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O'Connor et al.

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[54] **IGNITER MECHANISM FOR SOLID PROPELLANTS UNDER HIGH FLUID HEAD**

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[52] **U.S. Cl.** **102/70**, 166/63

[51] **Int. Cl.** **F23q 7/02**

[58] **Field of Search** 102/20, 21, 28, 39–70, 102/96, 87; 60/252; 166/63

[56] **References Cited**

UNITED STATES PATENTS

2,974,727	3/1961	Goodwin	166/63 X
3,088,274	5/1963	McKinnon et al.	60/252
3,286,628	11/1966	Young et al.	102/28
3,318,395	5/1967	Messmer	166/63 X

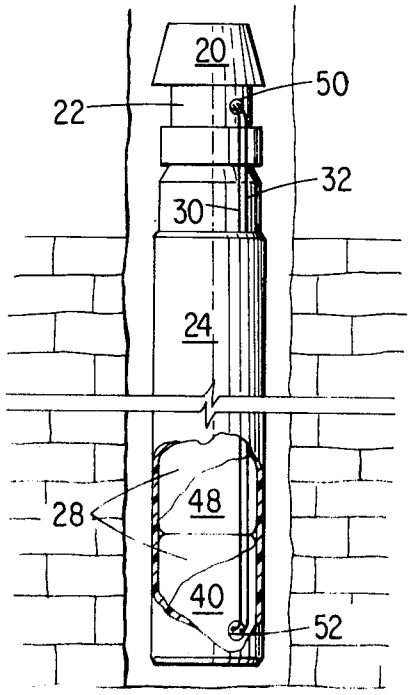
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[57] **ABSTRACT**

An igniter is describe capable of operating at high bottomhole pressures, i.e., greater than 2,000 psi. To prevent the influx of well fluids into the recess which has been drilled into a portion of the main propellant, it is filled with a plastic or viscous propellant. A flame squib or resistance wire is immersed in the viscous propellant. Any pressure exerted by well fluids against the viscous propellant serves to force it into void spaces around the flame squib thus protecting the squib as well as the surrounding primary propellant from direct contact with aqueous well fluids.

10 Claims, 3 Drawing Figures



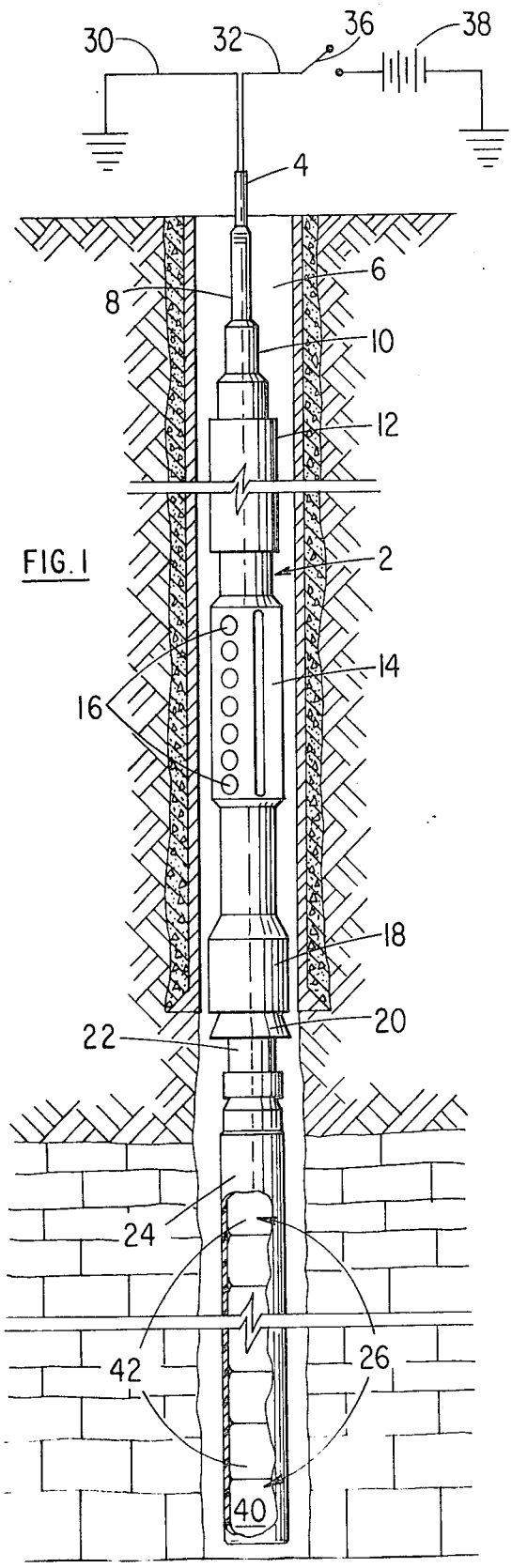
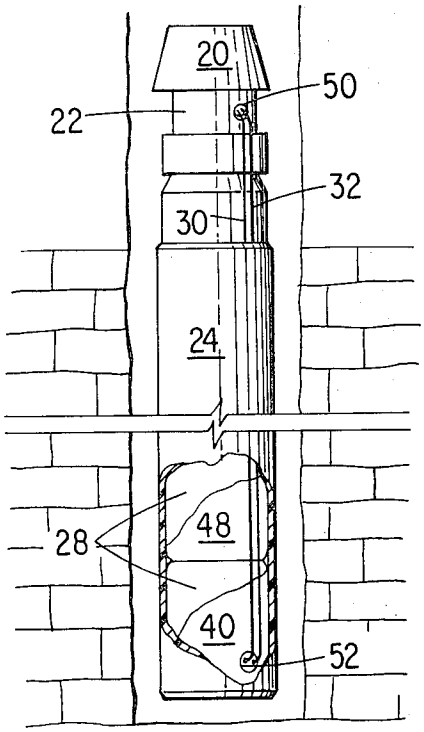


