United States Patent

[11] 3,602,304

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[22] Filed **Apr. 2, 1970**
[45] Patented **Aug. 31, 1971**
[73] Assignee **Amoco Production Company Tulsa, Okla.**

[54] **CHECK VALVE FOR USE IN GAS FRACTURING**
4 Claims, 2 Drawing Figs.

[52] **U.S. Cl.** **166/63,** 166/65, 174/21
[51] **Int. Cl.** **F21b 43/00**
[50] **Field of Search** 166/63, 65, 299, 224; 174/21

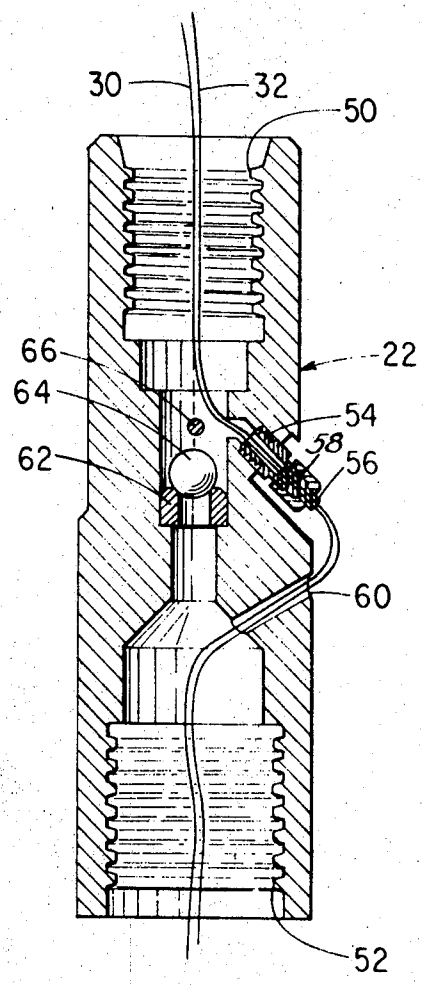
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ABSTRACT: In fracturing an underground formation by burning a propellant in a confined space within a well bore, the packer is set by gas pressure originating from a level above the packer. The pressure generated by burning the main propellant charge below the packer frequently is sufficient to dislodge it from the formation. The present invention overcomes this problem by the use of a suitable check valve carried between the packer and the main propellant charge. The valve traps the gases in the upper assembly which seats the packer. If pressure develops below the packer exceeding the gas pressure used to hold it against the well wall, the check valve opens, allowing gases to enter the packer from the packed off zone so that the tool will remain set until the fracture treatment has been completed.



