Oct. 21, 1947. M. SCHLUMBERGER 2,429,240

WELL CASING PERFORATOR

Original Filed Jan. 23, 1940 2 Sheets-Sheet 1

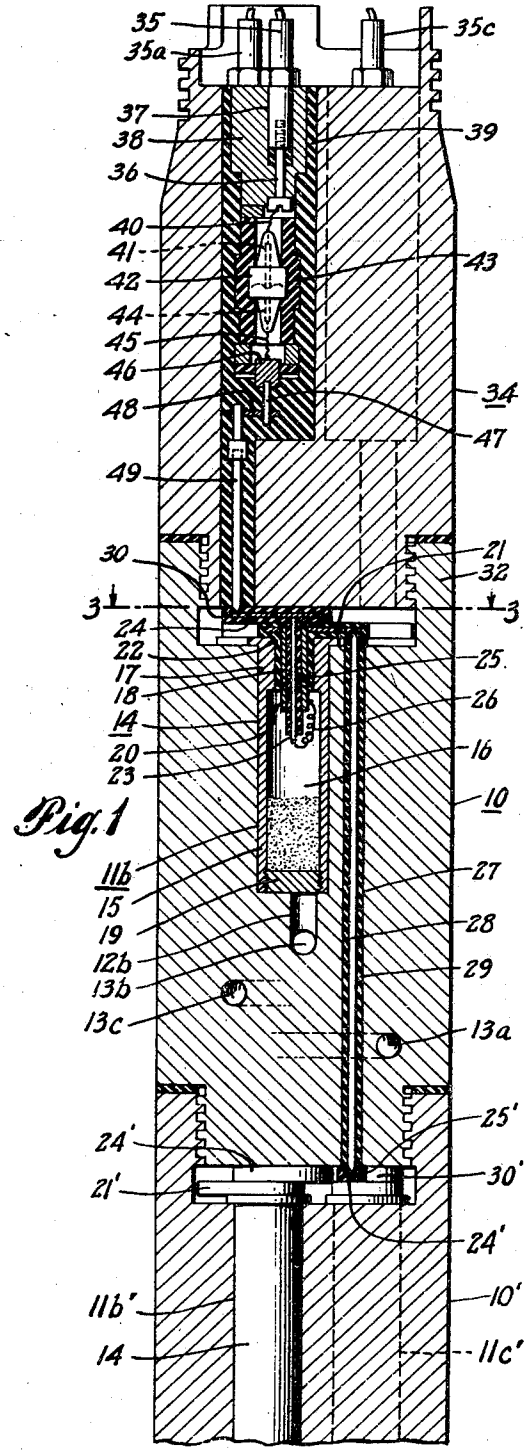


Fig. 1

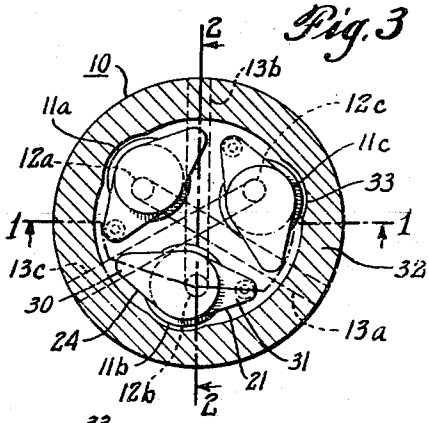


Fig. 3

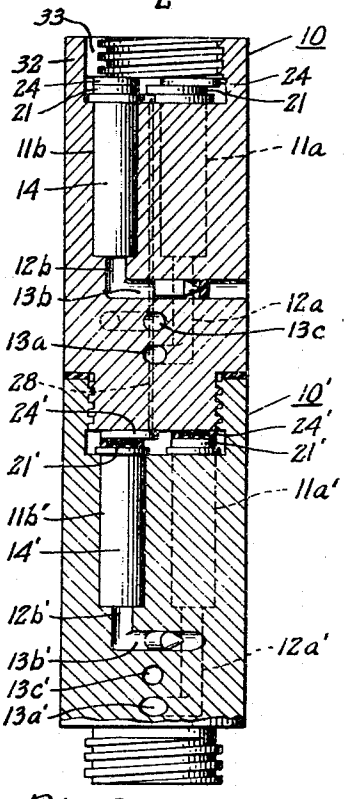


Fig. 2

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Fig. 4

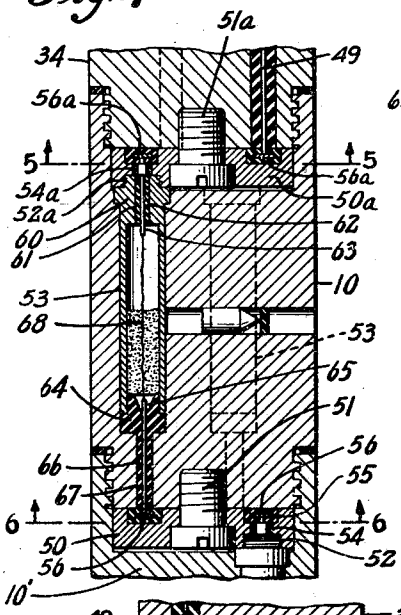


Fig. 5

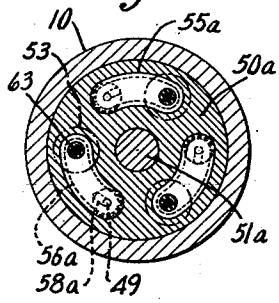
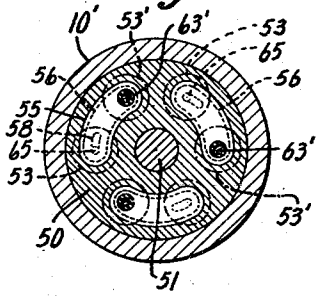


Fig. 6



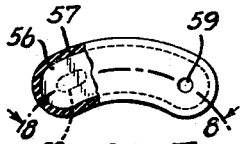


Fig. 7

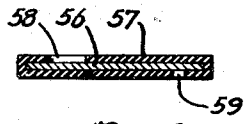


Fig. 8

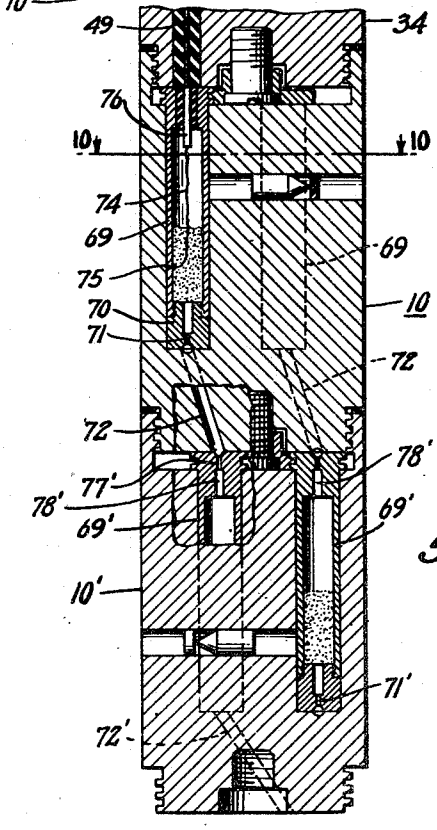


Fig. 9

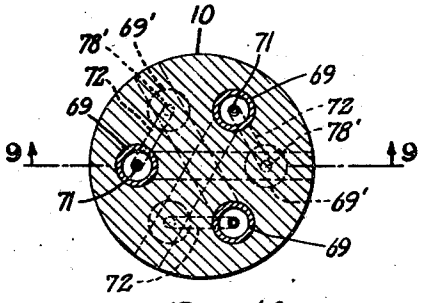


Fig. 10

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UNITED STATES PATENT OFFICE

2,429,240

WELL CASING PERFORATOR

Marcel Schlumberger, Saint Gaudens, Haute-Garonne, France; vested in the Attorney General of the United States

Original application January 23, 1940, Serial No. 315,157, now Patent No. 2,381,081, dated August 7, 1945. Divided and this application July 23, 1941, Serial No. 403,650. In France February 2, 1939

18 Claims. (Cl. 164—0.5)

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This invention relates to firing devices and more particularly to new and improved apparatus for perforating well casings and the like.

