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FRACTURING FORMATIONS SELECTIVELY

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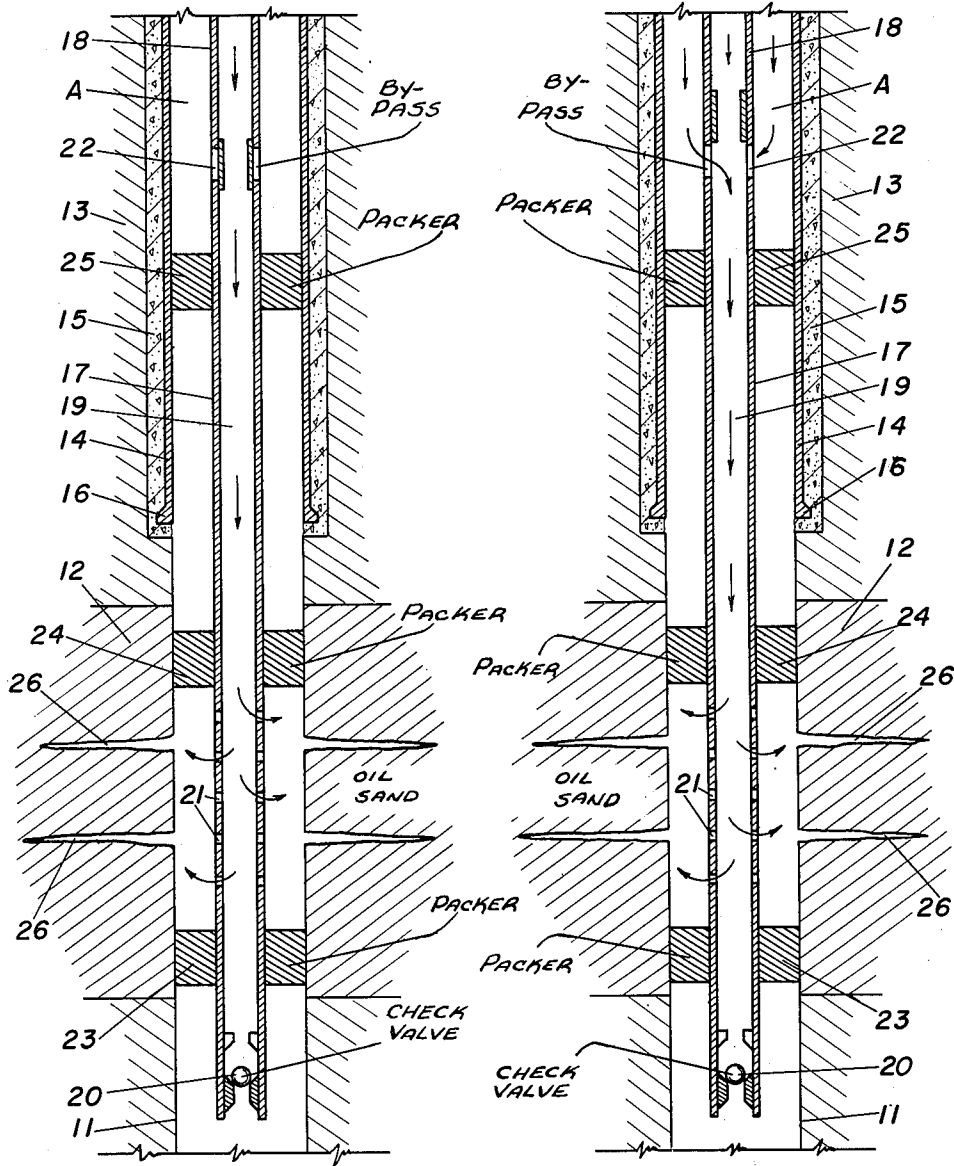


Fig. 1.

Fig. 2

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4 Claims. (Cl. 166—42)

The present invention has to do with a method and apparatus for fracturing formations. More particularly, it has to do with a method and apparatus for fracturing a selected zone in a formation from which a fluid is to be produced. In its more specific aspects, the invention has to do with a method and apparatus which allows fracturing of a selected zone in a producing formation to be conducted at a rate above that heretofore obtainable.

The invention has to do with apparatus which comprises, in combination, an elongated tubular member having a continuous internal passageway. The elongated tubular member is adapted to be connected at an upper end to a pipe string and is provided with a plurality of ports adjacent a lower end thereof communicating the passageway with an outer surface of the member. A first valve means is arranged in the member below the ports for closing off the passageway from flow introduced downwardly in the continuous passageway. A first packer is arranged below said ports on the member and a second packer is arranged on the member above said ports adapted to isolate said ports in a selected zone when the packers are set. A third packer is arranged on the member a substantial distance from the second packer adapted when set to prevent fluid flow from above said third packer to above said second packer and to prevent pressure from being exerted on a region in a well bore between the second and third packers. A by-pass valve means is arranged above the third packer communicating, when open, the internal passageway with an outer surface of the member and is adapted to allow flow of fluid from above said third packer exteriorly to said tubular member to the internal passageway and then outwardly from the tubular member.

