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J. E. ECKEL ET AL

2,224,538

METHOD AND APPARATUS FOR GRAVEL-PACKING WELLS

Filed June 2, 1939

2 Sheets-Sheet 1

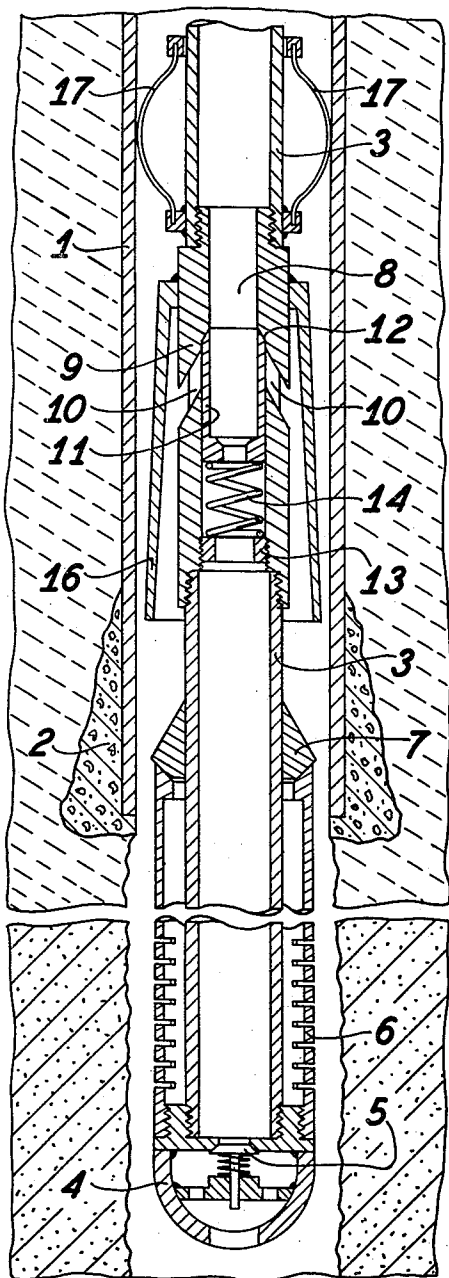


FIG. 1

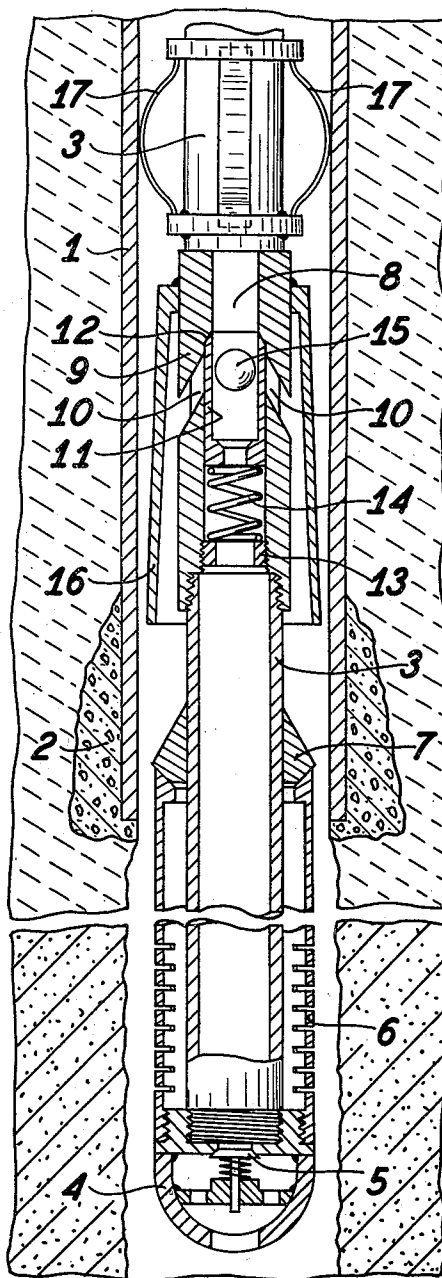


FIG. 2

John E. Eckel INVENTOR.
BY Carl E. Reistle Jr.
P. L. Young ATTORNEY.