Copending application Serial No. 315,157, filed January 23, 1940, for Gun perforator, of which this application is a division, is addressed to perforating apparatus comprising an assembly of similar units each of which is provided with a plurality of gun bores and cartridge chambers therein. Each unit includes igniting means for each gun therein and the apparatus is so designed that when the units are assembled, at least one continuous ignition path extends through the perforator.

This application is directed to similar apparatus in which the units are so designed that, when assembled, the axes of the guns therein lie along a helix about the periphery of the perforator.

It is an object of the invention, accordingly, to provide new and improved well casing perforating apparatus comprising a plurality of assembled similar units in which the axes of the guns in the respective units lie along a helix about the perforator assembly.

Another object of the invention is to provide new and improved means for firing the guns in a well casing perforator of the above character in successive order.

A further object of the invention is to provide new and improved well casing apparatus of the above character in which a given interval of time elapses between the firing of each adjacent gun.

Another object of the invention is to provide means for indicating at the surface of the earth that a gun in the well casing perforator has been fired.

Other features of the invention will become apparent from the following detailed description of several preferred embodiments taken in connection with the accompanying drawings, in which:

Fig. 1 is a view in longitudinal section, taken along line 1—1 of Fig. 3, and looking in the direction of the arrows, through a well casing perforator constructed according to the present invention;

Fig. 2 is a view in longitudinal section, taken along line 2—2 of Fig. 3, looking in the direction of the arrows and illustrating two of the perforating units of the well casing perforator;

Fig. 3 is a view in section taken along line 3—3 of Fig. 1, looking in the direction of the arrows;

Fig. 4 is a view in vertical section of a modified form of the invention;

Fig. 5 is a cross-sectional view taken along line 5—5 of Fig. 4, looking in the direction of the arrows;

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Fig. 6 is a crosss-sectional view taken along line 6—6 of Fig. 4;

Fig. 7 is a view in plan of a detail of the apparatus shown in Fig. 4;

Fig. 8 is a view in section of the detail shown in Fig. 7 taken along line 8—8 thereof and looking in the direction of the arrows;

Fig. 9 is a view in longitudinal section through a further modification of the invention; and

Fig. 10 is a cross-sectional view taken along line 10—10 of Fig. 9, looking in the direction of the arrows.

Figs. 1, 2 and 3 illustrate one form of the invention in which each of the perforator units comprises three longitudinally extending cartridge chambers, the axes of which form the apices of an equilateral triangle about the axis of the unit, each one of which is provided with a laterally extending gun barrel passing through the longitudinal axis of the unit. The units are so designed that when assembled to form a well casing perforator, the axes of the guns lie upon a helix about the periphery, and the guns are adapted to be fired by electrical igniting circuits extending through each unit in the perforator assembly.

Referring to Figs. 2 and 3, one of the perforator units 10 is shown, in which are provided three cartridge chambers 11*a*, 11*b* and 11*c*, the axes of which are located parallel to the axis of the unit 10, forming the respective edges of an equilateral prism coaxial thereto. The cartridge chambers 11*a*, 11*b* and 11*c* are provided at their lower extremities with longitudinally extending conduits 12*a*, 12*b* and 12*c*, which communicate with a plurality of laterally extending gun barrels 13*a*, 13*b* and 13*c*, the axes of which are disposed at an angle of 120° with respect to each other. In order that the gun barrels 13*a*, 13*b* and 13*c* may lie in different transverse planes through the perforator unit 10, the conduits 12*a*, 12*b* and 12*c*, respectively, are made of different lengths.

Considering now Fig. 1, a cartridge 14 is shown in position in the cartridge chamber 11*b*, for example, and it is provided with a thin walled forward portion 15 forming a powder chamber 16 and a thicker walled rear portion 17 forming a passage 18. The front end of the cartridge 14 is closed by a suitable closure member 19. Within the passage 18 is disposed a hollow tubular conducting member 20 which is provided with a metal plate 21 at the upper extremity thereof, the

outer surface of both the plate 21 and the tubular member 20 being covered with suitable insulating material 22.

