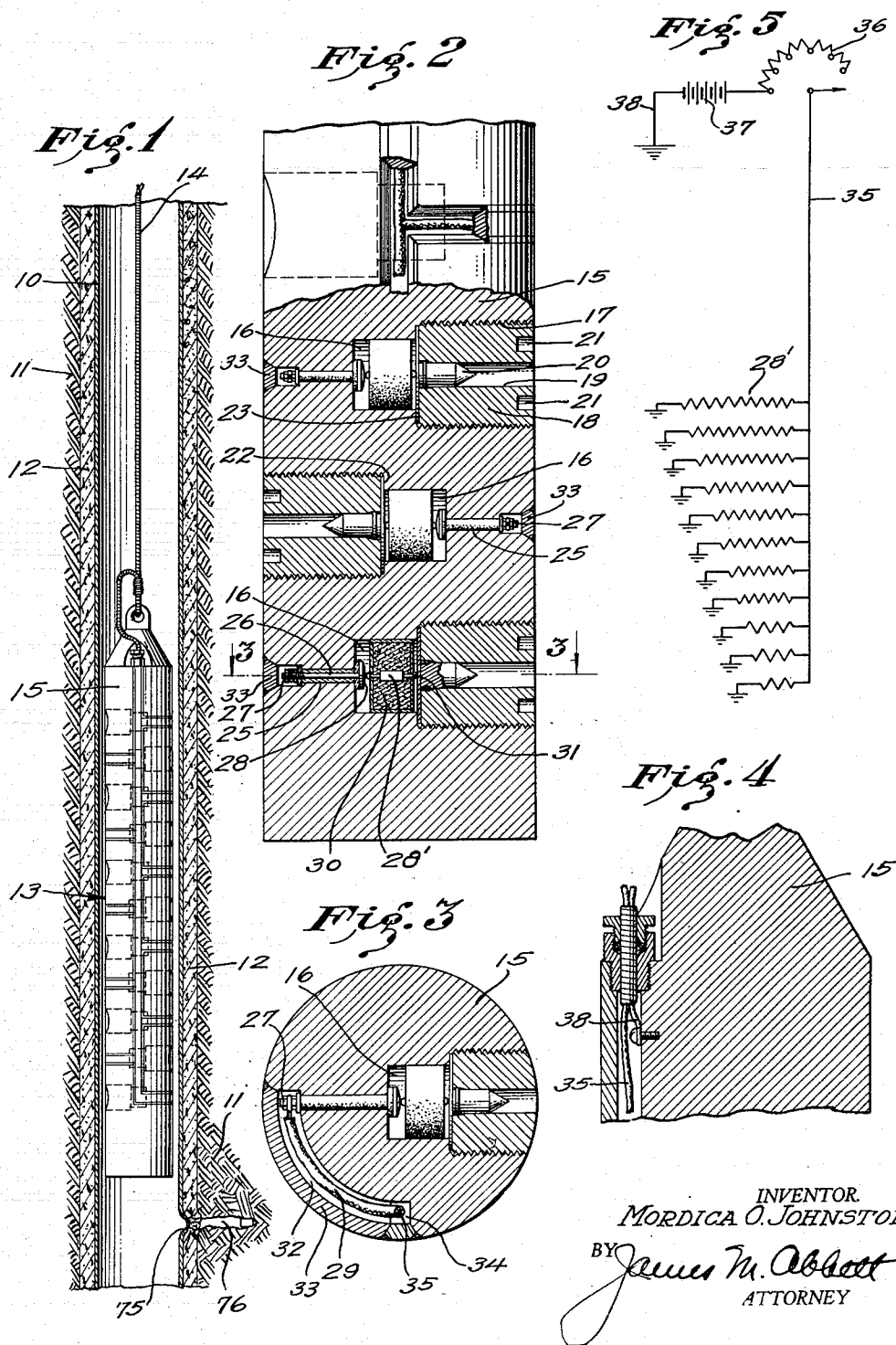
July 21, 1936.