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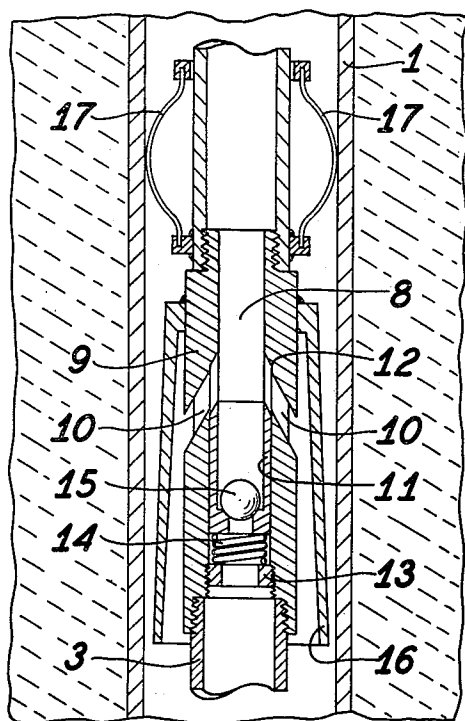


FIG. 3

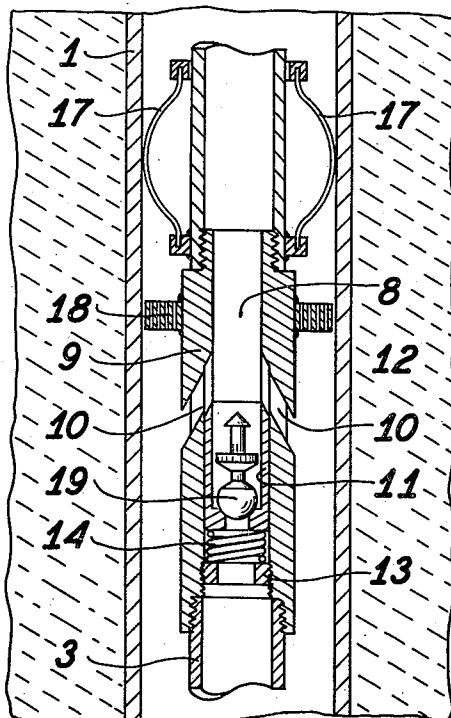


FIG. 4

John E. Eckel^{INVENTOR.}
BY Carl E. Reistle Jr.
P. L. Young^{ATTORNEY.}

UNITED STATES PATENT OFFICE

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METHOD AND APPARATUS FOR GRAVEL-
PACKING WELLSJohn E. Eckel and Carl E. Reistle, Jr., Houston,
Tex., assignors to Standard Oil Development
Company, a corporation of Delaware

Application June 2, 1939, Serial No. 276,940

11 Claims. (Cl. 166—21)

The present invention relates to a process and apparatus for forming a cavity in a bore hole and for placing gravel or like material into the cavity formed.

It is known to the art to set a screen into the production zone of a well, to form a cavity around the screen and to fill the cavity with gravel. The hereinafter described invention is an improved method for washing out a cavity and placing gravel in the cavity around the screen and apparatus for carrying out the above described improvement.

More specifically, the invention involves fitting tubing with a valve, a screen and a setshoe, the valve containing side ports and being located in the tubing at a point above the screen and setshoe. The tubing fitted as above described is then lowered into a bore hole until the screen is at a producing level. A wash liquid is then forced down the tubing and out through an aperture in the setshoe into the bore hole. The wash liquid passes upwardly around the strainer, and since it has a relatively high velocity it washes solids loose from around the strainer, and as it flows upwardly in the space between the casing and the side of the hole, it carries the entrained solids which have been washed loose. We call this the method of washing by normal circulation. In this washing step not only a portion of the producing formation, but also drilling mud and other matter which may have been deposited in the hole during the drilling is removed to form a cavity.

When a cavity of suitable size has been formed by washing, the valve in the tubing is opened by dropping a ball or plunger down the tubing, and then liquid carrying entrained gravel is forced down the tubing and out the opened side ports of the valve and into the previously formed cavity. The velocity of the liquid is diminished and its direction of flow is changed as it passes into the cavity, and the reduction in velocity and change in direction of flow of the liquid allows the entrained gravel to settle to the desired position in the cavity.

The invention involves the above described procedure for washing out a cavity and placing gravel therein, apparatus for carrying out the washing out and graveling operation, and a valve operated by means of a drop ball or plunger which is adapted to be used in carrying out the above described procedure.

Further objects and advantages of the present invention will appear from the following description of the accompanying drawings in which:

Fig. 1 is a vertical sectional view through a

casing in a bore hole in which a tubing equipped with a valve, screen and setshoe has been lowered. The valve is shown in its closed position;

Fig. 2 is a view of the apparatus shown in Fig. 1 showing a plunger being dropped down the tubing to operate the valve in the tubing;

Fig. 3 is a cut showing the valve illustrated in Figs. 1 and 2 after the plunger has struck the inner sleeve of the valve and has caused it to open; and

Fig. 4 is a cut similar to Fig. 3 and shows modifications of the apparatus illustrated in the preceding figure.

