Sept. 20, 1966 F. H. K. REYNOLDS, JR 3,273,659

WELL SAMPLING AND TREATING TOOL

Filed Aug. 19, 1963 3 Sheets-Sheet 1

FIG. 1.

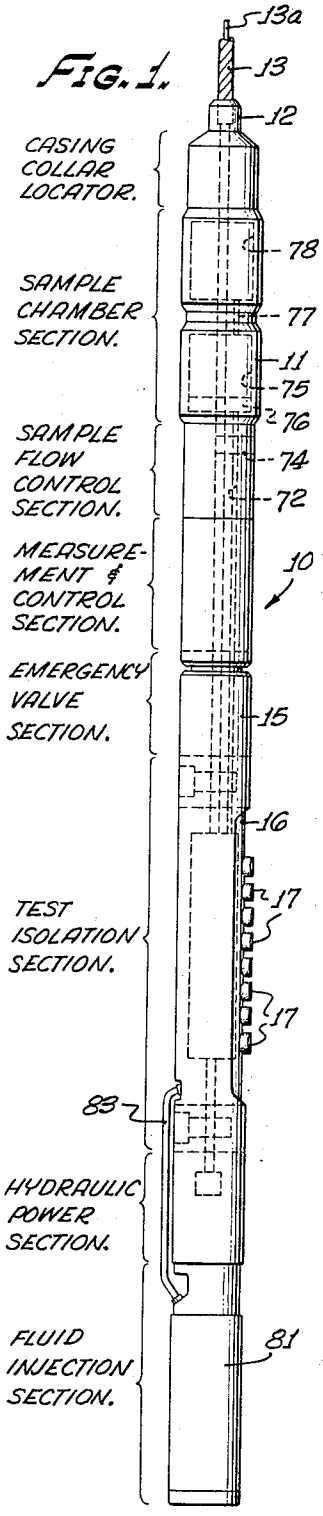


FIG. 2a.

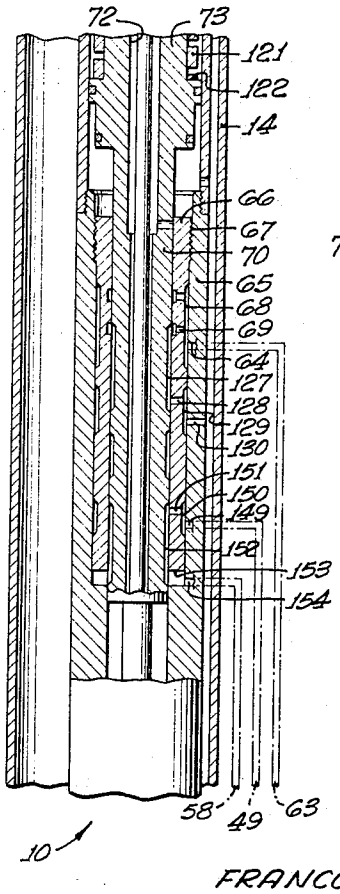
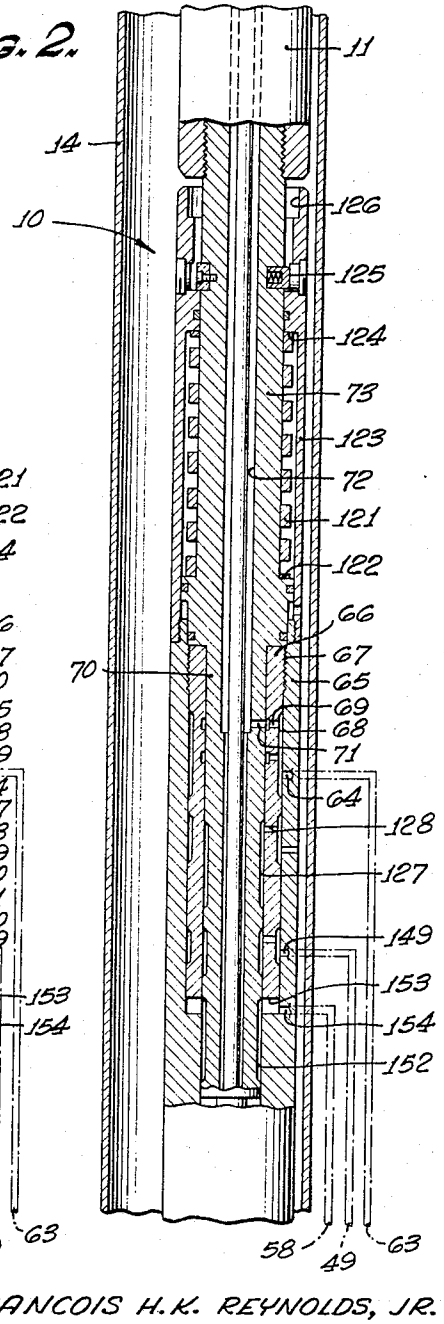