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CASING PERFORATING GUN

2,048,451

Filed Dec. 19, 1932

2 Sheets-Sheet 1



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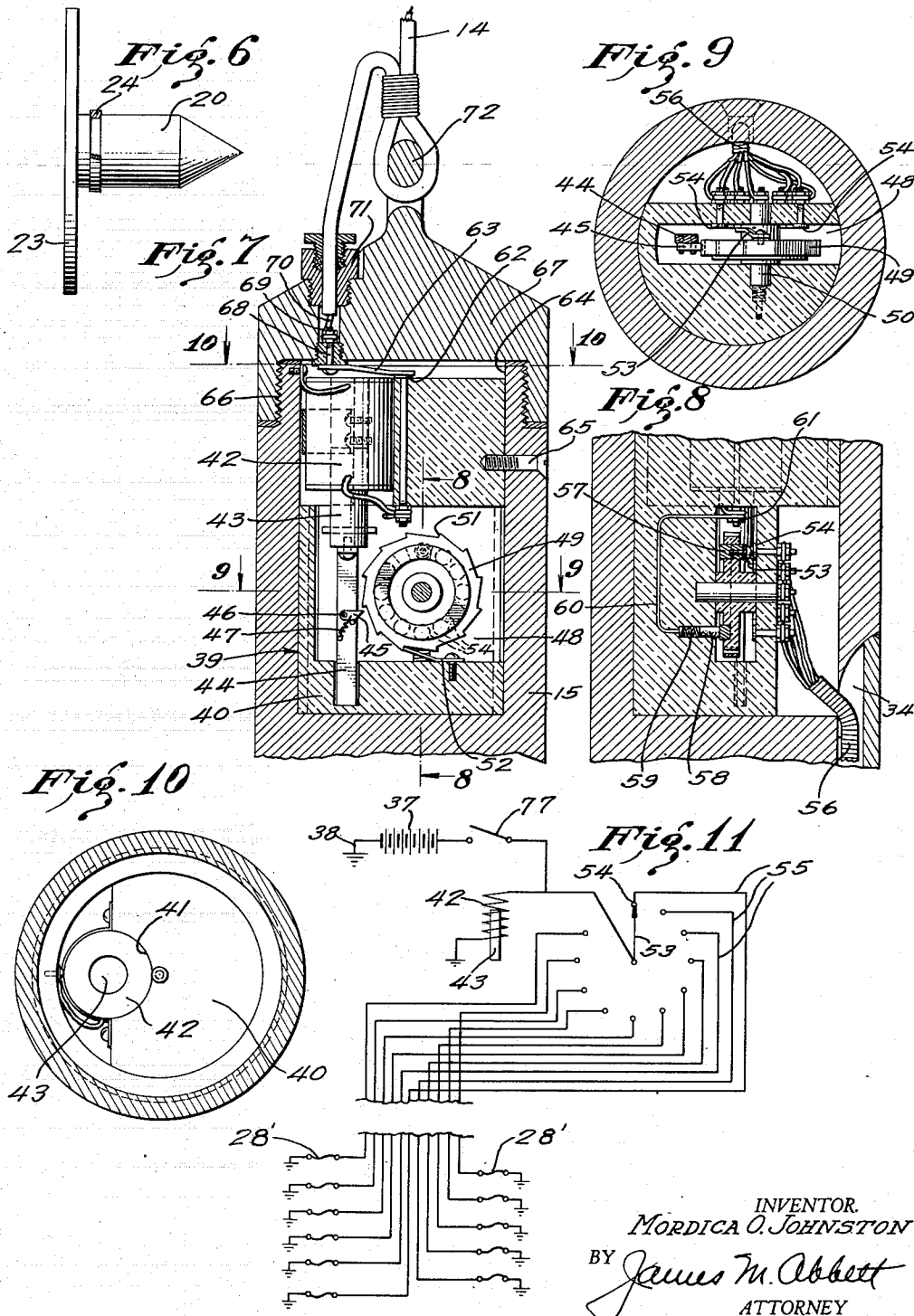
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2 Sheets-Sheet 2