In Fig. 1, numeral 1 designates a casing set in a bore hole and numeral 2 designates a conventional cement plug at the bottom of the casing. Lowered into the casing is tubing 3 at the bottom of which is attached setshoe 4 containing back pressure valve 5. Attached to setshoe 4 is screen 6, the top opening of which is closed by shoulder 7 which is attached to the tubing. At a point in the tubing above the screen is a valve 8 which is formed as follows:

An outside sleeve 9 containing ports 10 is fitted with an inside sleeve 11 which fits slidably in outside sleeve 9 and operates to open and close the side ports 10 of the valve. Outside sleeve 9 contains a projection or shoulder 12 at a point above ports 10 to control the upward movement of inside sleeve 11. The downward movement of inside sleeve 11 is controlled by the upper portion of member 13 which is attached to outside sleeve 9 by screw threads and by coil spring 14 which is supported by member 13 and which acts to keep inside sleeve 11 in its uppermost position. Attached to the tubing at a point above valve 8 is a projection 16 and a centering guide 17.

The apparatus is used in the following manner: After the casing is cemented in the well in the conventional manner, the apparatus is assembled with the tubing 3 attached to setshoe 4 by left hand threads or other suitable releasing means. Outside the tubing and attached to the upper end of the setshoe is screen 6, the top of the opening between the screen and the tubing being closed by shoulder 7 which keeps materials from falling through the opening as the apparatus is lowered into the well. The above described valve 8 is attached in the tubing at some point above the screen, and centering guides 17 are attached to the tubing above the valve. The apparatus is then lowered at the end of a string of tubing into a bore hole until the shoe rests on the bottom of the hole with the screen at a producing level. A wash liquid which, may, for ex-

ample, be oil or water, depending upon the varying circumstances, as is well known in the art, is then pumped into the tubing string and passes out of the back pressure valve 5 of the setshoe and into the bottom of the hole. The wash liquid washes sand and like material out of the bottom of the hole and up out of the hole between the tubing and the casing, thus forming a cavity in the producing zone.

- 10 After a sufficiently large cavity has been formed, ball 15 is dropped into the upper end of the tubing and falls through the tubing as shown by Fig. 2. The ball falls through the outside sleeve 9 and strikes the inside sleeve 11 closing off the 15 bottom of sleeve 11 and the liquid pressure above it causes sleeve 11 to compress spring 14, moving the sleeve downwardly and opening the valve, as shown in Fig. 3. Liquid carrying entrained gravel is now pumped down through the tubing 20 and out through open ports 10 into the cavity which has been previously formed. Projection 16 causes material passing out through ports 10 to make a sharp change in direction, in order to pass upwardly between the tubing and casing. 25 As liquid containing gravel passes into the cavity, the reduced velocity of the liquid as well as its changed direction causes the gravel to drop down into the bottom of the hole and allows the liquid to pass upwardly between the tubing and the casing and out of the hole. When the cavity is filled with gravel, which is evidenced by a sharp rise of liquid pressure in the tubing, the graveling is discontinued and the tubing is released from the setshoe and raised upwardly to allow the liquid 35 flowing from the producing strata through the deposited gravel into the screen to enter the bottom of the tubing and flow upwardly therethrough. The flow of liquid in this direction opens the valve and allows the liquid to be removed from the producing zone of the well.

- 40 The modification shown in Fig. 4 shows a strainer 18 substituted for the projection 16 of Fig. 1. This strainer acts to reduce the velocity of the liquid flowing upwardly between the tubing and the casing and assures that gravel will not pass upwardly with the liquid. In Fig. 4 is also shown a closure 19 which may be substituted for the ball 15 shown in Figs. 1, 2 and 3. While, as above disclosed, liquid passes upwardly through the tubing 3 while the well is producing it may on some occasions be advantageous to remove the closure from the tubing. In such cases, the element 19 shown in Fig. 4 may be substituted for the ball 15 in closing the valve. This element 55 may be readily withdrawn from the tubing by means of a fishing tool attached to a wire line. Such fishing tools are well known to the art. It is evident that other valve closures besides the two modifications shown in the drawings may be used.

- 60 Manifestly, other means for causing the above described valve to open may be employed. For example, a shear pin may be used to hold the valve in a closed position, such a size of pin 65 being selected that, when the plunger is dropped down the tubing and strikes the valve, the pin shears and allows the valve to open. Similarly, trigger arrangements may be employed which allow the valve to open when the plunger dropped 70 down the tubing strikes the valve.

- As a modification of the above-described procedure the cavity in the producing formation may be formed by underreaming and the cavity may then be washed out and gravel deposited 75 therein. The step of underreaming in a bore

hole is well known to the art and when used in the above described procedure, is carried out in the conventional manner. When this procedure is employed, the washing step is used principally for washing off from the face of the producing formation the layer of mud formed thereon during the underreaming step.

Obviously, the specific embodiments described above are merely illustrative of the present invention which is not limited thereto, but only 10 by the appended claims in which it is intended to claim the present invention as broadly as the prior art permits.

