

Feb. 26, 1957

C. E. REISTLE, JR

2,783,026

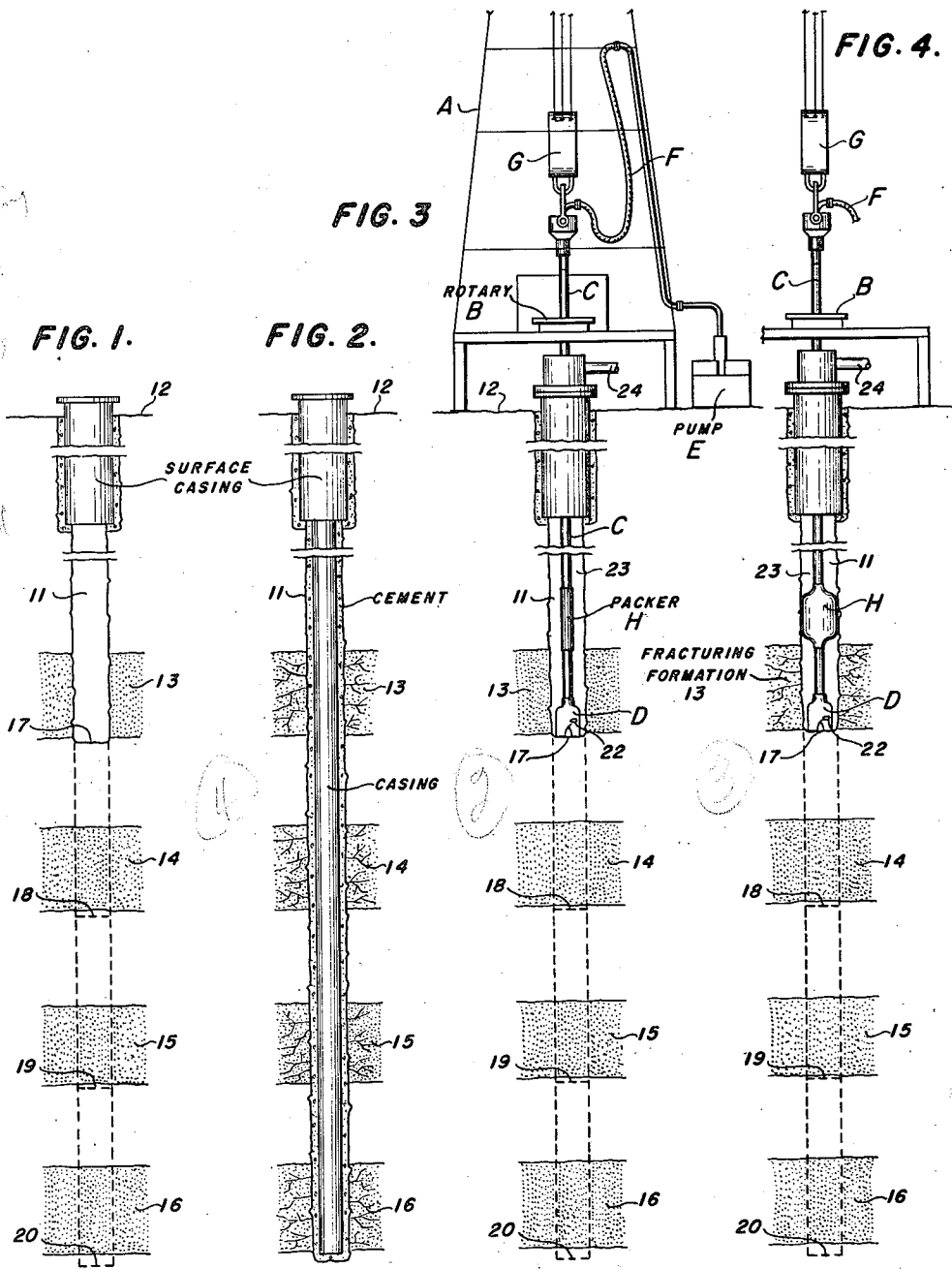
METHOD FOR FRACTURING FORMATIONS

Filed May 7, 1954

2 Sheets-Sheet 1

*Method  
Transition fracturing  
by fluid pressure  
between drilling  
steps*

*drilling stopped  
while for another  
fracturing*



1039  
X 101.

INVENTOR.  
Carl E. Reistle Jr.  
BY *JB McKean*  
ATTORNEY.