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2,048,451

CASING PERFORATING GUN

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23 Claims. (Cl. 81-188)

This invention relates to an oil tool and particularly pertains to a gun for perforating well casing. In the drilling of oil wells and the production of flowing wells it often occurs that it is necessary to perforate the well casing along its portion which extends through oil bearing sands. This is often done by mechanical perforating means. In some instances the well casing is surrounded by a section of cement through which perforations must be made in order to establish communication between the oil sands and the interior of the casing. The usual type of perforator may form perforations through the well casing but it is difficult to obtain any type of perforator which might be inserted into a well and lowered to a desired depth and which would act to perforate the well casing, as well as a surrounding area of cement and oil restricting formations. It is the principal object of the present invention to provide means for perforating a well casing or the like at any point in its length, and at the same time insuring that the perforation will continue outwardly through the formation surrounding the well casing to establish a free flow of oil into the casing.

The present invention contemplates the provision of a gun carrying a plurality of projectiles, which gun may be lowered into a well casing to a desired depth and may then be fired to cause the projectiles to fire in succession and selectively at the control of the operator.

The invention is illustrated by way of example in the accompanying drawings in which:

Figure 1 is a view in vertical section and elevation showing a fragmentary portion of the casing perforator with which the present invention is concerned.

Fig. 2 is an enlarged view in section and elevation showing the details of construction of one form of the gun with which the present invention is concerned.

Fig. 3 is a view in transverse section through one of the firing chambers of the gun as seen on the line 3-3 of Fig. 2.

Fig. 4 is an enlarged view in fragmentary section showing the manner in which electrical connection is made from a conduit.

Fig. 5 is a view in diagram showing the manner in which the type of gun disclosed in Figs. 1 and 2 may be progressively fired by electrical means.

Fig. 6 is a view in side elevation showing the construction of one of the projectiles to be used in the gun.

Fig. 7 is an enlarged view in vertical section showing another form of firing mechanism by

which the firing chamber of the gun may be successively fired.

Fig. 8 is a view in vertical section through the firing mechanism as seen on the line 8-8 of Fig. 7.

Fig. 9 is a view in transverse section through the gun as seen on the line 9-9 of Fig. 7.

Fig. 10 is a view in transverse section showing the upper portion of the firing mechanism as seen on the line 10-10 of Fig. 7.

Fig. 11 is a view in diagram showing the wiring arrangement of the firing mechanism disclosed in Fig. 7.

Referring more particularly to the drawings, 10 indicates a well casing. This casing extends down through earth formation 11 and may be set in a circumscribing wall of cement indicated at 12. In instances where the stratum of oil sand is relatively narrow as to vertical height it is not necessary to perforate a well casing for any considerable length, but where the stratum of oil sand is of great depth, as is common in most California oil fields it is necessary to perforate the casing for a considerable distance along its length. This can best be done by providing a perforating structure which is capable of forming perforations along a considerable length of well casing without being repositioned. Such a structure is shown in Fig. 1 of the drawings where it will be seen that a substantially cylindrical casing perforating unit 13 is supported in a well casing 10 as suspended upon a cable 14. The cable in the present instance is indicated as the electrical conduit through which wires are led to the firing mechanism of the perforator. In the form of the invention shown in Figs. 1 to 5 the casing perforator is fired electrically from a selective mechanism controlled by an operator stationed above the ground. The casing perforator is formed with a cylindrical body 15 having a plurality of firing or explosive chambers 16 spaced throughout the length of the cylindrical body 15 and disposed horizontally and radially. The outer ends of the firing chambers 16 are formed with an enlarged cylindrical counterbore 17. These counterbores are internally threaded to receive a muzzle block 18 having a center smooth bore 19 through which a projectile 20 may be forced by an explosion of powder within the firing chamber 16. The muzzle blocks 18 are formed at their ends with recesses 21 to receive a spanner wrench by which the blocks may be readily turned and removed from their position since it is necessary to remove each of these blocks when the gun is loaded. A shoulder 22 is formed at the bottom of the counterbore 55