FIG. 2.



FRANCOIS H.K. REYNOLDS, JR.
INVENTOR.

BY Lyon & Lyon
ATTORNEYS.

Sept. 20, 1966 F. H. K. REYNOLDS, JR 3,273,659

WELL SAMPLING AND TREATING TOOL

Filed Aug. 19, 1963 3 Sheets-Sheet 2

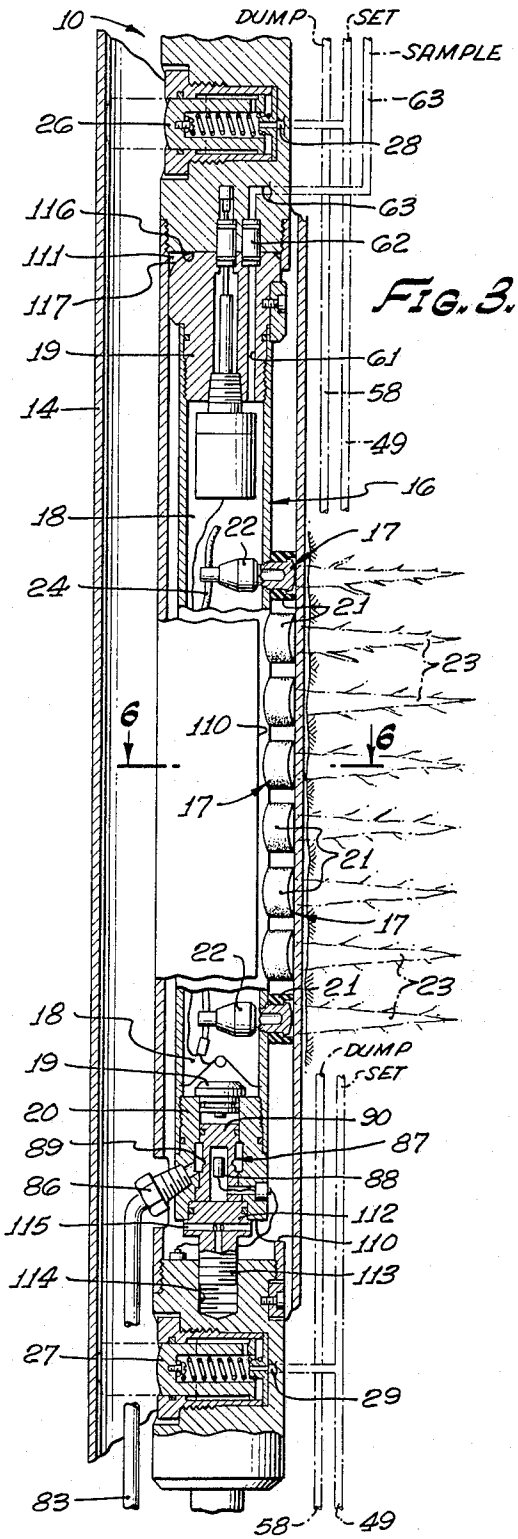


FIG. 3.