Disposed within the tubular member 20 and concentric therewith is a conducting rod 23 which extends for a short distance beyond the tubular member 20 into the chamber 16 in the cartridge 14. The conducting rod 23 is provided at its upper extremity with a metal plate 24, the surface of both being encased in suitable insulating material 25. A wire filament 26 for igniting the powder charge within the chamber 16 is connected at one end to the tubular member 20 and at its other end to the conducting rod 23 and the energizing circuit therefor is traced through the conducting plate 24, the conducting rod 23, the wire filament 26, the tubular conducting member 20 and the plate 21.

Within the perforator unit 10 are provided three longitudinally extending bores 27, the axes of which are disposed substantially at the apices of an equilateral triangle, and each of which is adapted to accommodate a conducting rod 28. The rods 28 are provided with pointed ends which project slightly beyond the upper and lower faces of the perforator unit 10 and they are insulated therefrom by sleeves of suitable insulating material 29.

As shown in greater detail in Fig. 3, each of the conducting plates 24 is provided with a laterally extending portion 30 and each conducting plate 21 is provided with a similar projecting portion 31. The cartridge 14 is so assembled that the projection 30 on the plate 24 is disposed substantially 180° away from the projection 31 on the plate 21 and it is inserted into the cartridge chamber 11b in such fashion that the projection 31 on the plate 21 is disposed adjacent the pointed end of one of the rods 28.

The perforator units are so designed that when the unit 10, for example, is threadedly secured to the unit 10', the pointed end of the conducting rod 28 of the perforator unit 10 pierces the insulating layer 25' covering the projection 30' of the conducting plate 24' while the pointed end of a similar conducting rod in the perforator unit 10' makes an analogous connection with the conducting plate 21'.

It will be apparent, therefore, that, in operation, current will flow through the conducting plate 24, the conducting rod 23, the filament 26, the tubular conducting member 20 and the conducting rod 28 in the perforator unit 10 to the contact plate 24' of the next lower perforator unit 10'. In this fashion current is supplied to each series of cartridges 14 in the assembled perforator.

It will be noted further that in this embodiment of the invention the current path is not along a line parallel to the axis of the assembled perforator. On the contrary, the current flows along a line parallel to the axis of the perforator unit 10, then along a line located at an angle of approximately 115° away and parallel to the axis of the next succeeding perforator unit 10' and so on through the respective units of the assembled apparatus.

In order that the cartridges 14 may be readily inserted within the respective cartridge chambers in the perforator unit 10, the internally threaded skirt portion 32 thereof may be suitably notched as at 33, for example.

The well casing perforator is made up by screwing together a plurality of units 10, 10', etc., the number depending upon the number of shots which are to be fired into the casing. The topmost unit 10 is then screwed to a connector unit 34 by means of which the respective igniting circuits in the perforator apparatus may be electrically connected to corresponding conductors in the supporting cable (not shown).

The connector unit 34 is of a special type which is adapted to break an igniting circuit each time that a gun is fired, thereby indicating to the operator at the surface of the earth that the firing operation has been succesful. Circuit breaking means of this character is used in each of the three igniting circuits in the well casing perforator. For the sake of simplicity, however, only one igniting circuit and the circuit breaking means therefor are shown in Fig. 1.

Referring again to Fig. 1, the conductor 35 in the supporting cable is secured by means of a conventional tap screw 36 within a recess 37 formed in a conducting block 38. The block 38 is insulated from the connector unit 34 by means of suitable insulating material 39. The tap screw 36 is electrically connected through a wire 40 to one contact element 41 of a conventional type mercury switch 42 which is vertically disposed within a sleeve 43 made of flexible material such as rubber, for example, and which contains just enough mercury to remain in contact with the contact element 41 when the connector unit 34 is at rest.

The other contact element 44 of the switch 42 is connected by means of a conductor 45 to a conducting block 46. The block 46 is connected by means of the conductors 47 and 48 to an insulated conducting rod 49 which is adapted to engage the projection 30 on the conducting plate 24 in the first perforator unit 10.