17 and forms a surface against which a packing disc 23 of the projectile 20 may seat and which plate will be clamped in position when the muzzle block 18 is screwed tightly against it. Attention is particularly directed to this construction for the reason that a perforating gun of this type must be operated at a considerable depth within a well bore, and during which time an enormous hydrostatic pressure is imposed upon the gun and tends to force fluid into the firing chamber. The projectile 20 is preferably fastened to the packing disc 23, by spot welding the projectile 20 to the face of the packing disc 23. A gas ring commonly used in ordnance work is disposed around the rear of the projectile. This disc in the disclosure serves as a complete positive packing for the firing chamber and insures that under no circumstances is it possible for fluid to leak into the firing chamber and thus damage the charge of powder there contained. The disc 23 when clamped by the muzzle block also retards the exertion of explosive force upon the projectile until this force has become great enough to rupture the disc.

Extending longitudinally of the axis of the firing chamber and the bore 19 is a duct 25 which receives a conductor 26 attached at one end to a binding post 27 and carrying a firing element 28 at its opposite end. This element is in contact with a fuse 28' mounted within the powder charge 30 and which fuse is heated by the current passing from the contact 28 through the fuse 28' to be grounded at 31 upon the packing disc 23. As shown in Figs. 2 and 3, the element 28 is formed as a head larger than the duct 25 and acts as an explosive pressure resistant to normally prevent the conductor being blown from the duct. The binding post 27 is connected with a conductor 29 which is led around within the body 15 of the perforator along a groove 32. This groove is sealed by a strip of metal 33 which is preferably welded in place as so indicated in Figs. 2 and 3. These grooves communicate with a vertically extending groove 34 which carries a vertical conductor 35 leading to a rheostat 36. This rheostat in turn is connected with a source of electric energy 37, the other post of the source being connected with the ground at 38. In the diagram, Fig. 5, the various fuses 28' are indicated as having different ohmic value so that the firing chambers will be progressively fired as the rheostat 36 is manipulated to increase the amount of current passing through the conductor 35 and running through the ground. It is desirable to fire the shots separately and successively in order to prevent the production of an undue accumulation of pressure in the well casing at one time. This would tend to cause an upheaval in the fluid contents of the casing and might result in the bursting of the casing.

In the form of the invention shown in Figs. 7 to 11, inclusive, the construction and arrangement of the firing chambers and the muzzle blocks is the same as previously described, but a positive means is provided for separately setting off the charge of powder in each of the firing chambers. This structure, as shown in Fig. 7, comprises a unit 39. The unit includes a frame of dielectric material 40, preferably of bakelite. At the top of this frame and at one edge thereof is a recess portion 41 to receive a solenoid 42 having a plunger 43. The plunger projects from the lower end of the coil 42 and carries a trip bar 44. This bar is fitted with a pawl 45 pivoted to the bar upon a pin 46 and held in a tripping

position by a spring 47. A rectangular recess 48 is formed transversely of the bar and centrally thereof, as shown in Fig. 9. This recess accommodates the trip bar 44 and a ratchet wheel 49 which is mounted upon a spindle 50. The ratchet wheel is formed with a plurality of teeth around its circumferential edge adapted to successively trip the ratchet as the pawl 45 engages one of the teeth indicated at 51.

A spring 52 is mounted within the frame structure 40 and yieldably rests against the periphery of the ratchet wheel 49 and prevents reverse rotation of the ratchet wheel at the same time holding the wheel against accidental movement. Mounted upon the face of the ratchet wheel 49 is a yieldable contact finger 53 which is carried with the ratchet wheel and is designed to move successively into contact with the several faces of contact buttons 54 which are mounted upon the frame structure 40 and are arranged along a circle concentric with the axis of the ratchet wheel and agreeing with the path of travel of the contact member 53. The various contact buttons 54 are diagrammatically indicated in Fig. 11 and are shown as being separately connected with conductors 55 which lead to the different fuses 29 in the firing chambers. The various conductors 55 are placed within a cable 56 which cable extends downwardly in a groove 34 previously described as being formed longitudinally of the body 15 of the perforator. The contact spring 53 is secured to a commutator ring 57 mounted upon the opposite side of the ratchet wheel from the contact spring 53 but in electrical connection therewith. A brush 58 constantly bears against the face of the ring and is yieldably held in this position by a spring 59. A conductor 60 is in electrical contact with the brush 58 through the spring. This conductor is shown as imbedded within the frame structure 40 and as being fastened to a binding post 61. The binding post 61 has an enlarged head 62 at its upper end against which a spring contact member 63 may be brought to bear.

