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DROPPABLE TOOL FOR INJECTING FLUID

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Fig. 1.

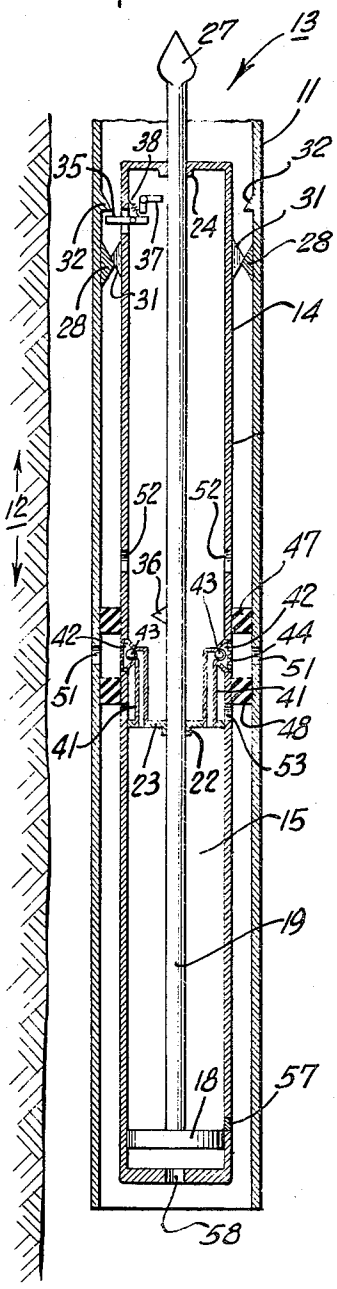


Fig. 2.

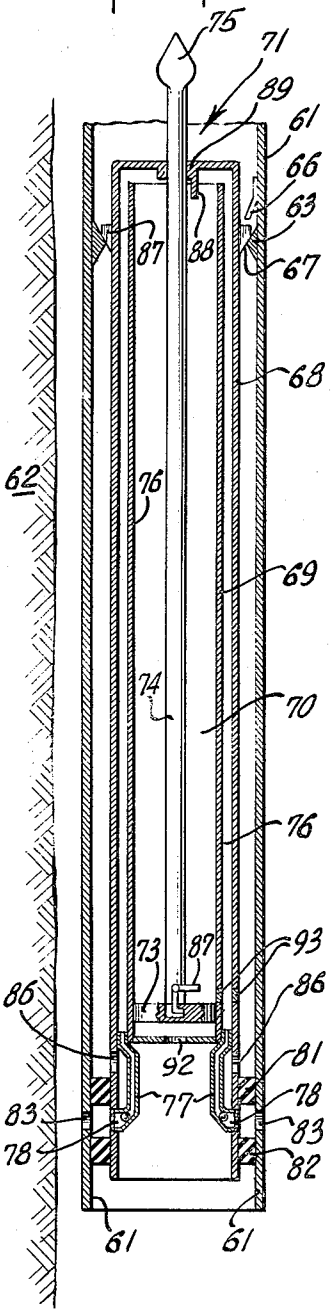
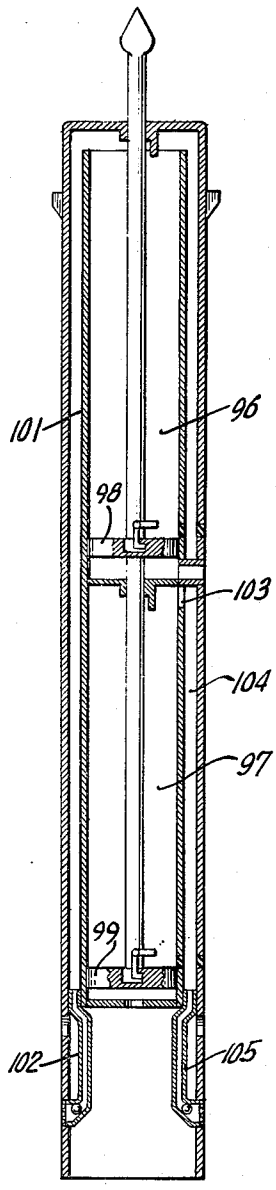


Fig. 3.



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DROPPABLE TOOL FOR INJECTING FLUIDS

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This invention concerns a tool for use in deep well operations. More specifically, the tool according to this invention is for use in operations involving the injection of a fluid at predetermined locations downhole.

While various tools are known that provide for releasing fluids contained therein within a well, none of these is adaptable for dropping into the well and thereafter ejecting a quantity of fluid at a location as fixed by the position of tubing within the well. Thus, a tool according to this invention is adaptable for use in many operations including an improved manner of injecting a particular fluid into a given location downhole during or after the time when an injectivity profile survey is being run. The improvement involved in the use of a tool according to this invention, includes the benefits of eliminating one string of tubing and reducing the quantity of particular fluid needed. These benefits being those which accrue over the prior situation where a known arrangement is employed to inject a third fluid between the upper and lower streams of an ordinary injectivity profile or similar procedure.

Consequently, it is an object of this invention to provide an improved tool for use in various procedures involving introduction of a particular fluid at a given location in a deep well.

Briefly, the invention concerns a dropable tool for injecting fluid in deep wells wherein tubing is employed. Such tool comprises in combination an elongated tool body having landing stop means on the exterior thereof for cooperative engagement with complementary stop means in said tubing. The tool also comprises catch means for holding said tool in place when landed in said tubing and a cylindrical chamber for containing said fluid. The tool also comprises a piston in said chamber for displacing said fluid from said chamber, and a piston rod for moving said piston in said chamber, the said piston rod extending out the top of said tool body and having an enlargement at the extremity thereof for engagement by an overshot. Finally, the tool also comprises a passageway for directing displaced fluid to a predetermined location relative to said tool body, and comprises a latch for releasing at least a part of said tool from said landed position for withdrawal up the well.

The foregoing and other objects and benefits of the invention will be more fully appreciated in connection with the detailed description which follows and that is illustrated in the drawings, wherein:

FIGURE 1 is a schematic illustration of a tool according to the invention, as seated in tubing that is employed therewith;

FIGURE 2 is another schematic illustration, which shows a modification of the tool according to the invention also illustrating the tubing structure associated therewith; and

FIGURE 3 is similarly a schematic illustration, showing still another embodiment or modification of a tool according to the invention but omitting the tubing that would be employed therewith.

Referring to FIGURE 1, it is pointed out that the illustration indicates a portion of a tubing string **11** that is situated downhole in a bore hole having side walls **12** (shown on left side of the figure only) that it is desired to treat by injection of a fluid at some particular location vertically therealong. The location might be determined

in various ways (or by combinations thereof) e.g. by having run an injectivity log or various types of density logs, etc. Then when the fluid is to be injected, it may be directed to the desired location by setting up a two stream injection with the interface between streams situated at the location. With the injection streams thus situated the tubing **11** (and tool therein) is vertically adjusted so that the point of release of the fluid to be injected is opposite the location, i.e. at the interface between injection streams. Consequently, when the fluid is released it is confined between the injection streams.

Within the tubing string **11** there is shown a tool **13**, according to the invention. It is generally elongated in shape and includes a tool body **14** that has a chamber **15** at the lower portion thereof. Chamber **15** is cylindrical in shape and there is situated therein a piston **18** that has attached thereto a piston rod **19**. Piston rod **19** passes through a packing gland **22** situated in an upper wall **23** of the chamber **15**. The piston rod **19** extends all the way through the tool and out of the upper end thereof through a guide **24**. At the upper extremity (when in a vertical position as illustrated) of the piston rod, there is an enlargement **27** that is shaped for receiving an overshot (not shown) in order to be able to cause the fluid to be displaced, as will appear more fully below.

The tool **13** has an outside diameter such that it may free fall within the tubing **11** and thus insertion of the tool may be carried out after the tubing string has been made up in the hole, by dropping the tool within the tubing. When the tool reaches that portion of tubing string **11** (usually near the lower end thereof) which contains a landing stop shoulder **28**, a plurality of stop lugs **31** that are located on the outside of body **14**, will come in contact with stop shoulder **28** of the tubing and arrest the tool **13** at this position within the tubing.

The landed position (which is illustrated in FIGURE 1) of the tool **13** brings into play a latch structure that will act to hold the tool in place against any upward movement within the tubing. This latch arrangement may take the form schematically illustrated which includes a shoulder **32** located on the inner surface of tubing **11**, spaced slightly above the shoulder **28**. Shoulder **32** has a horizontal lower surface (when tubing **11** is vertical as shown) and a tapered upper surface so that as the tool body **14** reaches its landed position, a pivoted latch arm **35** will pivot when it comes in contact with shoulder **32** and then will fall into place below the shoulder so as to hold the tool **14** against upward movement until released. The release of the pivoted arm **35** is effected by the action created as a finger **36** (that is attached to the piston rod **19**) comes into contact with a pivoted lever arrangement **37** which will release the arm **35** so that a spring **38** may act to pivot the arm and thus release the restraining effect of arm **35** relative to shoulder **32**. It will be observed that this releasing action does not take place until after the piston rod **19** has been drawn upward sufficiently to raise the piston **18** substantially to the top of chamber **15**. Consequently, substantially all of the fluid which was contained in chamber **15** will have been displaced.

As the piston **18** is raised for displacing fluid contained in the chamber **15**, this fluid is forced out through a plurality of tubes **41** that connect the upper wall **23** of the chamber **15** with a corresponding plurality of guarded openings or ports **42**. The fluid thus flows out through the walls of tool **14** at a plurality of circumferentially spaced points located approximately midway of the length of the tool body **14**. In conjunction with the ports **42**, there are a corresponding plurality of check valves **43** that may take any feasible form and are illustrated as each having a ball contained within the tapered portion of the corre-

sponding port 42, while there is a screen 44 or other structure for retaining the ball therein. Such screen 44 is located across the mouth of each of the ports 42.

It will be observed that when the tool 14 is in its landed position there are packers 47 and 48 located above and below the longitudinal location of the ports 42 (on the tool 14) but which packers are carried by the inner walls of the tubing string 11. These packers act to confine the fluid flowing out of ports 42 on the tool 14, to a predetermined longitudinal location along the tubing string 11. At this location there are a ring of openings or perforations 51 through the walls of the tubing, in between the packers. Consequently, as fluid is ejected from the chamber 15 it is directed through the perforations 51 of the tubing 11, and thus is injected into the bore hole at a predetermined depth therein depending upon the positioning of tubing 11 relative to the bore hole walls.

In order to provide for flow of fluid within tubing 11 past the tool 13, even when the tool is landed for injecting fluid through the tubing perforations, there is a by-pass provided. This includes by-pass openings 52 through the body 14 of the tool and situated somewhat above the ports 42 (when the tool is upright as illustrated) sufficiently to be higher than the upper packer 47, when the tool is landed in the tubing 11. Fluid from the annulus between the tool 13 and the walls of tubing 11 may then pass in through openings 52 and around the tubes 41 to again pass out through a ring of additional openings 53 that are located through the body 14 of the tool, just above upper wall 23 of the chamber 15. It will be noted that openings 53 are also arranged longitudinally along the tool 13 relative to the stop lugs 31 so that the location of the openings is below the lower packer 48 when the tool is landed. Furthermore, it will be observed that passage for fluid flow past the stop shoulder 28 is provided by having lugs 31 spaced apart peripherally around the body 14 of the tool.

In order to fill the chamber 15 with fluid that is to be injected downhole, there is a valve structure 57 that might take various forms. In the form illustrated it is intended to indicate it as being constructed of soft material, e.g. rubber, inserted in an opening through the body 14 of the tool. The rubber insert has an opening therein (not shown) which is normally squeezed shut, but through which a hollow needle or the like may be injected for providing entrance of the fluid that is to be placed within the chamber 15.

At the lower end of the tool body 14 there is an opening 58 through the bottom wall, that is provided to allow well fluid to enter as the piston 18 is moved upward so as to avoid any back pressure on the piston.

It is to be noted that the illustrated elements of a tool according to the invention, that have been so far described, are all schematically shown. Consequently, any feasible structure which would provide for the indicated actions and mechanical inter-relations involved could be employed. Thus, there is no invention in any of the mechanical details per se, but rather in a combination of elements which have been indicated schematically.

Referring to FIGURE 2, it is pointed out that this illustrates a different embodiment of the invention that may be employed for providing a greater volume of fluid to be injected as well as for injecting fluid close to the lower end of the tubing string. In this modification there is a tubing string 61 that is shown downhole beside bore hole walls 62. The tubing string 61 contains an annular shoulder 63 within the tubing, which shoulder acts as a stop in the same manner as did shoulder 28 in the FIGURE 1 modification. In this instance there is a spring catch element 66, situated slightly above the shoulder 63, with the free end of the catch downward. This arrangement provides for passage of a plurality of lugs 67 by depressing the free end of the catch 66 when in contact

therewith. The lugs 67 are attached to the outside of a body 68 of tool 71. The body 68 is in general similar to the body 14 of the FIGURE 1 modification.

Within the tool body 68, there is a concentric sleeve 69 that forms the walls of a fluid chamber 70 which has a piston 73 therein. Releasably attached to piston 73, there is a piston rod 74 that extends upward through the top of the tool body 68 and terminates in an enlarged member 75 that is similar to the enlargement 27 of the FIGURE 1 modification.

It will be observed that the fluid contained in chamber 70 will flow (when displaced by movement of piston 73) through an annular passage 76 located between sleeve 69 and the tool body 68. At the lower end of this annular passage 76, there are a plurality of tubes 77 to carry the fluid out through a ring of ports 78 that are substantially the same as the ports 42 of the FIGURE 1 modification. In addition, there are check valve structures in connection with each of the ports 78, for preventing any back flow of well fluids as the tool is being dropped into place.

There are a pair of packers 81 and 82 carried on the inside of the tubing 61, and situated on either side of a ring of perforations or holes 83 through the tubing. The latter are for permitting passage through the walls of tubing 61 of the fluid to be injected into the borehole. It will be noted that these packers (81 and 82) are located further down the tubing string 61 relative to stop shoulder 63, as compared with location of packers and stop shoulder in the FIGURE 1 modification. In the structure of this modification (FIGURE 2) the flow of fluid to be injected will pass through the tubing close to the lower extremity thereof.

In this modification (FIGURE 2) the by-pass structure includes a ring of openings 86 through the body 68 of the tool 71. These are in general near the lower end of the body 68 but are sufficiently spaced from the end to be located above the packer 81, when the tool is landed. In this case fluid may flow around the seated tool 71 from the annular space between body 68 and the tubing 61, past the packers 81 and 82, by flowing through openings 86 and around the tubes 77 thence out of lower open end of tool body 68.

The release arrangement in FIGURE 2 is such that only the piston rod 74 is freed, after the fluid in chamber 70 has been substantially all forced out by movement of the piston 73 to the top of the chamber. Such release is accomplished by providing a latching pivoted lever arrangement 87 that is carried on the piston rod 74. The latch holds the piston 73 attached to the rod 74 until the trip arm portion of arrangement 87 contacts a lug 88 that extends downward from a packing gland 89 which is carried by the top of the tool body 68. The indicated contact between the lug 88 and tripping lever structure 87, will release the catch and permit piston rod 74 to be withdrawn uphole by the overshot (not shown) that is attached to the free end of a wire line. The tool body 68 and other elements are left downhole, and may be removed from the tubing after it has been withdrawn.

In this modification there is an opening 92 in the bottom wall of chamber 70 which allows well fluid to enter below piston 73 and prevent back pressure thereon. Also, it is to be noted that there are a pair of valve elements 93 located in the walls of tool body 68 and in the concentric sleeve 69 so as to permit filling of the chamber 70 in a similar manner as was described above for filling chamber 15 of the FIGURE 1 modification.

Referring to FIGURE 3, it is to be observed that a modification of the tool is illustrated which provides for simultaneous injection into the formation of at least two fluids, if desired. In this instance, the tubing is not illustrated but only the tool structure alone. It will be understood that the tubing elements are substantially the same as those illustrated in FIGURE 2. Furthermore, since most of the elements of the FIGURE 3 modification are the same as the corresponding elements of the FIGURE 2

modification, only the elements which are different need be described here.

The fluid chamber is divided into two portions so that there is an upper chamber **96** and a lower chamber **97**, each having a piston **98** and **99** respectively, therein. Also, it will be noted that the passageway or fluid as it is displaced from chambers **96** and **97** is divided into two separate paths, one for each chamber. The fluid from chamber **96** passes out through tubes **102** via an annular passageway **101**, while the fluid from chamber **97** passes through an opening **103** in the concentric sleeve wall of the chamber **97** to a separated semiannular passage **104**. The passage **104** is connected to one or more tubes **105** for directing the fluid from chamber **97** out of the discharge ports.

It will be clear that many different arrangements and modifications may be made by any one skilled in the art without departing from the principles involved in this invention. Thus for example, it might be desirable to modify this tool for reversing the flow of fluid with respect to the fluid containing chambers, so that the tool would act as a downhole fluid sampler. Furthermore, it is pointed out that a tool according to this invention may have various applications and may be useful in different methods without change in the principles of structure of the tool itself.

While certain embodiments of the invention have been described in accordance with the applicable statutes, this is not to be taken as in any way limiting the invention, but merely as being descriptive thereof.

I claim:

1. A droppable tool for injecting fluid in deep wells wherein tubing is employed, comprising in combination an elongated tool body having landing stop means on the exterior thereof for cooperative engagement with complementary stop means in said tubing, catch means for holding said tool in place when landed in said tubing, a cylindrical chamber means for containing said fluid, a piston slidably movable in said chamber means, a piston rod attached to said piston for moving said piston in said chamber means, said piston rod extending out the top of said tool body and having an enlargement at the extremity thereof for engagement by an overshot, passageway means connected to said cylindrical chamber means for directing the displaced fluid to a predetermined location relative to said tool body, means for confining said displaced fluid to a predetermined longitudinal location in the annulus between said tubing and said tool and including openings in said tubing for causing injection of said fluid into the bore hole at such location, fluid by-pass means for providing a path around said confining means to permit circulation of fluid freely through said annulus, and latch means for releasing at least part of said tool from said landed position for withdrawal up the well.

2. The invention according to claim **1** wherein said confining means comprises packers in said tubing located above and below perforations in the tubing at said predetermined location.

3. The invention according to claim **2** wherein said fluid by-pass means comprises openings through said tool body situated above and below the upper and lower extremities of said packers when the tool is landed in the tubing.

4. The invention according to claim **1** wherein said latch means includes means for leasing the entire tool from the landed position.

5. The invention according to claim **4** wherein said latch means comprises a finger on said piston rod for engaging said catch means after said piston has displaced the fluid.

6. The invention according to claim **5** wherein said catch means comprises a shoulder on said tubing and a trippable latch on said tool body for cooperation with the shoulder.

7. The invention according to claim **1** wherein said latch means includes means for releasing only said piston rod leaving the remainder of the tool for removal when the tubing is pulled.

8. The invention according to claim **7** wherein said latch means comprises a trippable latch carried by said piston rod, and a trip lug on said tool body.

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