FIG. 1

FIG. 2



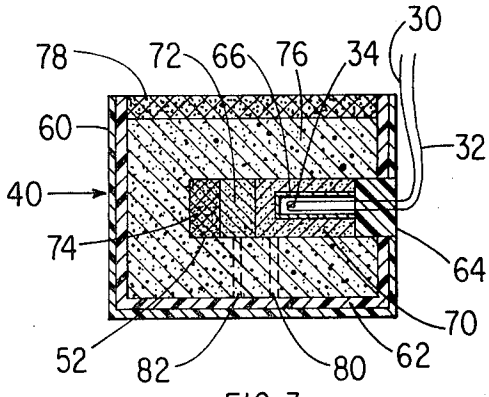


FIG. 3

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IGNITER MECHANISM FOR SOLID PROPELLANTS UNDER HIGH FLUID HEAD

INTRODUCTION

The present invention relates to the use of propellants for the purpose of stimulating the production of fluids from certain underground formations. More particularly, it is concerned with an improved igniter mechanism for igniting the propellant, especially in applications where high fluid pressures are encountered.

BACKGROUND OF THE INVENTION

Prior to the present invention, flame squibs or other available igniter mechanisms were found to be satisfactory for ignition of propellant charges in wells where the fluid head was low, i.e., not in excess of about 500 psi. In wells with a high fluid head it was found that the high bottomhole pressure damaged the squib or equivalent ignition mechanism. Several different kinds of ignition systems were tried, but in every case it was found that they became inoperable because of their failure to withstand the pressure resulting in wetting of the propellant charge with the well fluids in the area of initial ignition. Bottomhole pressures encountered in this work were of the order of 2100 psi, i.e., a 5000-foot well standing full of water.

DESCRIPTION OF THE INVENTION AND DRAWINGS

We have now discovered an improved ignition means capable of withstanding the high bottomhole pressures encountered in the deeper wells, e.g., 4000 feet and greater. Primarily, this is accomplished by filling the void space around the flame squib with a highly combustible, viscous liquid or soft plastic material which serves to protect both the squib and the propellant from invasion by well fluids.

Referring to the drawings, FIG. 1 is an elevational view of a suitable apparatus for use in fracturing formations by burning of propellant charges ignited by means of our novel ignition mechanism.

FIG. 2 is an enlargement of the lower section of FIG. 1, illustrating in further detail the wiring arrangement used to ignite the flame squib employed in our invention.