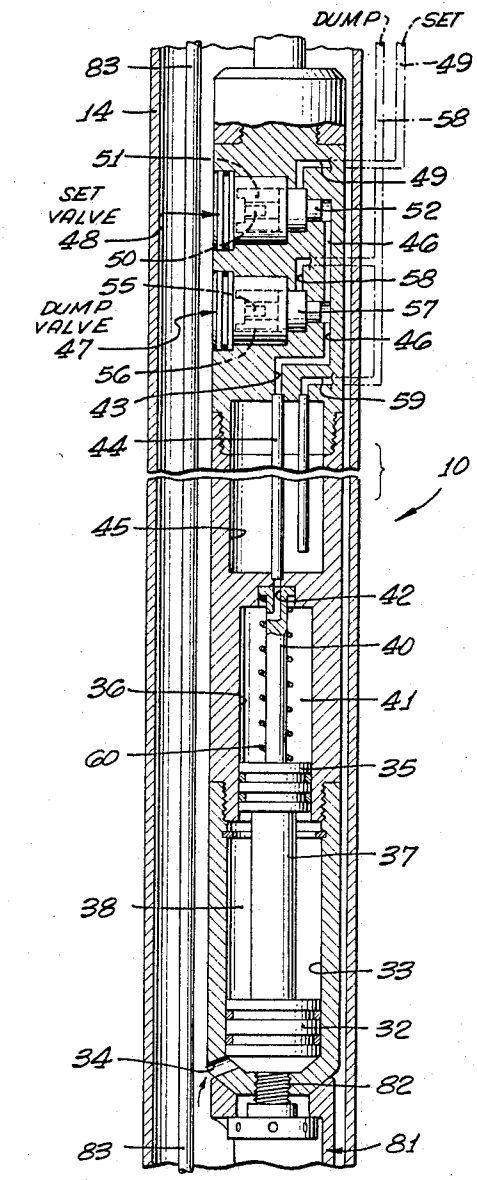


FIG. 4.

FRANCOIS H.K. REYNOLDS, JR.
INVENTOR.

BY Lyon & Lyon
ATTORNEYS.