When the assembled perforator is at rest, the contact element 41 dips into the mercury in the switch 42 so that electric current flows normally therethrough to the firing circuit. However, when a shot is fired, the entire perforator assembly sustains a violent shock which displaces the mercury and temporarily breaks the electrical firing circuit. The break in the circuit may be readily indicated in any suitable manner, as, for example, by listening to a telephone receiver connected in the circuit at the surface of the earth. In this fashion, it is possible to check the firing of the shots by noting the break produced in the electrical circuit by the shock sustained when a gun is fired.

In operation, the filaments in the cartridges in each igniting circuit are ignited successively by adjusting the value of the current flowing therethrough. To this end, the igniting filaments of different electrical characteristics are used, the lowermost one in the perforator being designed to be ignited first. When any filament has been ignited, for example, the filament 26, the force of the explosion destroys the insulating material 22 and 25, thereby grounding the rod 23 to the perforator body, so that the igniting circuit remains closed. The flow of conducting bore hole liquid into the powder chamber 11b through the gun bore 13b after the projectile therein has been fired also tends to ground the conducting rod 23, in which case the igniting circuit is completed directly through the conducting bore hole liquid.

In the embodiment shown in Fig. 4, a disc 50 is secured to the bottom of the perforator unit 10 by means of a conventional tap screw 51. The disc 50 is provided with internally threaded recesses 52 therein within which are secured the cartridges for firing the guns. Each threaded

recess 52 communicates through a narrow passage 54 with a larger sector-shaped recess 55 formed in the upper face of the disc 50, within which is disposed a metallic plate 56 of approximately the same shape, which is enclosed in suitable insulating material 57.

As shown in greater detail in Figs. 7 and 8, a small portion of the insulation is removed from the upper face of the plate 56, forming a slot 58 therein and part of the insulation is removed from the lower face of the plate 56 to form a small hole 59 therein which is adapted to register with the narrow passage 54 in the disc 50. The connector element 34 is provided with a similar disc 50*a* and corresponding parts have been designated with corresponding reference numerals with the subscript *a*.

The cartridge 53 is provided with an upper closure member 60 having a passage 61 therein, within which is disposed an insulating sleeve 62 having a contact rod 63 therein. The cartridge 53 also has a lower closure member 64 made of suitable insulating material, in which is inserted a conducting rod 65. The conducting rod 65 is enclosed in a sleeve 66 of insulating material within a passage 67 in the perforator unit 10 and it is provided with a pointed end which is adapted to project through one of the slots 58 into engagement with one of the plates 56 in the disc 50. A wire filament 68 is connected between the contact rod 63 and the contact rod 65, which filament serves to ignite the powder in the cartridge 53.

When the perforator units 10, 10', etc., are assembled as shown in Fig. 4, it will be noted that the contact rods 65 on the cartridges 53 in the perforator 10 extend through the upper slots 58 in the insulation 57 into engagement with the contact plates 56. Also, the contact rods 63 of the cartridges 53 in the perforator unit 10 project through the passages 54*a* in the disc 50*a* into engagement with the contact plates 56*a* as shown in Fig. 5. Similar connections obtain between the perforator units 10 and 10' as illustrated in Fig. 6 so that three continuous firing circuits are produced in the assembled perforator.

It will be apparent that in this modification the successive cartridges 53 through which the firing current passes are located in different radial planes, the angle between any two successive radial planes being approximately equal to the angle subtended by the contact plate 56. The successive cartridges 53 are ignited in the same manner as described above in connection with the cartridges shown in Figs. 1–3.

Figs. 9 and 10 illustrate another embodiment of the invention in which ignition is transmitted automatically from one cartridge to another cartridge located along a different generatrix of the perforator. In this embodiment, each cartridge 69 is provided with a lower closure portion 70 having a very narrow bore 71 formed therein. The bore 71 is adapted to register with a narrow inclined passage 72 formed in the perforator unit 10 which extends to the cartridge 69' in the next perforator unit 10' which is located on a different generatrix.