FIG. 3 is a detailed sectional view of the lowermost end of the propellant charge shown in FIG. 2 taken along line 3—3. Referring again to FIG. 1, the tool 2 is suspended on an armored cable 4 into cased well 6. The tool is lowered into the well by means of cable 4 affixed to cable head 8. Firing unit 10 containing an igniter assembly joins cable head 8 and anchor actuating propellant chamber 12. The latter contains a propellant charge varying in size depending on the depth at which the anchor and packer are to be set. To the base of propellant chamber 12 the upper end of anchor 14 is engaged. Anchor 14 is equipped with slips 16 that project out horizontally against the casing by means of gas generated when the propellant in chamber 12 is ignited. This same charge also serves to set packer 18 through the upward movement of setting wedge 20. At the base of setting wedge 20 is an adapter sub 22 which joins wedge 20 with propellant container 24 constructed preferably of a combustible material such as plastic, for example, polyvinyl chloride, or magnesium.

Within container 24 is a series of propellant canisters 26 encased in a water resistant paper 28.

Conductor wires 30 and 32 lead to armored cable 8 and function to fire both the anchor actuating propellant and the main propellant charge, the lowermost end of which contains a flame squib 34 as shown in greater detail in FIG. 3. Electrical switch 36 is closed at ground level to introduce current from power source 38 to firing unit 10 which in turn activates the charge in anchor actuating propellant chamber 12. Preferably, with a time delay of 100 to 150 milliseconds, current is introduced into flame squib 34 which serves to initiate slow burning unit 40. The anchor activating propellant is fast acting while the propellant in canister 40 is slow burning. This permits anchor 14 and packer 18 to be set in position before propellant charge 40 burns. The latter builds up sufficient pressure in the packed off space to initiate a fracture in the formation. Pressure built up within said packed off space by ignition of fast burning propellant 42 is sufficient to extend the initiated fractures to a location up to about 50 feet from the well. If the pressure under packer 18 builds up to a higher value than that trapped in the packer, a check valve arrangement such as that described and claimed in co-pending application U. S. Ser. No. 25,125, filed April 2, 1970 by Clarence R. Fast et al now U.S. Pat. No. 3,602,304 may be employed. This valve is located in adapter sub 22 and opens when excessive pressure builds up underneath the packer, permitting the pressure to enter the packer-anchor combination and keep the tool in a set position. After completion of the burning of propellant 42, the pressure in the tool is bled off by pulling on armored cable 4 which opens a spring-loaded pressure release valve. When pressure above and below packer 18 is equalized, anchor slips 16 are retracted by means of built-in springs and the assembly brought to the surface.

In FIG. 2, wires 30 and 32 are brought outside of the upper portion of sub 22 through an opening 50. These wires run between paper wrapping 28 and plastic carrier 24 until they reach the lowermost canister 40 which contains the slow burning propellant. Near the base of canister 40, wires 30 and 32 enter a recess 52 where they make contact with flame squib 34 as shown in FIG. 3.

In FIG. 3 the igniter mechanism illustrated therein and constituting the lowermost portion, e.g., 3 inches, of canister 40 comprises a thin, e.g., 1/16 inch, phenolic resin outer shell 60 lined with a resilient layer 62 of polyurethane or equivalent material. Back of plug 64, sealing off opening 52 is flame squib 34, equipped with electrical resistance wire enclosed within a copper or aluminum shell 66, one end of which is affixed to the interior of plug or seal 64, the opposite end thereof being closed. After the current flows into squib 34 via wires 30 and 32, a delay mechanism of about 125 milliseconds is designed into the squib to assure that it does not ignite before firing unit 10 activates the propellant in actuating chamber 12 setting anchor 14 and packer 18. We have found this design to be a significant improvement over previous igniter mechanisms because the latter permitted water to be forced back into the cavity surrounding the flame squib causing the adjacent propellant to become wet thereby rendering the igniter unreliable. With the design pro-