Feb. 26, 1957

C. E. REISTLE, JR

2,783,026

METHOD FOR FRACTURING FORMATIONS

Filed May 7, 1954

2 Sheets-Sheet 2

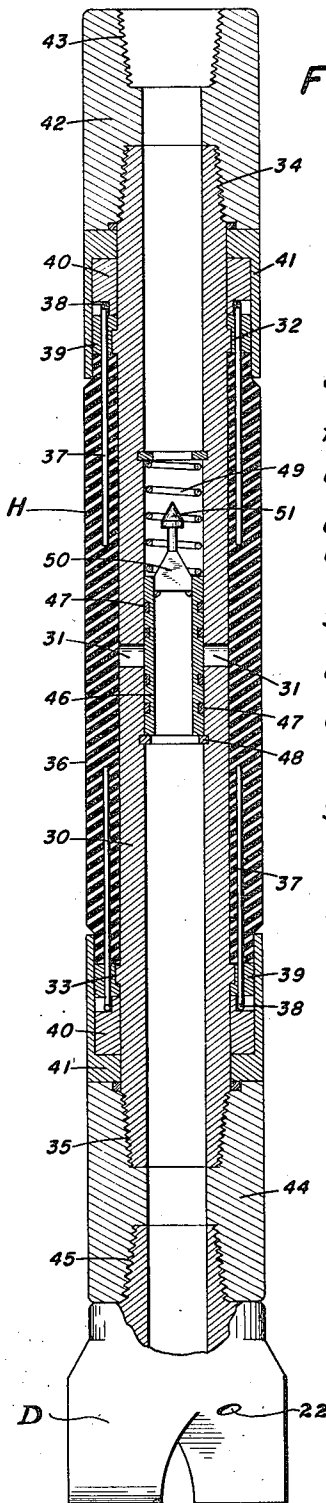


FIG. 5.

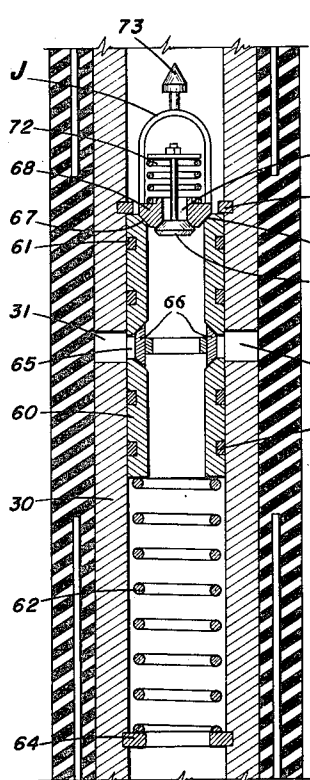


FIG. 6.

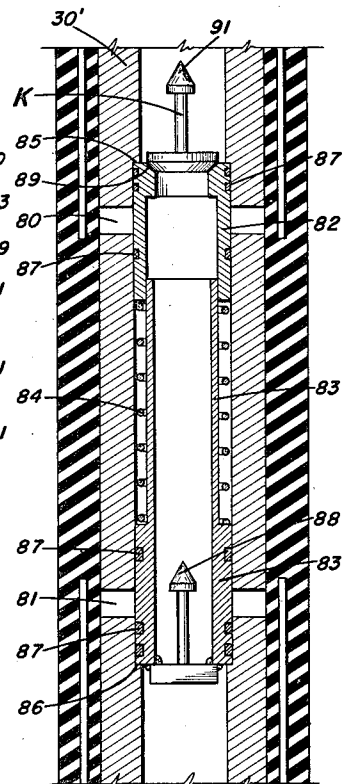


FIG. 7.