We claim:

1. Apparatus for application to a well comprising, in combination, a tubular screen, a setshoe attached to the lower end of said screen, and a string of tubing adapted to be lowered into the screen and attached to the setshoe, said tubing being fitted with a valve at a point above the screen which may be opened at will and, when opened, causes a discharge from the sides of the tubing at a point above the screen. 15
2. Apparatus for placing gravel at a producing level of a well comprising tubing fitted with a valve provided with side ports, the valve operating to open the side ports when a plunger dropped down the tubing strikes the valve. 25
3. Apparatus for washing a cavity around a tubular screen set at a producing level and for depositing gravel in the cavity comprising a setshoe containing a backpressure valve attached to the lower end of the screen, tubing fitting inside the screen and attached to the setshoe, said tubing being fitted with a valve containing side ports at a point above the screen which operates to open said side ports when a plunger is dropped down the tubing and strikes the valve. 35
4. A process for washing out a cavity around a screen set at a producing level of a bore hole and for depositing gravel in the cavity comprising the steps of lowering tubing fitted with a screen and a setshoe containing a backpressure valve into a bore hole, forcing liquid out of the tubing at a point below the screen to wash out a cavity, closing off the tubing at a point above the screen and at the same time opening ports located in the tubing at a point above the screen and forcing gravel into the tubing and out through said ports into the cavity, the general direction of travel of the gravel being opposite that of the material removed in forming the cavity. 40
5. A process as in claim 4 in which both drilling mud and producing formation is removed in washing out the cavity. 55
6. A valve adapted for use in the lower end of a string of tubing in washing and graveling a bore hole comprising an outside sleeve having its interior fitted with a shoulder and containing ports in its walls, an inside sleeve fitting inside the outside sleeve and moving slidably therein, the sleeve and ports being so arranged that, when the inside sleeve rests against the shoulder of the outside sleeve, it closes the ports, and when it slides away from this position, it opens the ports, a member attached to the outside sleeve adapted to retain a spring fitting inside the outside sleeve in the space between the member and the inside sleeve, and a member adapted to slide freely in the outside sleeve to open the side ports of the valve when it strikes the inside sleeve. 65
7. A process comprising the steps of setting a screen in a bore hole, forcing liquid into the 75

bore hole at a point below the screen and washing material up around the screen and out of the bore hole, thus forming a cavity around the screen, then forcing gravel into the bore hole at a point above the screen so that it drops into the cavity around the screen.

8. A valve adapted for use in the lower end of a string of tubing in washing and graveling a bore hole comprising an outside sleeve containing ports, an inside sleeve fitting slidably inside the outside sleeve, and means to retain the inside sleeve in such a relation with the outside sleeve as to keep the ports closed until the pressure in the tubing reaches a predetermined amount, and to allow the inside sleeve to uncover the ports when the pressure in the tubing reaches said predetermined amount.

9. A method of completing a well comprising the steps of placing a screen at the bottom of a bore hole, establishing liquid circulation out through an opening in the bottom of said screen and upwardly around said screen to form a cavity and remove foreign matter from around the screen, then diverting circulation above said screen to introduce and deposit gravel around said screen, then stopping the circulation of liquid downwardly into the bore hole and allowing liquid from the formation adjacent the cavity to flow through said gravel and screen and upwardly through said bore hole to the surface of the earth.

10. A method of completing a well wherein all of the operations are performed by control from the surface requiring only an initial trip in the hole comprising the steps of lowering into a bore hole a screen attached to a string of pipe, said

pipe being provided at a point above said screen with a valve having side ports, placing the screen at the bottom of the bore hole, establishing fluid circulation down through said pipe and screen and up around the screen to form a cavity and remove foreign matter from around said screen, closing said valve above the screen and diverting circulation through the side ports and introducing and depositing gravel around said screen, then closing said side ports and opening said valve to permit fluid from the formation to flow through said gravel, screen and valve upwardly through said pipe to the surface.

11. A valve controllable from the surface adapted for use in a string of tubing in a bore hole comprising an outside sleeve having its interior fitted with a shoulder and containing ports in its walls, an inside sleeve fitting inside the outside sleeve and moving slidably therein, the sleeve and ports being so arranged that, when the inside sleeve rests against the shoulder of the outside sleeve, it closes the ports, and when it slides away from this position, it opens the ports, a member attached to the outside sleeve adapted to retain a spring fitting inside the outside sleeve in the space between the member and the inside sleeve, and a member adapted to slide freely in the outside sleeve and to open the side ports of the valve when it strikes the inside sleeve, said member being placed within said tubing at the surface and positioned within said inside sleeve by the force of gravity and fluid pressure within the tubing.

JOHN E. ECKEL.
C. E. REISTLE, JR.