vided by our invention, however, when water under high pressure is forced against seal **64** and around the edges thereof, its principal area of contact is with plastic propellant **70** which on being subjected to such pressure tends to fill any voids or channels into which the water might otherwise force its way thus preventing movement of well fluids into the igniter mechanism. Prior to the present invention, a dry, granular, rapid-burning material such as smokeless powder was used but without being in the semi-liquid or plastic form as taught in our invention. In that case, water at high bottomhole pressures, e.g., 2000 psi, readily came in contact with both the smokeless powder surrounding the flame squib and with the ammonium nitrate propellant, i.e., in the area of initial ignition. In accordance with our invention, recess **52** existing around squib **34** is filled with a semi-liquid or plastic rapid burning material **70** such as, for example, a mixture of equal parts of smokeless powder and nitrocellulose cement. Other substitutes for rapid-burning material **70** may comprise the combination of gun cotton or the equivalent thereof and nitrocellulose dissolved in butyl acetate, a pyroxylin lacquer or nitromethane. Drilled cavity **52** may be filled completely with the aforesaid mixture or it may in addition to such mixture contain separate charges of U. S. Flare pellets 72 and JT-1 pellets **74** to assure that sufficient heat is supplied to ignite propellant **76** surrounding recess **52**. The U. S. Flare pellets are comprised of potassium nitrate with boron and a binder of a readily ignitable polyester. The JT-1 pellets are largely ammonium nitrate held together by means of a polyvinyl acetate binder containing catalysts and other additives used in propellant manufacture. Both of these materials, i.e., the Flare pellets and JT-1 pellets, burn substantially faster and hotter than ordinary ammonium nitrate. The charge surrounding recess **52** is preferably a propellant such as ammonium nitrate using cellulose acetate as the binder. This gives a product capable of igniting much more readily than similar propellants using an asphalt binder. However, the latter is generally preferred in making up the remainder of the total propellant charge, and in FIG. **3** is designated as **78**.

Weep holes running from the plastic, rapid burning material **70** are designated by dashed lines **80** and **82**, respectively. These aid in diverting some of the gaseous combustion products generated on ignition, thereby assisting in preventing a possible rupture of the base of the igniter mechanism due to rapid generation and expansion of said products. A rupture and sudden depressurization may cause flame out.

The igniter mechanism described above has operated without failure since its development in a number of wells having a bottomhole hydrostatic pressure of the order of 200–2500 psi, igniting the remainder of the sustainer charges, i.e., approximately **250** pounds in the total charge.

In performing the fracturing operation, we employ a propellant configuration that will permit slow burning of approximately 1/10 to ¼ of the charge in the packed off zone. At this stage, enough combustion products are produced to increase pressure so that a fracture or fractures in the formation are initiated. The remainder of the propellant charge should be of such a character or configuration that it burns rapidly, e.g., 0.2 in./sec under well conditions. Rapid burning and generation of combustion gases at high pressure thus permits extension of the fractures started by the slow burning propellant. Regulated burning of the propellant charge is accomplished by preparing the latter so that the initial portion of the charge, e.g., 20–50 pounds of a 200-pound charge, burns from the end in the same manner as a cigarette. To do this the propellant is placed in a suitable restrictor material such as a cardboard or waterproof paper cylinder that will resist ignition from hot gases along the sides of the propellant contained therein. The remaining portion of the propellant is either naturally a faster burning material or has a configuration such that it will ignite from the initial portion but will not burn from end to end as is true in the case of a cigarette. The aforesaid remaining portion is made up of several sustainer units which may have one or more holes bored in or near the center of the units so that after the initial igniter unit has burned, the remainder of the charges will burn very rapidly because of their increased surface area. It may be desirable to have the major or fast burning portion of the propellant in sections so that it can be readily placed in the well. In any event, these sectional joints should be resistant to the penetration of well fluids and be restricted to the penetration of hot gases so that well fluids will not enter the centrally drilled hole in the propellant and prevent rapid combustion. The propellant charge may be made up of a solid igniter and, if desired, additional slow burning, e.g., 0.05 to 0.1 in./sec, sustainer units. The other portion of the charge has some fast burning sustainer units that can ignite from the slower burning propellant sections. The fast burning units can be prepared by embedding fast burning igniter cord in the propellant, such as, for example, Du Pont's Pyrocore igniter cord. This product is in the form of a small diameter continuous tubing containing an ignition composition. Its core is designed to promote ignition at the speed of detonation. By embedding such a material in the sustainer unit, instant ignition of the unit can be obtained. When the igniter cord is activated by the adjacent igniter or sustainer unit, the fast burning sustainer unit can be made to burn at as many surfaces as desired.