In this embodiment, the guns in the uppermost perforator unit 10 are preferably fired electrically and to this end the cartridge 69 is provided with an igniting filament 74 grounded at one end to the metallic cartridge case 75 and connected by means of an insulated conductor 76 to the contact rod 49 which is connected to the conductor 35 in the supporting cable.

When the cartridge 69 is fired by passing electrical current through the igniting filament 74, the powder gases pass through the narrow bore 71 in the lower closure member 70 of the cartridge 69 to the inclined passage 72, where they are allowed to expand. The expanded gases then pass to the upper end of the cartridge 69' in the next perforator unit 10' where they flow through a restricted aperture 77' and through a passage 78' to the charge of powder contained within the cartridge 69', which is ignited thereby.

The passage through the restricted bore 71 and the subsequent expansion in the inclined passage 72' produce a delay in the transmission of ignition so that a certain interval of time elapses between the firing of the successive cartridges.

From the foregoing, it will be apparent that the invention provides new and improved well casing perforating apparatus which is characterized by simplicity and increased safety of operation. Moreover, the applicant's novel circuit breaking means provides an indication at the surface of the earth each time that a gun is fired, thus enabling the operator to ascertain if the apparatus is functioning properly.

While several specific embodiments have been described in detail hereinabove, the invention is not intended to be limited thereto, but is susceptible of numerous changes in form and detail within the scope of the appended claims.

I claim:

1. A well casing perforator comprising, a plurality of units detachably assembled in consecutive series in a longitudinal direction, each unit being provided with at least one longitudinally extending powder chamber having at least one gun barrel communicating therewith, the axes of the powder chambers in adjacent units being angularly spaced apart about the axis of the perforator, and igniting means for each of said chambers, said igniting means being so associated with one another as to form a complete ignition path extending through the perforator.

2. A well casing perforator comprising, a plurality of units detachably assembled in consecutive series in a longitudinal direction, each unit being provided with at least one longitudinally extending powder chamber having at least one gun barrel communicating therewith, the axes of the powder chambers in adjacent units being angularly spaced apart about the axis of the perforator, and electric igniting means for each of said chambers, said igniting means being electrically connected with one another so as to form a complete ignition path extending through the perforator.

3. A well casing perforator comprising a plurality of units detachably assembled in consecutive series in a longitudinal direction, each unit being provided with at least one longitudinally extending powder chamber having at least one gun barrel communicating therewith, the axes of the powder chambers in adjacent units being angularly spaced about the axis of the perforator, an explosive charge in each of said powder chambers, means providing restricted communication between said respective powder chambers and means for igniting the explosive charge in a powder chamber at one end of said perforator, whereby ignition will be transmitted successively to said respective powder chambers.

4. A well casing perforator which comprises, in combination, a plurality of units detachably assembled in consecutive series in a longitudinal direction, each unit being provided with at least two longitudinal powder chambers and at least

one gun barrel for each chamber, and igniting means for each of said chambers, the igniting means of one chamber being adapted to be connected automatically, upon assembly of said units, to the igniting means of a chamber of the next unit located on a different longitudinal line, so as to constitute at least two complete ignition paths extending through said series of units, each along a non-rectilinear line.

5. A well casing perforator which comprises, in combination, a plurality of units detachably assembled in consecutive series in a longitudinal direction, each unit being provided with at least two longitudinal powder chambers and at least one gun barrel for each chamber, and powder ignition means for each of said chambers, the ignition means of one chamber being adapted to be operatively connected, upon assembly of said units, to the ignition means of a chamber of the next unit located on a different longitudinal line so that each series of chambers thus connected together is located on a helix.

6. A well casing perforator which comprises at least one body member having a longitudinal axis, provided with at least two cartridge chambers having axes parallel to the axis of said body member and located in peripheral regions thereof, at least two longitudinally extending conduits communicating with each of said chambers, respectively, and means forming at least one barrel hole extending from each of said conduits to the outer wall of said body member in a direction transverse to its axis and passing through the central portion of the body member.