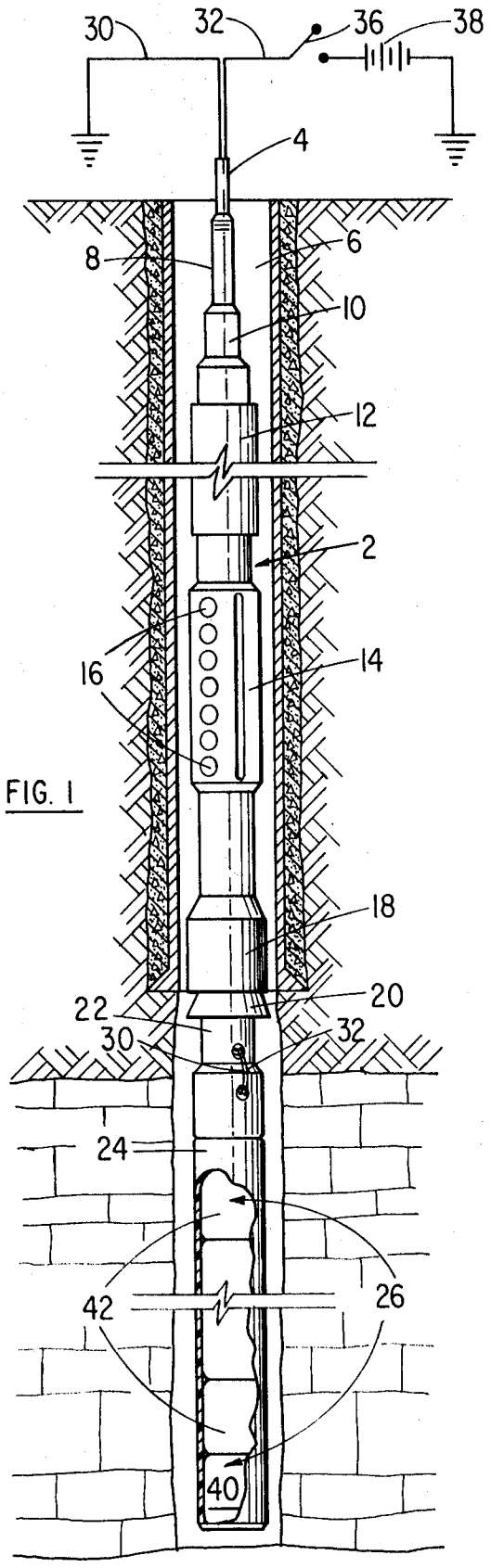


FIG. 1

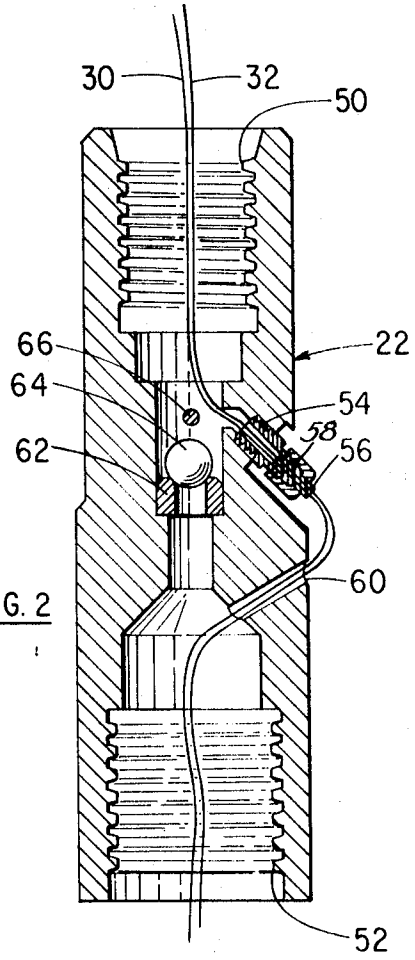


FIG. 2

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CHECK VALVE FOR USE IN GAS FRACTURING

The present invention relates to the use of propellants for the purpose of stimulating the flow of fluids from an underground formation. More particularly, it is concerned with a novel improvement in the type of apparatus employed in the stimulation of said formation in producing fractures therein with propellants.

BACKGROUND OF THE INVENTION

In producing fractures in a formation by the use of propellants, for example, in accordance with the technique described and claimed in copending application U.S. Ser. No. 25,064, filed Apr. 2, 1970, by C. R. Fast et al., the tool employed must remain securely fixed in the well bore while the propellant is burning in order to create sufficient pressure within the confined zone to form the desired fracture. In apparatus of the type referred to in said application which will be described in further detail below, the packer holddown tool above the main propellant charge is about 12 feet long and contains a special propellant charge which actuates the anchor and casing packer just prior, e.g., 100–500 milliseconds, to ignition of the main propellant charge. The propellant which actuates the anchor and packer is fast acting, while the propellant in the main charge is slower burning. Under these conditions the tool sets or is fixed in the casing before the main charge burns. If the pressure under the packer builds up to a higher value than that trapped in the packer, the latter will be dislodged, making it impossible to generate the pressures required to initiate and extend fractures in a confined portion of the formation.

DESCRIPTION OF THE INVENTION AND DRAWINGS

In accordance with our invention, if the pressure below the packer exceeds that above it, such condition in the system is instantaneously corrected by the use of a suitable pressure responsive valve such as a ball and seat check valve located between the packer seating wedge and the main propellant charge. This valve is carried in a hollow pressure retainer-electrical connector sub having a bypass around the valve for electrical lead wires which run on down to an igniter mechanism located in the lowermost portion of the propellant charge. The ball and seat check valve traps the gases in the upper assembly which seats the anchor-packer assembly prior to the ignition of the lower propellant charge. If pressure developed by the gases in the burning of the lower propellant charge exceeds the pressure in the chamber above, the check valve will open, allowing the gases to enter the anchor-packer assembly from the packed off zone so that the tool will remain set until the gas fracturing treatment is completed.

In the drawings,

FIG. 1 is an elevational view of apparatus used in practicing our invention shown as disposed in a well.

FIG. 2 is an enlarged sectional view of the pressure retainer-electrical connector sub shown in FIG. 1 generally as 22 in which the check valve of our invention is contained.

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 propellent 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 special 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 resistance paper.