The present invention has also to do with a method for fracturing a formation traversed by a well which involves the steps of isolating a zone in the formation and then flowing a fracturing fluid at a pressure in excess of the breakdown pressure of the formation to the formation to fracture same and then increasing the flow of fractured fluid delivered to the formation to an extent that the fracturing of the formation is accomplished at a rate above that normally obtainable heretofore.

The fracturing fluid employed in the present invention may suitably be an aqueous or oily medium which contains a material, such as sand or finely divided granular material and the like, which when the formation is fractured will serve to maintain the fractures open. In short, the granular material or sand in the fracturing liquid will serve to prop the fractures open. The fracturing liquid including finely divided solid particles, such as has been described, may be prepared by adding a heavy substance to a liquid hydrocarbon such as crude or refined petroleum fractions. The heavy substance may be a colloid or a metallic soap of organic acids or olefinic polymers of high molecular weight such as polypropylene as well as natural or synthetic rubber, resinous bodies and the like. These materials may be formed into a gel and

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applied as the fracturing liquid or, as stated before, the fracturing liquid may suitably be a suspension of sand in an oily or aqueous medium. The so-called gel acids containing a suitable propping agent, as the solid particles may be termed, may be employed. French Patent 987,352, granted April 11, 1951, describes at some length liquids and/or fluids which may suitably be employed in the practice of the present invention for fracturing formations.

The invention will be further described by reference to the drawing in which Fig. 1 illustrates a preferred apparatus for practicing the invention and showing the by-pass valve closed; and Fig. 2 is a view similar to Fig. 1 but with the by-pass valve open.

Referring now to the drawing, numeral 11 designates a well which has been drilled into a producing formation such as oil formation 12 which is covered by overburden 13. The borehole 11 is cased to a point above formation 12 with a casing 14 which is sheathed by cement sheath 15 as is well known. Casing 14 is provided with a casing seat 16. Arranged within the casing 14 is a tubular member 17 which is connected at an upper end to a pipe string 18 and which, in turn, is suspended from the well head, not shown. The tubular member 17 is provided with a continuous internal passageway 19 for flow of fluids therethrough and is closed off at a lower end by a ball check valve 20 or a similar valve means which will allow flow of fluid upwardly through the passageway 19 but which will resist flow in a downward direction. Adjacent the lower end of the tubular member 17 is a plurality of ports 21 which communicate the passageway 19 with an outer surface of member 17. Adjacent an upper end of the tubular member 17 is a by-pass valve means 22 which serves when open to allow communication with an annulus A between the casing 14 and passageway 19 of the tubular member 17. The tubular member 17 carries a first packer 23 which is arranged below the ports 21 and a second packer 24 which is arranged above the ports 21 and serve to enclose the ports when the packers are set. Arranged adjacent an upper end of the tubular member 17 but below the by-pass valve means 22 is a third packer 25 which serves to allow pressure to be exerted only on the area of the borehole 11 isolated by the packers 23 and 24.

The apparatus of the present invention is employed in the following manner: It is desired to form fractures in oil formation 12 which is a low permeability formation at a selected point; such fractures will increase the permeability of the formation and allow production to be had from the formation 12. The casing 14 is seated as shown in step 1 of the drawing on the casing seat 16 and sheathed in cement to prevent fluids from proceeding up through the space between the well bore and the outer surface of the casing. The tubular member attached to a pipe string is then run into the well 11 and may be provided with packers 23, 24 and 25. Packers 23 and 24 are arranged respectively below and above the ports 21 and are set, by means of a wire line or other means well known to the art such as setting down weight to shear a pin and the like, allowing a selected portion of the formation 12 to be isolated. A third packer 25 either carried by the tubular member 19 or run on a wire line is set in the casing above the packer 24; thus with packers 23 and 24 set and packer 25 set in the casing fluid may be injected only in that portion of the formation enclosed by the lower two packers 23 and 24. Hydraulic pressure is then exerted on the formation 12 by pumping a fracturing fluid such as one of the type described down the passageway 19 and through the ports 21 at a pressure sufficient to cause the formation of fractures 26 in the formation 12. Breakdown pressure of