Sept. 20, 1966 F. H. K. REYNOLDS, JR 3,273,659

WELL SAMPLING AND TREATING TOOL

Filed Aug. 19, 1963 3 Sheets-Sheet 3

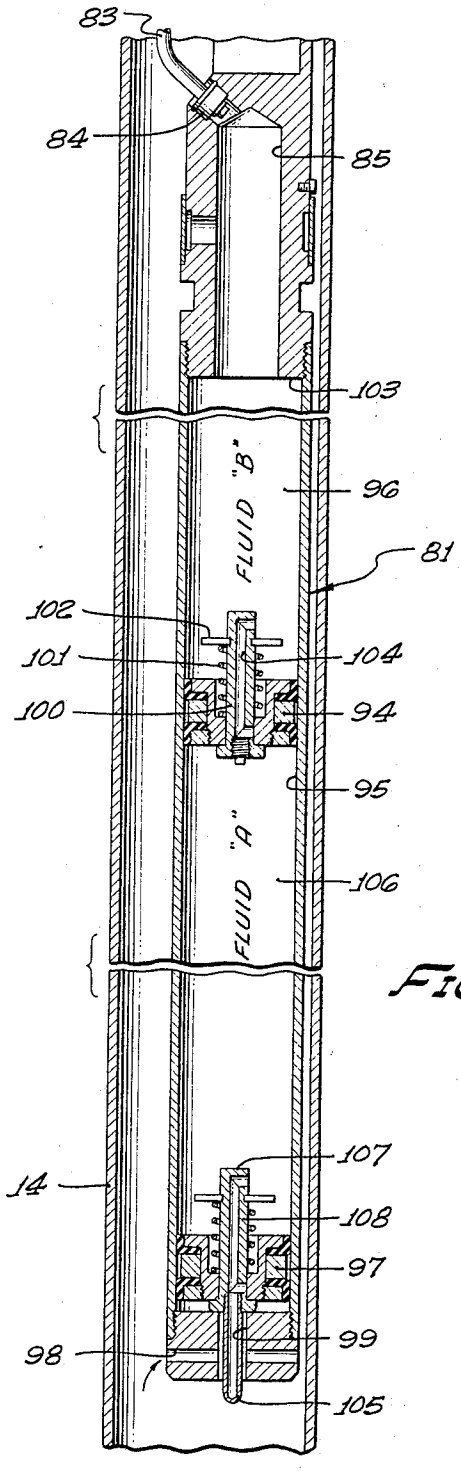


FIG. 5.

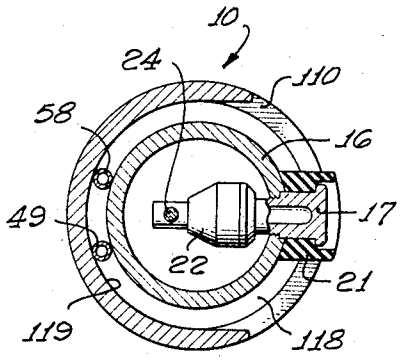


FIG. 6.

FRANCOIS H. K. REYNOLDS, JR.
INVENTOR.

BY Lyon & Lyon

ATTORNEYS.

United States Patent Office 3,273,659 Patented Sept. 20, 1966

3,273,659

WELL SAMPLING AND TREATING TOOL

Francois H. K. Reynolds, Jr., Houston, Tex., assignor to Halliburton Company, Duncan, Okla., a corporation of Delaware

Filed Aug. 19, 1963, Ser. No. 302,823
12 Claims. (Cl. 175—4)

This invention relates to well tools of the type adapted to be lowered into a well on a wire line, and is particularly directed to improvements in a tool of this general type adapted to operate within the well casing for securing a sample of formation well fluid, and also for injecting well-treating fluids into the formation. Certain features of this invention find particular usefulness in a tool adapted to operate inside a well casing, while other features of this invention are useful in either cased hole or open-hole operations.

It is an important object of this invention to provide a well testing and treating tool of the type described which may be lowered into the well casing on a wire line to perform sequentially the steps of perforating the casing, obtaining a sample of the well-formation fluid, plugging the perforations by means of cement, and freeing the tool from the well casing so that it may be retrieved with its sample of well-formation fluid, by means of the wire line.

It is another important object of this invention to provide a well tool capable of injecting well-treating fluids into the well formation in open-hole operations or through perforations formed in the casing. An example of an important use of the latter capability lies in treating the well formation for sand consolidation by injecting a plastic material, followed by injection of a chemical hardener.

Other and more detailed objects and advantages will appear hereinafter.

In the drawings:

FIGURE 1 is a side elevation in diagrammatic form showing a well tester and treater device embodying this invention.

FIGURE 2 is a sectional elevation of a portion of the device shown in FIGURE 1 and illustrating the emergency valve parts in one position.

FIGURE 2A is a view similar to FIGURE 2, showing the emergency valve parts in another position.

FIGURE 3 is a sectional elevation constituting a continuation of the lower end of FIGURE 2.

FIGURE 4 is a sectional elevation constituting a continuation of the lower end of FIGURE 3.

FIGURE 5 is a sectional elevation constituting a continuation of the lower end of FIGURE 4.

FIGURE 6 is a transverse sectional view taken substantially on the lines 6—6, as shown in FIGURE 3.

Referring to the drawings, the tool body generally designated 10 includes an upper portion 11 having a coupling 12 provided with mechanical and electrical connections for the wire line 13. The tool 10 is lowered into the well casing 14 by means of this wire line 13, and the electrical lead or leads 13A, forming a part of the wire line, are used to operate various electrical devices on the tool as described below. The lower portion 15 of the body 10 supports a barrel member 16 provided with a longitudinal row of fluid sample inlet elements 17 which project laterally from the barrel 16 for contact with the inner surface of the well casing 14.