INVENTOR.  
Carl E. Reistle Jr.,

BY

*J. B. McKean*  
ATTORNEY.

1

2,783,026

## METHOD FOR FRACTURING FORMATIONS

Carl E. Reistle, Jr., Houston, Tex., assignor, by mesne assignments, to Esso Research and Engineering Company, Elizabeth, N. J., a corporation of Delaware

Application May 7, 1954, Serial No. 428,275

1 Claim. (Cl. 255—1.8)

The present invention is directed to a method for producing and treating a borehole.

In accordance with the present invention, a borehole is drilled by the rotary drilling method using a drill bit carried at the lower end of a string of drill pipe. The lower end of the drill pipe adjacent the drill bit is provided with a packing means operable from the surface of the earth whereby after the borehole has been extended through a selected formation it is packed off to form a cavity in fluid communication with the surface of the earth through the bore of the drill pipe and the pressure exerted on the walls of the cavity increased until the fracture of said selected formation is indicated by a decrease in the resistance to liquid flow into said formation. After the selected formation has been fractured the packing means is retracted by manipulations performed at the surface of the earth so that its diameter is reduced to that of the normal diameter of the drill pipe and the drilling continued to extend the borehole through a selected second formation where the operation is repeated to fracture the second formation. This operation may be repeated as the hole is extended down through its desired depth so that all of the formations of possible future production have been fractured when the well is completed at its desired depth. The borehole may be cased and thereafter perforated adjacent a selected formation or selected formations in the usual fashion.

Other objects and advantages of the present invention may be seen from the following description taken in conjunction with the drawing in which

Fig. 1 is in the form of a sectional view of a borehole and projected borehole indicating a series of strata which may be possible producing zones;

Fig. 2 is a view of the completed cased borehole of Fig. 1;

Fig. 3 is in the form of a schematic drawing showing an arrangement for fracturing a selected formation;

Fig. 4 is in the form of an elevation, partly in section, showing a specific embodiment of a packing means which may be used when carrying out the method of the present application;

Fig. 5 is an elevation, partly in section, showing another specific embodiment of a packing means which may be used in carrying out the method of the present case; and

Fig. 6 is in the form of an elevation showing another embodiment of a packing means which may be used when carrying out the method of the present application.

Fig. 7 is an elevation view showing another embodiment of a packing means which may be used when carrying out the method of the present invention.

The drilling of wells by the rotary method is well known to the drilling art. In general, the operation is performed by the use of a drilling bit carried at the lower end of a hollow drill stem. A drilling fluid is circulated downwardly through the bore of the drill stem and out through eyes in the drill bit so that it removes the cuttings from the bottom of the borehole and carries them upwardly

2

in the annulus between the wall of the hole and the drill bit to the surface of the earth.

The art of increasing the productivity of oil and gas wells by sealing off and exerting pressure on a selected formation to cause said formation to fracture is known to the art. For a description of such a procedure see U. S. Reissue Patent 23,733, reissued to Riley F. Farris, November 10, 1953. As disclosed in the reissue patent, a selected formation is preferably isolated by packers and a low penetrating fluid or gelled fracturing liquid is placed in position adjacent said selected formation and pressure is applied to the low penetrating fluid to build up hydrostatic pressure great enough to cause the formation to part or fracture. This pressure is referred to as "formation breakdown pressure." After the breakdown pressure has been reached and the formation fractured, the pressure ceases to rise as additional fluid is injected and assumes a roughly constant value. The formation breakdown pressure therefore is a pressure at which an increase in rate of fluid injection into the formation will not materially increase the fluid pressure.