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any given formation may be easily determined and a pressure in excess of the breakdown pressure is exerted on the formation through the hydraulic fluid or fracturing fluid, as it may be termed, introduced through the passageway 19. Since a large percentage of the available horsepower for fracturing a given formation is consumed in flowing the fluid through the tubing of pipe string it is desirable to reduce the amount of pump horsepower required. Thus it has been the practice heretofore while fracturing to pump down the annulus A and pasageway 19 but this is only possible in operations where the entire producing interval is open to the fracturing fluid and where the break-down pressure sufficient to crack the formation and lift the overburden can be safely imposed on the casing. In my invention an amount of pressure is imposed on the hydraulic fluid through passageway 19 sufficient to permit initial fracturing of the formation 12. Thereafter, as shown in step 2 of the drawing, immediately after the fractures 26 have been formed the by-pass valve 22 is opened allowing flow from the annulus A to the fracture 26 permitting fluid to be delivered at higher rates with a lower consumption of horsepower. Stating this otherwise, an increased volume of fluid is made available to fractures 26 of formation 12 by pumping down both the annulus A and the passageway 19 and diverting the flow from the annulus A into the passageway 19 at a point immediately above the packer 25. In short without increasing the pressure to a point where it might rupture the casing 14 it is possible to increase the volume and/or the velocity of flow of the fracturing liquid to an extent that a higher rate of fracturing is obtained with consumption of less horsepower than was obtainable heretofore. Thus, in accordance with the present invention a sufficient amount of pressure is initially exerted on the isolated zone enclosed between packers 23 and 24 sufficient to fracture the formation 12 and thereafter an increased flow of liquid is delivered to the formation 12 into fracture 26 by opening up the annulus A to the passageway 19 at a point just above the packer 25.

After the fractures 26 have been formed, as described, the fracturing liquid may be removed from the fractures 26 or flushed therefrom from formation 12 and production had up the passageway 19 through the member 17 and pipe string 18, by-pass valve 22 being closed, as desired, by a wire line or by setting down weight on the pipe string 18 and other well known means for manipulation of such valves.

For a description of the by-pass valves and packers employed in the present invention reference may be had to the Composite Catalogue of Oil Field and Pipe Line Equipment, vols 1 and 2, 1951.

The nature and objects of the present invention having been completely described and illustrated, what I wish to claim as new and useful and to secure by Letters Patent is:

1. Apparatus for fracturing formations which comprises, in combination, an elongated tubular member having a continuous internal passageway, adapted to be connected at an upper end to a pipe string, provided with a plurality of ports adjacent a lower end thereof communicating the passageway with an outer surface of the member, first valve means for closing off said passageway arranged in said member below said ports, a first

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packer arranged on said member below said ports and a second packer arranged on said member above said ports adapted to isolate said ports in a selected zone when set, a third packer arranged on said member a substantial distance above the second packer adapted when set to prevent fluid flow from above said third packer to above said second packer, and a second valve means arranged in said member above said third packer communicating, when open, said internal passageway with an outer surface of said member and adapted to allow flow of fluid from the exterior of said tubular member above said third packer into said tubular member and thence through said ports between said first and second packers.

2. Apparatus for fracturing formations which comprises, in combination, an elongated tubular member having a continuous internal passageway, adapted to be connected at an upper end to a pipe string, provided with a plurality of ports adjacent a lower end thereof communicating the passageway with an outer surface of the member, a ball check valve in said member for closing off said passageway arranged below said ports, a first packer arranged on said member below said ports and a second packer arranged on said member above said ports adapted to isolate said ports in a selected zone when set, a third packer arranged on said member a substantial distance above the second packer adapted when set to prevent fluid flow from above said third packer to above said second packer, and a valve means arranged in said member above said third packer communicating, when open, said internal passageway with an outer surface of said member and adapted to allow flow of fluid from the exterior of said tubular member above said third packer into said tubular member and thence through said ports between said first and second packers.

3. A method for fracturing a formation traversed by a well having a casing with a tubing arranged in the casing in which the casing is exposed to pressure of fracturing fluid without exceeding rupturing pressure of the casing which comprises isolating a zone in said formation to be fractured, pumping a fracturing fluid to said zone down the tubing at a pressure in excess of the breakdown pressure of the formation to fracture said formation, continuing the pumping of fracturing fluid down the tubing to the fractured formation, pumping fracturing fluid down the annulus between the casing and tubing, and then commingling the fracturing fluid being pumped down the tubing and the casing annulus in said tubing at a point adjacent said zone to increase the flow of fracturing fluid to said fractured formation.

4. A method in accordance with claim 3 in which the commingled fracturing fluid increases the rate of fluid pumped to said fractured formation.

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