7. A well casing perforator which comprises, in combination, a plurality of metal units, detachably assembled together in consecutive series in a longitudinal direction, each unit being provided with at least one longitudinally extending cartridge chamber therein, having at least one gun barrel communicating therewith, a cartridge in said chamber, an igniting filament in the cartridge, a pair of contacts on said cartridge and connected to said igniting filament, and at least one insulated conducting rod extending through said unit, one end of said conducting rod being in engagement with one of said cartridge contacts and the other end of said rod being in engagement with one of the contacts on the cartridge in the corresponding powder chamber in the next unit, and the conducting rods and cartridge contacts in the respective units being adapted to cooperate to form at least one complete ignition circuit extending through the perforator.

8. A well casing perforator which comprises, in combination, a plurality of metal units detachably assembled together in consecutive series in a longitudinal direction, each unit being provided with at least one longitudinal cartridge chamber opening into one face thereof and extending to a distance from the other end thereof, and at least one gun barrel for said chamber, extending transversely of said longitudinal direction, a cartridge in said chamber, including a tubular metal casing closed at both ends, an explosive charge in said tubular casing, two longitudinal rods extending through the rear portion of said casing, said rods being insulated from each other and from the cartridge casing, a filament connected to the ends of said rods within the casing, two superposed metallic plates connected to said rods, respectively, adjacent the outer face of said rear portion of the cartridge casing, and adapted to be retained between said end part of the cartridge and the front face of the preceding unit, an insulating layer on each face of said plates, a conducting rod having sharp pointed ends extending throughout each unit for connecting one of said plates with another plate of the next unit, upon assembly of said units, said insulating layers being adapted to be crushed by the explosion of the charge in the cartridge, whereby the metal of each cartridge case and therefore the metal of the corresponding unit will be connected directly with a conducting rod of the preceding unit when a cartridge in the first mentioned unit is fired.

9. A well casing perforator which comprises, in combination, a plurality of metal units detachably assembled together in consecutive series in a longitudinal direction, each unit being provided with at least one longitudinal cartridge chamber opening into one face thereof and extending to a given distance from the other end thereof and at least one barrel hole for said chamber extending transversely of said longitudinal direction, a cartridge in said chamber, including a tubular casing closed at both ends, a charge of powder in said tubular casing, two longitudinal rods extending through the rear portion of said casing, an insulating layer around each of said rods, a filament connected to the ends of said rods within said casing, two superposed metallic plates of disymmetrical shape connected to said rods, respectively, adjacent the outer face of said rear portion of the cartridge casing in different angular positions, respectively, and adapted to be retained between said end part of the cartridge and the front face of the preceding unit, an insulating layer on each face of each of said plates, a conducting rod having sharp pointed ends extending throughout each unit for connecting one of said plates with the plate of the next unit located in a different angular position, upon assembly of said units, said insulating layers being adapted to be crushed by explosion of the powder in said cartridge, whereby the metal of each cartridge casing and therefore the metal of the corresponding unit will be connected directly with a conducting rod of the preceding unit when a cartridge in the first mentioned unit is fired.

10. A well casing perforator which comprises, in combination, a plurality of metal units detachably assembled together in consecutive series in a longitudinal direction, each unit being provided with at least one longitudinal cartridge chamber opening into one face thereof and extending to a distance from the other end thereof and at least one barrel hole for said chamber, extending transversely of said longitudinal direction, and intermediate the inner end of said chamber and said other end of said unit, a small conduit connecting said chamber and the corresponding barrel, a cartridge in said chamber, including a tubular casing closed at both ends, a charge of powder in said tubular casing, two longitudinal rods extending through the rear portion of said casing, an insulating layer around each of said rods, a filament connected to the ends of said rods within the casing, two superposed metallic plates connected to said rods, respectively, against the outer face of said rear portion of the cartridge casing and adapted to be retained between said rear portion of the cartridge and the front face of the preceding unit, an insulating layer on each face of each of said plates, a conducting rod having sharp pointed ends extending throughout each unit for connecting one of said plates with another plate of

the next unit, upon assembly of said units, said insulating layers being adapted to be crushed by the explosion of the powder in the cartridge, whereby the metal of each cartridge casing and therefore the metal of the corresponding unit will be connected directly with a conducting rod of the preceding unit when a cartridge in the first mentioned unit is fired.