Turning now specifically to Fig. 1, a borehole 11 is shown extending from the surface of the earth 12. This borehole is shown as penetrating a potentially productive formation 13. Arranged in sequence below potential formation 13 are other potentially productive formations 14, 15, and 16. As shown in the drawing, borehole 11 has been extended so that it has just penetrated formation 13. The projected extension of the borehole is indicated by dashed lines. In accordance with the present invention when the borehole 11 has been drilled to penetrate through formation 13 with its lower end terminating at 17, the annulus between the drill bit and the borehole immediately above formation 13 is packed off and formation 13 fractured. After the fracturing step, the packing element is caused to retract to its normal diameter and the borehole extended to dashed line 18, which is immediately below the second potentially productive formation which is to be fractured and the operation repeated to fracture formation 14. The borehole is then extended to depth 19 as indicated by dotted lines and potentially productive formation 15 fractured and the drilling operation then resumed until the hole reaches depth 20 as indicated by dashed lines when the potentially productive formation 16 is fractured. In this manner, each stratum selected as a potentially productive formation is fractured immediately after it is drilled so that when the well is completed as a cased well, as shown in Fig. 2 and provided with a casing 21, the selected formations 13, 14, 15, and 16 behind the casing have been fractured. Thus, if the casing is opened at any or all of these points by suitable means, such as perforating the casing, the formation is in a desired fractured condition which increases its potential productivity over its naturally unfractured condition.

Fig. 3 is a schematic figure illustrating the arrangement of parts of the drilling equipment for fracturing formation 13. As seen in this drawing, a drilling derrick A is mounted over the borehole provided with a rotary table B with a drill stem C carrying a drilling bit D at its lower end. A mud pump E is arranged to pump fluid through hose F into the upper end of the drill string, the drilling fluid passing downwardly through the bore of the drill stem and out through eyes 22 of the drill bit D at its lower end adjacent the bottom of the borehole. The drilling fluid carrying cuttings from the bottom of the borehole passes upwardly through annulus 23 between the drill stem and the wall of the borehole and discharges through outlet 24. During the drilling operation, a portion of the weight of the drill pipe is supported from the drilling derrick by means of the usual hoisting assembly G.

3

In the embodiment shown in Fig. 3, the string of drill pipe is provided with a packing means H at its lower end adjacent the drilling bit D. This packing means during the steps of rotating the drill pipe for deepening the borehole has substantially the same diameter as the remainder of the drill pipe. It will be understood that the drill stem does not necessarily have a constant diameter throughout its length but may consist of lengths of pipe secured together by tool joints having a diameter greater than the diameter of the lengths of pipe. However, in its deflated condition, packing means H has a diameter no greater than the maximum diameter of any other portion of the drill stem.

Fig. 4 is a fragmentary view of a portion of the arrangement of Fig. 3 but showing packing member H expanded to seal off a cavity including the uppermost potential formation 13 which should be fractured from the remainder of the annulus between the drill string and the borehole. With the cavity at the lower end of the borehole packed off and in communication with the surface of the earth through the bore of the drill string C the selected formation 13 may be fractured. After the fracturing step has been carried out, packer means H may be reduced in diameter as shown in Fig. 3 and the drilling operation resumed to deepen the hole. Thus, as the hole penetrates each selected formation in turn each selected formation may be fractured in the same manner as described. It is unnecessary to remove the drill stem from the borehole in order to carry out the fracturing step so that the fracturing operation may be carried out without seriously increasing the time required to extend the borehole to the desired depth.

The specific embodiment of a packing means suitable for use as the packing means H, shown in Figs. 3 and 4, is shown in Fig. 5. In this embodiment a tubular valve body 30 is provided with side ports 31, outwardly extending circular shoulders 32 and 33 and threaded ends 34 and 35. Arranged over the central portion of valve body 30 is rubber sleeve 36 with each of its ends provided with a series of longitudinally extending holes for receiving metal reinforcing means consisting of rods 37 attached to ring 38. A retaining ring 39 is provided at each end of the assembly with longitudinally extending passages for receiving reinforcing rods 37. The rubber sleeve and reinforcing rod at each end is then held in position by a retaining ring 40 and retaining sleeve 41. The retaining sleeve at the upper end of the device is held in position by coupling 42 secured with suitably mating threads to threaded end 34 and having threads 43 for engagement with the drill string. The retaining sleeve 41 at the lower end of the assembly is held in position by threaded coupling 44 secured by mating threads to threaded end 35 of body 30 and having its lower end provided with threads 45 for the attachment of drill bit D.