Conductor wires 30 and 32 lead to armored cable 4 and function to fire both the anchor actuating propellant and the main propellant charge, the lowermost end of which contains a flame squib. A suitable squib for this purpose is the type described and claimed in copending application U.S. Ser. No. 25,063, filed Apr. 2, 1970 by Clarence R. Fast et al. 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 from about 100 to about 500 milliseconds, current is introduced into a flame squib located in and which serves to ignite 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 resulting packed off space to initiate a fracture in the formation. Pressure built up within said confined space by ignition of fast burning propellant 42 is sufficient to extend the initiated fractures to a position of up to about 50 feet away from the well. If the pressure under packer 18 builds up to a higher value than that trapped in the packer, the check valve of our invention serves to render the tool operable by allowing the gases in said confined or packed off space to enter the anchor-packer assembly so that the tool will remain set until the gas fracturing treatment is completed. This valve is located in special 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 the fast acting 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, sub 22 is equipped with threaded portion 50 and 52 adapted to threadedly engage spreading wedge 20 and propellant container 24, respectively. Conductor wires 30 and 32 are run through the interior of the tool down to about midway of sub 22 at which point they are diverted through threaded outlet 54 containing seal 56. In the upper portion of seal 56 is a plastic (Teflon) plug 58 through which conductor wires 30 and 32 are run. The seal is constructed so that as it is tightened in passageway or outlet 54, plug 58 becomes a closer and closer fit around the wires and eventually forms a fluidtight joint. The wires are then inserted into passageway 60 and then on down through the inside of container 24 to propellant charge 40 where said wires are connected to a suitable igniter mechanism. In the interior narrow portion of adapter sub 22 is situated a tapered valve seat 62 adapted to receive ball 64 to form the check valve. Just above ball 64 is a retainer pin 66 which serves as a stop to prevent ball 64 from traveling on up the tool when gaseous combustion products resulting from burning of propellant charge 26 flow through the valve and on up into packer 18 and anchor 14 to provide the pressure necessary to keep the tool in a set position in instances where the pressure in the confined zone below packer 18 tends to exceed the pressure within packer 18 and anchor 14. Likewise, the ball and seat check valve serves to trap the gases in the upper assembly which seats packer 18 and anchor 14 prior to ignition of lower propellant charge 26. The success of tool 2 as an apparatus for gas fracturing operations is dependent upon the use of sub 22 to effect a mechanical-electrical connection between the packer-anchor assembly mentioned above and the propellant charge below affixed to sub 22. More than 40 laboratory and field tests have been conducted demonstrating the success of both the tool and the check valve of our invention.

It will be apparent that modifications and refinements to the check valve design of our invention can readily be made to accommodate a change in propellant charge and/or packer-anchor assembly and a multiple electrical lead. The basic

design described herein permits the use of a single conductor armored wire line and a surface source of 110 volts AC to initiate two separate ignition systems. It also allows an anchor-packer assembly to be actuated by one electrically initiated gas generating package and the second propellant package to be electrically initiated by a delay flame squib.

In employing the device of our invention we prefer a propellant configuration that will permit slow burning of approximately one-tenth to one-fourth 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 reminder 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 of the speed of detonation. By embedding such material in the sustainer unit, instant ignition of the unit can be obtained. When the igniter cord is activated by the adjacent igniter of 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 nonuniform 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 of each treatment. With this size of propellant charge, about 15,000 B.t.u. of heat and 3,600 s.c.f. of gas are generated in less than 1 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 wire line operated casing packer-hydraulic holddown 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.

It will be apparent that modifications and refinements to the check valve design of our invention can readily be made to accommodate a charge in propellant charge and/or packer-anchor assembly and a multiple electrical lead. The basic design described herein permits the use of a single conductor armored wire line and a surface source of 110 volts AC to initiate two separate ignition systems. It also allows an anchor-packer assembly to be actuated by one electrically initiated gas generating package and the second propellant package to be electrically initiated by a delay flame squib.

We claim:

1. An apparatus for use in fracturing underground formations comprising

an elongated tubular body having a lower disposable portion adapted to contain a propellant charge and an upper portion having means responsive to fluid pressure for setting said apparatus in a well,

said apparatus having a combination a hollow pressure retainer-electrical connector sub joining said upper and lower portions,

said sub comprising a pressure responsive valve located within said sub and fluidtight means in said sub for bypassing electrical conductor means around said valve.

2. The apparatus of claim 1 wherein said valve consists essentially of a ball and seat check valve.

3. The apparatus of claim 1 wherein the means for bypassing said valve comprises separate passageways above and below said valve and leading from the interior to the exterior of said sub, the uppermost of said passageways being provided with a fluidtight seal.

4. The apparatus of claim 1 wherein the means for bypassing said valve comprises separate passageways above and below said valve and leading from the interior to the exterior of said sub, the uppermost of said passageways being provided with a fluidtight seal.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,602,304 Dated August 31, 1971

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It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 4, line 21, "15,000" should read -- 150,000 --;

line 36, "charge", first occurrence, should read -- change --.

Claim 1, line 51, "a", first occurrence, should be -- in --.

Signed and sealed this 7th day of March 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents