

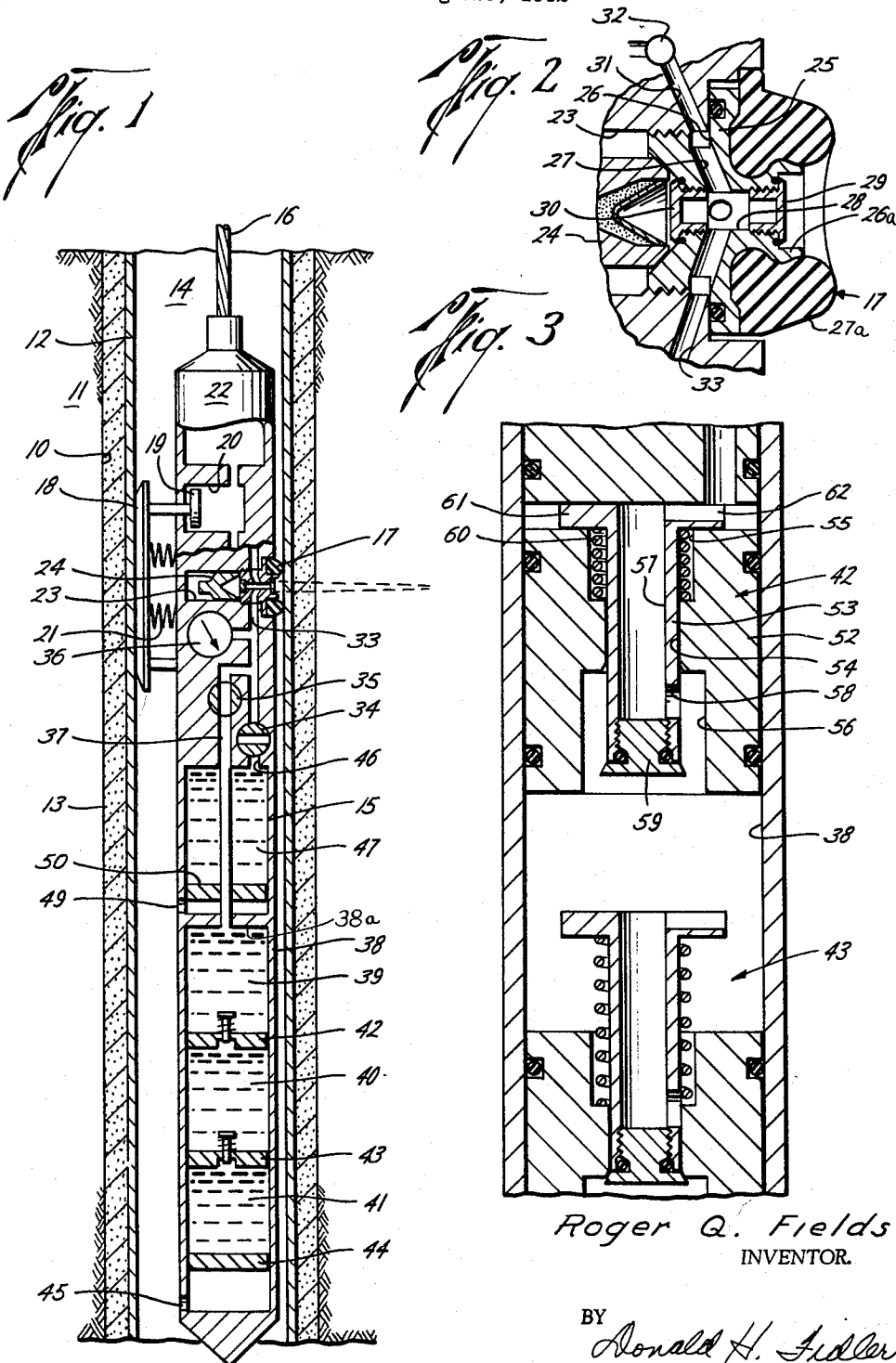
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WELL BORE APPARATUS

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1

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WELL BORE APPARATUS

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This invention relates to apparatus for use in oil wells, and, more particularly, to apparatus for selectively treating earth formations through a perforation.

With new and improved investigating techniques in sub-surface exploration for oil in the oil industry, it has become possible to identify the boundaries of productive formations with considerable accuracy so that, for example, a productive formation with a thickness of, say, 6" may be located and opened for production. It has now been determined that, in certain instances, that only a few good perforations are necessary for economical production. In fact, in many instances, only a single perforation is required to produce the formation. Of course, in extremely thin intervals of formation, there is only space enough for one perforation. A common problem found in many of the oil and gas formations opened by perforations is that the formations are so unconsolidated that, in production, the flowing fluids produce sand; that is, particles of sand from the formations are produced with the fluid. In the well bore, the sand may settle out so as to eventually fill up the well bore or may be carried to the surface with the fluid where its effect on production equipment is quite deleterious.

To solve this problem, treating fluids which consolidate the formation sand have been developed. A typical example of a treating fluid is a thermosetting sand consolidation plastic which contains formalin, a meta-para-cresol mixture and guanidine carbonate. To use such a cementation agent, however, it is desirable to wash the perforation before introducing the cementation agent and following cementation it is desirable to flush the perforation with a washing fluid. To obtain a proper action the fluids should be kept separated from one another.

It is accordingly an object of the present invention to provide new and improved apparatus for use in the introduction of a treating fluid locally to the formation which maintains separation of fluids.

Apparatus, in accordance with the present invention, includes with means for isolating a section of a well bore from borehole fluid and means for perforating the isolated section of the well bore, means for introducing one or more treating agents into the isolated perforation in separated stages. This is accomplished by normally closed separator pistons which are opened in response to discharge of fluid to provide a fluid communication path therethrough.

The novel features of the present invention are set forth with particularity in the appended claims. The present invention, both as to its organization and manner of operation, together with further objects and advantages thereof, may best be understood by way of illustration and example of certain embodiments when taken in conjunction with the accompanying drawings in which:

FIG. 1 is a cross section of a cased borehole wherein the apparatus by which the present invention is practiced is shown schematically in cross section;

FIG. 2 is a view in cross section of the apparatus of the present invention; and

FIG. 3 is a view in cross section of a detail of the apparatus shown in FIG. 1.

Referring now to FIG. 1, a borehole 10 traversing the

2

various earth formations 11 receives a casing 12 which is suitably secured therein by a column of cement 13 between the casing and the borehole. In the casing 12, prior to the production of the well, is a well control fluid 14, such as mud, which is calculated to be at a higher pressure than the pressures expected to result from the opening of the formations to the casing so that the formation fluids are under control at all times.

A well completion tool 15 is adapted to be suspended in the casing by means of a cable 16 spooled on a winch (not shown) in a customary manner. Tool 15 has fluid passage means 17 and a back-off shoe 18 which are positioned on opposite sides of the elongated tool body and arranged to move relative to one another between a contracted and extended position. To accomplish the relative movement, the back-off shoe 18 is connected to piston rods and pistons 19 which are received in hydraulic cylinders 20 (only one being shown in the tool body). Tension springs 21 are provided for facilitating the retraction of the back-off shoe 18 from the wall of the casing 12 toward the tool body at the completion of the operation. An exemplary hydraulic actuating system 22 for the cylinders 20 may be of the type illustrated in the Chambers Patent No. 2,674,313.

In the upper end of the tool, other devices such as radioactivity responsive instruments of various types may be employed to obtain logs of the formations so that the tool assembly may log the formation and, while still in the hole, a productive zone may be located and the perforator employed to open the formations.

As shown in FIGS. 1 and 2, the fluid passage means 17 includes an explosive chamber 23 in which a shaped charge 24 is received. A face plate member 25 (FIG. 2) is received in the explosive chamber 23 to mount the explosive charge 24 therein. The face plate member 25 has a forward bulb-like extension 26a and an annular resilient sealing pad 27a is attached to the face plate about the bulb-like portion 26a. The face plate member 25 has an outer annular groove 26 which is connected by radial bores 27 to a central bore 28. In the central bore 28, to either side of the open ends of bores 27, are frangible closure members 29, 30. The closure member 29 prevents fluids within the central bore 28 and fluids exterior of the housing from intermixing while the closure member 30 prevents fluids in the central bore 28 from coming in contact with the explosive charge 24. A passageway 31 opening to the annular groove 26 of the face plate member is connected to a normally closed valve 32 schematically shown in FIG. 2 which, when opened, admits well fluid to the passageway 31 for purposes which will hereinafter become more fully apparent.

As shown in FIG. 1, another passageway 33 in the tool connects the annular groove 26 of the face plate member 25 to a normally closed valve 34 and a normally open valve 35. A pressure sensing device 36 is connected to passageway 33 for determining pressure in the passageway. Device 36 which is schematically illustrated may be arranged and used in a conventional manner as disclosed in Patent No. 3,011,554. The normally open valve 35 is connected by a centrally located passageway 37 to a fluid treating cylinder 38 which is separated into three chambers 39, 40, 41 by spaced, movable, valve-piston members 42 and 43. The upper chamber, for example, contains a pre-flush fluid such as a saline solution, the intermediate chamber contains a plastic consolidation fluid such as a formaline-cresol mixture while the lower chamber contains an after flush fluid such as kerosene. The lower chamber 41 is formed between the valve-piston member 43 and a solid piston 44, the cylinder 38 below the piston 44 being opened by a port 45 to the well fluid.

In a manner which will hereinafter become more apparent, the well fluid acting on the lower piston 44 exerts pressure on the fluids in the chambers 39-41 which discharges the fluids in the chambers through the passageway 37 into the formations in sequence.

The normally closed valve 34 is connected by a conduit 46 to an annular chamber 47 formed in the cylinder 38 between a cylindrical wall surface of the housing, the tubular passageway 37 and an annular piston 50. Chamber 47, for example, contains a plugging fluid such as "Black Magic" oil base mud as supplied by Oil Base Inc. of Compton, California. At the lower end of the chamber 47, a port 49 is provided below annular piston 50 so that well fluid can act upon the piston 50 and urge the fluid from chamber 47 through conduit 46 whenever valve 34 is open.

Referring now to FIG. 3, the valve-piston members 42 and 43 are illustrated in detail. The valve-piston member 42 is shown in an open position and the valve-piston member 43 is shown in a closed position of operation. A valve-piston member 42 or 43 is comprised of a cylindrically shaped piston element 52 slidably mounted in the cylinder 38 and suitably sealed with respect to the cylinder walls. The piston element 52 has a central bore 54 to receive a valve element 53. Counterbores 55, 56 are in piston element 52 above and below a central bore 54. The valve element 53 is provided with a blind bore 57 having a lower opening 58 above a plugged end 59. The plugged end 59 of valve element 53 has a flanged portion which limits upward movement of the valve element in the piston element and also provides a seal in the bore 54 when engaged therewith. Spring means 60 are provided in the upper counterbore 55 to bear against a flange 61 on the upper end of the valve element 53 and maintain the valve element in its uppermost position in the piston element 52. In this uppermost position, it will be appreciated that the lower opening 58 of the valve element is closed relative to the counterbore 56.

The flange 61 on the valve element 53 is provided with one or more radially extending grooves 62. Hence, when a valve-piston member is moved upwardly, the valve-piston member will be closed until a flange 61 (which is larger than the lower counterbore 56 of a piston member) engages the lower surface of an adjacent piston member (or wall surface) whereupon the piston element 52 is moved relative to the valve element 53 to compress the spring 60 and place the opening 58 into fluid communication with the lower counterbore 56. Fluid communication through the valve-piston member is then established through the lower counterbore 56, the port 58, bore 57 and slots 62 in a flange 61. It will be noted that the piston element is sized so that the operation of one valve element does not interfere with the operation of the next valve element.