In setting the propellant charge either in a cased or open hole, it is generally preferred to place the charge in a relatively confined, packed-off section of the well. Thus, if the bottom of the charge is placed close, i.e., 5–10 feet from the bottom of the well, only an upper packer need be set. However, if the zone to be fractured is at an intermediate level it should be in a confined space formed by an upper packer, with the remainder of the hole being plugged back with sand, a bridge plug or other suitable means, up to a level of from about 5 or 10 feet from the base of the propellant charge. This is primarily to insure uniform and rapid burning of the major portion of the charge. If the latter is not placed near the bottom of the well, or the space immediately below the charge is not packed off or plugged back, the hot gaseous combustion products from the igniter section can travel down the well instead of moving upwardly past the outer surfaces of the sustainer units. This results in slower and non-uniform burning of the main charge. With relatively slow generation of the gases, fracturing extending pressures

generally cannot be reached before such gases are dissipated out into the formation.

The composition of the propellants used in the process of our invention vary rather widely, the principal objective being to employ a charge having the burning characteristics discussed above. Typical of such propellants are the ammonium nitrate type, preferably with from about 5–10 weight percent of an asphalt binder. Usually these compositions contain ½-1 weight percent of a stabilizer such as toluene diamine and 5 or 10 weight percent of a catalyst such as Prussian blue, ammonium chromate, potassium chromate or a mixture of chromates with metal oxides or silicates.

Propellants of the type described are used in the form of cylindrical sections typically 4 inches in diameter and 36 inches long for the igniter units, and the sustainer units are preferably 18 inches in length and 4 inches in diameter. Approximately 8 pounds of propellant should be used for each linear foot of hole exposed to treatment, with a minimum of 200 pounds in the total charge for each treatment. With this size of propellant charge, about 150,000 btu of heat and 3,600 scf of gas are generated in less than one minute. A charge of this weight (200 pounds) 4 inches in diameter is about 25 feet long. The propellant charge is preferably carried in a polyvinyl chloride tube, closed at the bottom end. The assembly of propellant charge and carrier is affixed to a wireline operated casing packer-hydraulic hold down tool and lowered into the well to the desired depth. Propellant charges of the type mentioned above, when used in accordance with our invention, create fractures in the formation for a distance of 50 feet or more, and will heat the area immediately adjacent the well to cause removal of scale and spalling of the formation face in open hole wells.

We claim:

1. An igniter mechanism for a propellant charge enclosed in a plastic casing, said mechanism comprising,

a chamber within said charge,

a cavity within said chamber,

an igniter means within said cavity,

a plug in the exterior end of said chamber through which said igniter mechanism extends, and

a flowable, plastic, rapid-burning propellant in said chamber in an amount sufficient to envelop said cavity and to substantially fill the remainder of said chamber so that when external pressure is applied to said plug such pressure is equalized by the plastic propellant in said chamber, thereby effecting a liquid-tight seal to prevent the movement of well fluids into contact with said igniter mechanism.

2. The igniter mechanism of claim 1, in which the igniter means is an electric flame squib.

3. The igniter mechanism of claim 2 wherein said squib has a built-in time delay of from about 100–500 milliseconds.

4. The igniter mechanism of claim 1, wherein the flowable, plastic, rapid-burning propellant is made of a mixture consisting essentially of nitrocellulose and nitrocellulose cement.

5. The igniter mechanism of claim 1 wherein the flowable, plastic, rapid-burning propellant is made of a mixture consisting essentially of smokeless powder and nitrocellulose cement.

6. The igniter mechanism of claim 4 wherein a pyroxylin lacquer is substituted for the nitrocellulose cement.

7. The igniter mechanism of claim 4 in which the two principal ingredients of said rapid-burning propellant are employed in substantially equal amounts.

8. The igniter mechanism of claim 1 in which means is provided for diverting from said chamber a minor portion of the gaseous combustion products resulting from ignition of said rapid-burning propellant.

9. The igniter mechanism of claim 5 in which the two principal ingredients of said rapid-burning propellant are employed in substantially equal amounts.

10. The igniter mechanism of claim 6 in which the two principal ingredients of said rapid-burning propellant are employed in substantially equal amounts.

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