The firing unit generally indicated at 39 is removably disposed within the bore 64 at the upper end of the perforator body 15 and is held in position by a screw 65. The upper end of the perforator body 15 is externally threaded as indicated at 66 and receives a cap 67 which closes the bore 64 and seals the firing mechanism against leakage. The contact spring 63 is carried on the cap 67 and is held by a screw 68 which carries a binding post 69. A feed wire 70 connects with this binding post and extends downwardly through a suitable stuffing gland 71. As shown in Fig. 7 the feed wire 70 is enclosed within an insulating cover and is looped through the eye 72 of the cap 67. The feed wire then extends upwardly as indicated at 14 in the drawings. If the feed wire is of sufficient tensile strength to support the weight of the perforating device it is not necessary to add other supporting means. It will be evident, however, that the device might be lowered on the sand line if desired. In the form of the device shown in Figs. 1 to 5, inclusive, current of variable value is used to set off the charges in the different firing chambers. In the form of the apparatus shown in Figs. 7 to 11, inclusive, current of constant value is used although successive impulses are employed.

In operation of the present invention as shown in Figs. 1 to 5, inclusive, the perforator 13 is assembled as there indicated and separate powder

charges 30 are placed within the different firing chambers 16. After that the firing chambers are closed by positioning the packing discs 23 within the threaded bore 17 of each of the firing chambers and then bring these discs to seat against the shoulder 22. As has been previously described, each of the packing discs 23 carries a projectile 20 which protrudes from its forward face and is disposed concentrically thereof. This insures that when the muzzle blocks 18 are screwed into the bore 17 the projectile 20 will be centered with relation to the block and will protrude into the bore or barrel 18 of the block. The projectiles are formed with conical points so that in the event mud or other extraneous matter becomes packed into the end of the barrel 19 it will be easily forced therefrom as the projectile moves outwardly through the barrel. Attention is also directed to the fact that when the projectile and its disc are in place in the form shown there is no possibility for the hydrostatic pressure of the fluid in the well bore to force its way into the firing chamber and to damage the explosive charge there enclosed. After all of the firing chambers have been loaded in the manner previously described the perforator 13 is lowered into the well to any desired depth and the successive charges of powder 30 are ignited by swinging the contact member of the rheostat 36 from point to point on the rheostat, at which time current of successively increasing values will be set up through the conductor 38, the source of electric energy 37 and the conductor 35, and will cause a fuse 28' of corresponding electric value to be heated so that its charge of powder may be ignited. This charge will then build up pressure within the firing chamber until the pressure bursts the packing disc 23. Due to this arrangement the explosion will be retarded until the powder has had an opportunity to become thoroughly ignited and a maximum explosive force created. The result will be that the packing disc 23 will be ruptured with considerable violence and the projectile 20 expelled from the muzzle block 18 with sufficient force to perforate the well casing, as indicated at 75 in Fig. 1, and to continue through the surrounding wall of concrete and into earth formation forming a bore, as indicated at 76 in Fig. 1.

In the form of the device shown in Figs. 7 to 11, inclusive, the various firing chambers are loaded as previously described, and when it is desired to fire the gun the switch 77 is temporarily closed. At each time the switch closes the magnet 42 will be energized and this will cause the solenoid plunger 43 to be drawn upwardly into the magnet coil. As this takes place the pawl 45 will engage a tooth 51 of the ratch wheel 49 and cause the ratchet wheel to move the length of one tooth. This will move the spring contact 53 from its neutral position to the position in contact with the first of the buttons 54. When the switch 77 is opened again the plunger 43 will drop by gravity and the pawl 45 will ride over the tooth 51 which is to be engaged on the next actuation of the pawl. At each successive closing of the switch 77 the contact member 53 will progress from contact with one button 54 to the next succeeding button. As each contact is made a circuit will be completed to one of the unfired firing chambers. This may be continued until all of the shots have been fired and the casing has thus been perforated throughout the length of the perforating apparatus. The perforating apparatus may then be withdrawn from the cas-

ing, and if desired may be reloaded so that another section of casing may be perforated.