Slidably arranged within body 30 is valve sleeve 46 provided with suitable seals such as O-rings 47 and normally sealing off side ports 31 with its lower end resting against shoulder 48 and biased in this position by spring 49. A spider 50 provided with a head 51 is attached to valve member 46. A conventional wire line, not shown in the drawing, may be lowered down the drill stem and engaged with head 51 whereupon an upward pull will draw sleeve 46 upwardly and expose side ports 31.

When using the embodiment of Fig. 5 to seal off a formation without removing the string of drill pipe from the borehole, rotation of the drill pipe is stopped and the conventional wire line with engaging member is dropped down the drill stem to engage with head 51 and tension is then taken in the wire line so that sleeve member 46 is moved upwardly to expose side ports 31. Thereupon pressure exerted by the drilling fluid through the drill stem C is increased to cause packer body 36 to expand outwardly and seal with the wall of the hole. It will be understood that the packer 36 will be expanded in

4

this manner since an increase in pressure transmitted down the drill stem will be passed on to the interior of packer 36 before it is transmitted through the eyes of the bit into the annulus of the well to the exterior of packing member 36. After the packer 36 is expanded the formation is fractured. This step in itself is old being disclosed in the prior art, for example, Reissue Patent 23,733. If desired, the sleeve may be held in its up position until a predetermined pressure has been exerted through side ports 31 after which the sleeve may be lowered to seal off side ports 31 and fracturing procedure continued. After the fracturing step is completed, the sleeve 46 may again be raised in its uppermost position and the pressure exerted through the bore of the drill stem allowed to come to equilibrium with the pressure in the annulus to deflate the packer so that its exterior diameter is reduced to the normal diameter of the drill stem. As another alternative, the sleeve 46 is maintained in its upper position throughout the fracturing procedure, then the pressure inside the drill pipe is allowed to come to equilibrium between the annulus and the interior of the drill stem and allows the packer to retract to the normal diameter of the drill stem. In any event, after the packer has been reduced to its initial diameter, the wire line is removed from the drill stem and drilling continued to deepen the borehole. It will be understood that the operation of inflating the packer, fracturing and deflating the packer may be repeated as many times as desired while the hole is being extended so as to fracture selected formations, each formation being fractured when it is adjacent the bottom of the borehole.

Another embodiment of packing means suitable for use as means H, as shown in Figs. 3 and 4, is shown in Fig. 6. In order to simplify the description, parts identical with the parts of Fig. 5 are identified with like reference characters. In the embodiment of Fig. 6 a sleeve valve 60 provided with sealing rings 61 is slidably arranged within valve body 30 and is biased by spring 62 into an upper position and is retained in this upper position by shoulder 63. The lower end of spring 62 is maintained in position by shoulder 64. Sleeve valve 60 is provided with side ports 65 in which are mounted check valves 66 which allow flow from side ports 31 of body 30 through ports 65 into the central passage but prevent flow in opposite direction. The upper end of valve body 60 is provided with a tapered seat 67. In normal drilling operations, the minimum flow area of the passage through body 30 is the interior diameter of valve sleeve 60. However, when it is desired to expand packer 36, an assembly J is dropped down the well. The assembly J consists of a body 68 having a tapered seat 69 which cooperates with tapered seat 67 of valve body 60 to make a fluid tight seal. Body 68 is provided with a central passage 70 which is sealed by valve member 71 which in turn is biased upwardly against a valve seat formed by member 60 by spring 72. A head 73 for engaging with a wire line is provided. When assembly J seats in the position shown in the drawing and hydrostatic pressure thereafter exerted down through the drill stem, the first action obtained is simultaneous movement of valve sleeve 60 and assembly J downwardly until side ports 31 are exposed whereupon packer 36 is expanded. At this point the operator may proceed with the formation fracturing step and after it is completed may remove assembly J by means of a wire line. The valves 66 allow packer sleeve 36 to retract to the normal diameter when valve sleeve 60 is in its upper position. As another alternative after the packer has been expanded and before the fracturing step, a wire line may be run through the drill stem to remove assembly J after which the fracturing step is carried out and subsequent to the fracturing step the pressure within the drill stem is equalized with that in the annulus and when this occurs pressure is released from the interior of the packer sleeve 36 through side ports 31 and valve 66

5

so that the packer 36 assumes its normal diameter thereupon drilling may be resumed to deepen the hole.