11. A well casing perforator which comprises, in combination, a plurality of metal units detachably assembled together in consecutive series in a longitudinal direction, each unit being provided with at least two longitudinal cartridge chambers forming each a blind hole extending from the rear end face of said unit to a distance from the front end thereof and at least one barrel hole for each of said chambers extending transversely of said longitudinal direction, a cartridge in said chamber comprising a tubular casing closed at both ends and fitted in said chamber, a charge of powder in said tubular casing, an ignition conductor extending throughout each of said cartridges, said unit being provided with a narrow passage extending from each cartridge chamber to the front end of said unit, a rod on said cartridge extending through said last mentioned passage and connected with said conductor, a second rod on the other end of said cartridge projecting from the rear end face of said cartridge and connected with said conductor, and a plurality of sector-shaped transmission members mounted on one end of each unit and adapted to connect the second mentioned rod of one cartridge with the first mentioned rod of a cartridge of the next unit located in a different radial plane.

12. A well casing perforator which comprises, in combination, a plurality of metal units detachably assembled together in consecutive series in a longitudinal direction, each unit being provided with at least two longitudinal cartridge chambers forming each a blind hole extending from the rear end face of said unit to a distance from the front end thereof and at least one barrel hole for each of said chambers extending transversely of said longitudinal direction, a cartridge in said chamber, comprising a tubular casing closed at both ends and fitted in said chamber, a charge of powder in said tubular casing, an ignition conductor extending throughout each of said cartridges, said unit being provided with a narrow passage extending from each cartridge chamber to the front end of said unit, a rod mounted on said cartridge and extending through said last mentioned passage, a second rod mounted on the other end of said cartridge, said second rod being connected with said conductor and projecting from the rear end face of said cartridge, a plurality of sector-shaped transmission members mounted on the end of each unit and adapted to connect the second mentioned rod of one cartridge with the first mentioned rod of a cartridge of the next unit located in a different radial plane, and means mounted on each unit for extracting the cartridges in the next unit when the perforator is disassembled.

13. A well casing perforator comprising a body adapted to be lowered into a bore hole and having at least one explosive charge therein, an electric circuit for igniting said explosive charge, and switching means having contacts responsive to the shock produced by the explosion of said charge for providing an indication that the explosion has taken place.

14. A well casing perforator comprising a body adapted to be lowered into a bore hole and having at least one explosive charge therein, an electric circuit for igniting said explosive charge, and a mercury switch in said circuit for breaking the circuit when the charge is exploded to indicate that the explosion has taken place.

15. A well casing perforator which comprises, in combination, a plurality of units detachably assembled in consecutive series, each unit being provided with at least one powder chamber having an explosive charge therein, and at least one gun barrel for said chamber, electric igniting means in each of said units for igniting said explosive charge in the chamber, said igniting means being adapted to be interconnected automatically from one unit to the next upon assembly of said units so as to constitute at least one ignition circuit extending therethrough, and switching means having contacts rendered operative by the shock of the explosion for temporarily breaking said circuit every time an explosive charge in one of said chambers is ignited.

16. A well casing perforator which comprises, in combination, a plurality of units detachably assembled in consecutive series, each unit being provided with at least one powder chamber having an explosive charge therein, and at least one gun barrel for said chamber, electric igniting means in each of said units for igniting the explosive charge in said chamber, said igniting means being adapted to be interconnected automatically from one unit to the next upon assembly of said units so as to constitute at least one ignition circuit extending therethrough, and a mercury switch in said circuit for temporarily breaking said circuit every time one of said explosive charges is ignited.

17. In a well casing perforator including a body adapted to be lowered into a bore hole, at least one explosive charge in the body, and an electric circuit for igniting said explosive charge, the combination of switching means having contacts in said circuit and responsive to the shock produced by the explosion of said charge for providing an indication that the explosion has taken place.

18. In a circuit for igniting an explosive charge in a gun adapted to be lowered into a bore hole, the combination of switching means in the gun, said switching means having contacts responsive to the shock produced by the firing of the explosive charge for providing an indication that the firing of said charge has taken place.

MARCEL SCHLUMBERGER.

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