It will thus be seen that the perforating apparatus here disclosed provides means whereby a charge of powder and a projectile may be lowered into a well without danger that the powder will be spoiled due to leakage of fluid into the firing chamber, and at the same time providing means whereby a plurality of shots may be separately fired at the option of the operator. The explosive retardent properties of the rupturable sealing disc irrespective of its fluid sealing properties builds up an initial pressure in the explosive chamber upon firing that compensates the velocity loss for the projectile due to the short length muzzle block that must be used in devices of this type.

While I have shown the preferred form of my invention as now known to me it will be understood that various changes may be made in the combination, construction, and arrangement of parts by those skilled in the art without departing from the spirit of the invention as claimed.

Having thus described my invention what I claim and desire to secure by Letters Patent is:

1. A casing perforator comprising a body adapted to be lowered into a well casing, a barrel formed in said body and opening at the outer end thereof, a firing chamber in the body behind said barrel and in communication therewith, and a projectile having a portion normally extending into the barrel and an imperforate rupturable portion located in and normally sealing the firing chamber from the barrel and confining the projectile within the barrel at the inner end thereof.
2. A casing perforator comprising a body member adapted to be lowered into a well casing, a firing chamber within the body member, said chamber being of relatively large area, a restricted muzzle bore communicating with and extending from said firing chamber and opening outwardly through the side of the body member, a projectile normally positioned in said muzzle bore and a rupturable disc carried by said projectile and closing the outer end of the firing chamber and the communication between the firing chamber and bore and constituting means for protecting the firing chamber from ingress of water through the bore.
3. A gun comprising a body member, a firing chamber located within the body, a muzzle block removably mounted transversely in said body member and adapted to be positioned at one end thereof and being formed with a central bore communicating at its inner end with said firing chamber and opening at its outer end through the side of said body member and uncovered, a projectile having a circular rupturable and imperforate disc portion and a bullet member carried on the outer face thereof, the disc portion of said projectile being normally positioned over the firing chamber to close the same, and being clamped by the muzzle block with the bullet extending into the bore of the muzzle block whereby ignition of a charge of explosive within the firing chamber will cause the disc to be ruptured and the bullet to be driven through and from the bore of the muzzle.
4. A casing perforator adapted to be lowered into a well casing and submerged in a fluid 70 creating an appreciable hydrostatic pressure, said perforator including a relatively heavy middle body portion having a transverse firing bore therein, said bore including a firing chamber within which an explosive charge may be placed, 75

a counterbore formed as an outward continuation thereof and providing a shoulder in a plane transverse of the firing chamber, an imperforate rupturable flat sealing disc disposed within the counterbore and seated upon said shoulder, a muzzle block detachably secured within the counterbore and clamping said rupturable disc in a seated position upon the seat within the counterbore and in a manner to seal the firing chamber against the pressure of the head of fluid within which the device is submerged, said muzzle block being formed with a central muzzle bore extending entirely through the block, and a projectile carried by said disc and positioned wholly within and at the base of the muzzle bore and adapted to be forced therefrom by the ignition of the explosive charge in the firing chamber and its subsequent rupture of the disc.

5. A casing perforator comprising a body member adapted to be lowered into a well casing, a firing chamber arranged within the walls of the body member, the firing chamber having an opening leading therefrom, a muzzle block detachably mounted in said opening and closely coupled with the firing chamber and having an open ended bore leading from the firing chamber outwardly through the side of the body member, a rupturable member clamped over the inner end of the bore between the firing chamber and the inner end of the muzzle block and closing said opening of the firing chamber, said muzzle block clamping the rupturable member in said position, and a projectile carried by the rupturable member and confined thereby within the bore of the muzzle block at the inner end of the bore.