Another embodiment of a packing means suitable for use as means H in Figs. 3 and 4 is shown in Fig. 7 in which parts identical to the parts of the embodiments of Figs. 5 and 6 are designated by identical reference characters. In the embodiment of Fig. 7, body 30' is provided with spaced side ports 80 and 81. Telescoping valve body members 82 and 83 are provided with spring 84 arranged to bias these members to an extended position at which time member 82 is engaged with shoulder 85 and member 83 is engaged with shoulder 86 of valve body 30. Members 82 and 83 are provided with sealing means 87 so that when they are in the extended position, as shown in the drawing, member 82 seals side ports 80 and member 83 seals side ports 81. A head 88 for engagement with a wire line is provided with valve member 83. The upper end of valve member 82 is provided with a tapered seat 89 for engagement with a corresponding tapered seat of member K which is adapted to be dropped down the drill stem and is provided with a head 91 for engagement with a wire line. In the embodiment of Fig. 7, during normal drilling operations member K is not in the drill stem so that drilling fluid may circulate through the central passage of body 30' with the limiting area of flow that of member 83 which carries the wire line engaging head 88.

When using the embodiment of Fig. 7, when packer 36 is to be expanded, member K is dropped down through the drill stem so that it seats on seat 89 of member 82. Thereupon exertion of hydrostatic pressure on member K forces it and member 83 downwardly against the bias of spring 84 until side ports 80 are exposed at which time the fluid pressure expands packer 36. When packer 36 has been expanded as described, a wire line is dropped down through the drill stem and engaged with and used to remove member K and member 83 is biased to its upward position by spring 84 and seals valve ports 80 as member K is withdrawn. At this point since valve ports 80 and 81 are both sealed, the packer remains expanded. The fracture step for fracturing the formation is then carried out with the interior of packer 36 sealed off. After the fracturing procedure has been completed and the fracturing pressure within body 30 has been released

6

the packer 36 is restored to its normal diameter by running a wire line through the drill stem to engage head 88 of valve member 83. An upward pull on the wire line then draws member 83 upwardly and exposes side ports 81. With side ports 101 exposed the pressure of the liquid within packer 36 and that in the bore of the drill stem as that in the annulus are equal and packer 36 retracts to its normal diameter. The wire line is then removed from the drill stem and drilling continued to extend the borehole. It will be understood that this operation may be repeated for as many formations as it is desired to fracture during the drilling operation without removal of the drill stem when performing the fracturing procedures.

While specific embodiments of packing means suitable for carrying out the present invention have been described, it will be understood that other means may be used if desired.

The present invention having been fully described and illustrated, what is desired to be secured by Letters Patent is:

A method for drilling and treating a borehole employing a downwardly movable drill string comprising the steps of drilling through a first productive formation, ceasing said drilling, sealing off the annulus between the drill string and a part of said first formation to establish a first isolated zone, exerting sufficient fluid pressure in said first zone while maintaining said drill string therein to fracture said first formation, releasing fluid pressure from said first zone, unsealing said first zone, drilling through a second productive formation, ceasing said drilling, sealing off the annulus between the drill string and a part of said second formation to establish a second isolated zone, exerting sufficient fluid pressure in said second zone while maintaining said drill string therein to fracture said second formation, releasing fluid pressure from said second zone and unsealing said second zone.

#### References Cited in the file of this patent

##### UNITED STATES PATENTS

|           |           |               |
|-----------|-----------|---------------|
| 2,642,142 | Clark     | June 16, 1953 |
| 2,663,545 | Grable    | Dec. 22, 1953 |
| 2,693,854 | Abendroth | Nov. 9, 1954  |