In the operation of this device, the tool is lowered to the level of interest and actuated so that the sealing pad 27a of the fluid passage means 17 is urged into sealing contact with the casing. At this time the pre-flush fluid from the upper chamber 39 is present in the space between the closure members 29, 30. Detonation of the shaped charge 24 causes a perforating jet to pass through the fluid and perforate the casing and cement and produce a penetration of the earth formations as indicated by the dotted lines in FIG. 1. By opening the closure member 29, the well fluid (which is at a higher pressure than the formation fluids) moves piston 44 and valve-piston means 43, 42 to immediately supply the pre-flush fluid in chamber 39 to the formations until such time as the first valve-piston member 42 engages an end wall 38a of the cylinder 38. At this time the valve element 53 is operated and the second chamber 40 is discharged through valve-piston member 42 and into the perforation. Subsequently, the contents of the third chamber 41 are discharged through valve-piston members 42, 43 when the valve-piston member 43 is opened. At this time, valve 35 is

closed and valve 34 is opened. The opening of valve 34 permits the plugging fluid in the chamber 47 to be discharged into the perforation. This completes the treating operation of the tool and the hydraulic system is then actuated to relieve the hydraulic pressure on the piston 19 and the valve 32 is opened so that well fluid can enter through the center of the sealing pad and thereby equalize the pressure across the sealing pad for easy retraction of the pad member. The tool may thereafter be retrieved from the well bore.

While particular embodiments of the present invention have been shown and described, it is apparent that changes and modifications may be made without departing from this invention in its broader aspects and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

What is claimed is:

1. Perforating and treating apparatus for use in a well bore comprising: a supporting body adapted to be suspended in a well bore, means on said body to sealingly isolate a section of a well bore; means in said body for perforating the isolated section; treating means in said body, said treating means including a cylinder with end walls, piston means disposed in spaced relation in said cylinder to form separate chambers, each of said chambers adapted to receive a treating fluid, said piston means including a piston having a bore therethrough, a tubular member received in said bore for relative longitudinal movement, said tubular member having a closed end adapted to cooperate with said bore in one longitudinal position to close said bore, resilient means to hold said tubular member in said one longitudinal position, said tubular member having a side port, said tubular member having its remaining end disposed above one side of the piston when said bore is closed, said remaining end being adapted to engage an end wall or another piston means to provide displacement of said tubular member and thereby place said side port into fluid communication with the other side of said piston.

2. Perforating and treating apparatus for use in a well bore comprising: a supporting body adapted to be suspended in a well bore, means on said body to sealingly isolate a section of a well bore; means in said body for perforating the isolated section; treating means in said body, said treating means including a cylinder with end walls, piston means disposed in spaced relation in said cylinder to form separate chambers, each of said chambers adapted to receive a treating fluid, said piston means including a piston having a central bore therethrough and counter bores extending to both sides of said piston, a tubular member received in said central bore for relative longitudinal movement, said tubular member having a closed end adapted to cooperate with said central bore in one longitudinal position to close said bore, resilient means in one of said counter bores cooperating with said tubular member to hold said tubular member in said one longitudinal position, said tubular member having a side port, said tubular member having its remaining end disposed above one side of the piston when said central bore is closed, said remaining end being adapted to engage an end wall or another piston means to provide displacement of said tubing member to place said side port into fluid communication with the other of said counter bores.

3. Fluid discharge apparatus for use in a well bore comprising: a supporting body adapted to be suspended in a well bore, sealing means on said body to isolate a section of a well bore, said sealing means having a central port, means coupled to said sealing means including a cylinder with end walls, piston means in said cylinder forming separate chambers, each of said chambers adapted to receive a fluid, said piston means including a piston having a bore therethrough, a tubular member received in said bore for relative longitudinal movement, said tubular

member having a closed end adapted to cooperate with said bore in one longitudinal position to close said bore, said tubular member having a side port, said tubular member having its remaining end disposed above one side of the piston when said bore is closed, said remaining end being adapted to engage an end wall or another piston means to provide displacement of said tubular member and thereby place said side port into fluid communication with the other side of said piston. 5

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