6. A casing perforator adapted to be lowered into a well casing and submerged in a fluid creating an appreciable hydrostatic pressure, said perforator including a relatively heavy body portion having a transverse firing bore therein, said bore providing a firing chamber at its inner end and a threaded counterbore portion continuing outwardly therefrom forming a shoulder in the transverse plane between the firing chamber and the counterbore, an imperforate flat rupturable sealing disk disposed within the counterbore and seated against said shoulder to form a partition wall between the counterbore and the firing chamber in the plane of said shoulder, a muzzle block threaded into said counterbore and having an end face by which the marginal area of the sealing disk is clamped against the shoulder, said muzzle block being formed with a central muzzle bore extending outwardly therethrough from the sealing disk, and a projectile fitting the muzzle bore and being carried at the inner end thereof and supported by the sealing disk.

7. A casing perforator adapted to be lowered into a well casing and submerged in a fluid creating an appreciable hydrostatic pressure, said perforator including a relatively heavy body portion having a transverse firing bore therein, said bore providing a firing chamber at its inner end and a threaded counterbore portion continuing outwardly therefrom forming a shoulder in the transverse plane between the firing chamber and the counterbore, an imperforate flat rupturable sealing disk disposed within the counterbore and seated against said shoulder to form a partition wall between the counterbore and the firing chamber in the plane of said shoulder, a muzzle block threaded into said counterbore and having an end face by which the marginal area of the sealing disk is clamped against the shoulder, said

muzzle block being formed with a central muzzle bore extending outwardly therethrough from the sealing disk, and a projectile fitting the muzzle bore and being carried at the inner end thereof and supported by the sealing disk, said muzzle bore being materially reduced in diameter as compared to the diameter of the firing chamber whereby a relatively small ruptured opening through the sealing disk will be made by relatively large explosive charge within the firing chamber.

8. In a casing perforator a body portion, a firing chamber within said body portion, a muzzle leading from said firing chamber and partitioned therefrom by a rupturable sealing disk, and a projectile of materially shorter length than the muzzle disposed at the inner end of the same and projected therethrough upon the exertion of explosive force within the firing chamber sufficient to rupture the sealing disk and to exert its force upon the projectile.

9. A well casing perforator comprising a body adapted to be lowered into a well casing, a gun including a gun bore and explosive chamber and mounted to discharge laterally of said body, frangible sealing and delayed fire means sealing the gun bore from its respective explosive chamber, means for sealingly retaining the frangible sealing means in place and means for discharging the gun.

10. A well casing perforator comprising a body adapted to be lowered into a well casing, a gun arranged to discharge laterally of said body comprising an explosive receiving chamber, a removable gun barrel communicating therewith and a rupturable sealing partition interposed between the gun barrel and explosive receiving chamber, said partition being removably held in place by said gun barrel, and means for discharging the gun.

11. A well casing perforator comprising a body, a combined supporting and electric conductor cable attached to said body for lowering the same into a well and supplying electrical energy thereto; a plurality of laterally directed gun units arranged in said body, each unit including a gun barrel, an explosive receiving chamber, and a frangible means separating the chamber from the gun barrel, and an electric firing means incorporating said cable and including within said body director means responsive to time spaced electrical impulses and conductors connecting the several chambers with said director means whereby explosive charges within the chambers may be set off sequentially.

12. In an oil well casing perforator, a gun unit adapted to fit within a well casing and discharge laterally therein, said gun unit comprising, an explosive receiving chamber, a gun barrel adapted to receive a projectile, a rupturable sealing partition interposed between the gun barrel and chamber, said partition being resistant to the initial combustion pressures of an explosive charge in the chamber whereby the action of said charge upon the projectile is delayed.

13. A well casing perforator comprising a laterally directed gun unit adapted to be lowered in a well casing, said unit comprising a relatively short gun barrel and an explosive chamber positioned rearwardly thereof, a projectile in said gun barrel at the inner end of the same, and means interposed between the gun barrel and explosive chamber to resist initial explosive pressure upon firing whereby there is built up a discharge pressure for the projectile in the ex-

plosive chamber that compensates the velocity loss due to the short gun barrel.

14. A well casing perforator comprising a laterally directed gun unit adapted to be lowered in a well casing, said unit comprising a relatively short gun barrel and an explosive chamber positioned rearwardly thereof, a projectile in said gun barrel at the inner end of the same, and rupturable sealing means interposed between the gun barrel and explosive chamber to resist initial explosive pressure upon firing whereby there is built up a discharge pressure for the projectile in the explosive chamber that compensates the velocity loss due to the short gun barrel.

15. A well casing perforator comprising a body adapted to be lowered in a well casing, a combined supporting and electric conductor cable attached to said body for lowering the same in the well and supplying electrical energy thereto, a plurality of laterally directed and electrically fired gun units in said body each adapted to be electrically connected with the conductor cable for firing, and means for sequentially connecting each unit with the conductor.

16. A well casing perforator comprising a body adapted to be lowered in a well casing, a plurality of laterally directed and electrically fired gun units in said body, means for conducting electric energy to said units individually, and means for sequentially connecting the units with a source of electric energy for firing.

17. A well casing perforator comprising a body adapted to be lowered in a well casing, means for supplying electric energy thereto, a plurality of laterally directed and electrically fired gun units in said body each adapted to be connected with the source of electric energy for firing, and electrically actuated firing directing means connecting the source of electric energy with individual gun units for sequentially firing the plural units.

18. A well casing perforator comprising a body, a gun arranged to discharge laterally therefrom having an inner explosive chamber and a removable outer barrel, a cartridge containing an explosive and a resistance element mounted in the explosive chamber, a conductor adapted to be connected with a source of electric energy extending through the body into engagement with the resistance element of the cartridge, and a sealing and fire retarding disk positioned between the gun barrel and the explosive chamber by the gun barrel also contacting the resistance element to complete an electric circuit therethrough for firing the gun.

19. A well casing perforator comprising a body adapted to be lowered in a well casing, successively actuated means for supplying electrical en-

ergy impulses of successively variable strength, a plurality of laterally directed gun units in said body adapted to be connected to the source of electric energy for firing, a resistance element in circuit with each gun unit for firing the same, and said resistance elements each being of a successively varied resistance corresponding to the varied strength of the electrical energy firing impulses to successively fire the gun units.

20. A well casing perforator including a gun arranged to discharge laterally therefrom having an inner explosive containing chamber and a duct extending through a wall thereof, and a contact means including a conductor fitting said duct, a contact head on the inner end of said conductor exposed to said chamber, a sealing means incorporating the rear side of said head and the contiguous wall of the chamber for sealing against pressures within said chamber, and the outer end of said conductor being adapted to be connected with a source of electric energy.

21. A well casing perforator including an electrically fired gun arranged to discharge laterally therefrom, an inner explosive containing chamber in said gun having a duct extending through a wall thereof, a conductor passing through said duct and adapted to be connected at its outer end with a source of electric energy, and an enlarged explosive igniting contact and pressure resisting head on the inner end of said conductor.

22. A well casing perforator comprising a body, a combined supporting and electric conductor cable attached to said body for lowering the same into a well and supplying electrical energy thereto, a plurality of laterally directed gun units arranged in said body, each unit including an explosive chamber with a firing resistance element therein and explosive retarding and sealing means, an electric firing means incorporating said cable and a firing directing means responsive to timed spaced electrical impulses, and conductors connecting the resistance elements of the several explosive chambers with the firing directing means for sequentially firing the gun units.

23. A well casing perforator comprising a body adapted to be lowered in a well casing, a plurality of laterally directed and electrically fired gun units in said body, means for conducting electric energy to said units individually including a single switch between the units and the source of electric energy, and means for sequentially connecting each individual unit with a source of electric energy for firing the units in sequence upon successive actuations of the switch.

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