As shown in FIGURE 3, the barrel member 16 comprises a tubular member having a cavity 18 therein closed by end members 19 and 20. Each of the elements 17 includes a ring pad 21 mounted on the outer surface of the barrel member 16 and shaped to have sealing engagement with the inner surface of the casing 14. Each

of the elements 17 also has an electrically fired jet-charge device 22, adapted to blast a perforation in the wall of the casing and through the cement sheath, mud cake, and into the well formation, as shown at 23. A primer cord 24 connects each of the jet-charge devices 22, so that they may be fired simultaneously. The jet-charge devices 22 are located within the cavity 18 of the barrel member 16, and fluid from the well formation passes through the casing perforations into the cavity 18 after the jet-charge devices 22 are fired.

The fluid sample inlet elements 17 are held in sealing contact with the inner surface of the casing 16 by means of laterally extendible piston elements 26 and 27 located on the body 10 above and below the barrel member 16, and projecting opposite to the direction of projection of the elements 17. The piston elements 26 and 27 are projected laterally to contact the casing 14 when hydraulic fluid under pressure is supplied to their respective inlets 28 and 29.

Hydraulic fluid under pressure for operation of the piston elements 26 and 27 is supplied by the hydraulic intensifier shown in FIGURE 4 and generally designated 31. This device includes a first piston 32 mounted to move in a first bore 33 and subjected to pressure due to hydraulic head of mud fluid in the casing acting on the lower end of piston 32 through port 34 in the body 10. A smaller piston 35 slides in a smaller bore 36 and is fixed to the piston 32 by means of the piston rod 37. The annular space 38 within the bore 33 and around the piston rod 37 is initially filled with a compressible fluid, such as for example air. A stationary post 40 is slidably received within a piston 35, and the piston rod 37. The annular space 41 within the bore 36 and around the post 40 is initially filled with hydraulic fluid, such as oil. When the piston 35 moves upward, the oil is forced through the outlet port 42 and into the conduit designated 43, communicating with the ports 28 and 29 of the hydraulically operated laterally extending piston elements 26 and 27. A part of this conduit 43 is formed by the central pipe extending through the low-pressure dump chamber 45 in the body 10. Another part of this conduit 43 is formed by the passageway 46, which communicates with both the dump valve 47 and the set valve 48. Both of these valves are electrically operated.

So long as the set valve 48 remains closed, no oil can flow from the passageway 46 to the passageway 49 leading to the piston elements 26 and 27, and the pistons 32 and 35 remain in the initial position shown in FIGURE 4. When the set valve 48 is opened by means of an electrical signal sent down the wire line 13, an explosive charge 50 ruptures a frangible sleeve 51 to cause the movable valve part 52 to move to the left, as viewed in FIGURE 4, under the force of the hydraulic fluid in passageway 46, thereby supplying hydraulic fluid under pressure to project the piston elements 26 and 27 into the phantom-line positions shown in FIGURE 3, in contact with the casing 14.

When it is desired to retract the piston elements 26 and 27, an electrical signal is sent down the wire line 13 to fire an explosive charge 55 in the dump valve 47, thereby fracturing a frangible sleeve 56 and to cause the movable valve part 57 to move to the left under the force of the hydraulic fluid in passageway 46. The hydraulic fluid under pressure is then vented through passageway 58 and passage 59 to the low-pressure dump chamber 45, which is initially filled with air at atmospheric pressure. The pistons 32 and 35 move to the end of their upward stroke, and the pressure of the hydraulic fluid in the conduit 43 falls to a very low value. The pressure of the hydraulic head of mud fluid in the interior of the casing 14 then pushes the piston elements 26 and

27 to retracted position, assisted by the action of the internal tension springs 60.

The set valve 48 and dump valve 47 are duplicates and are preferably of the construction shown in the co-pending application of Ernest H. Purfurst, Serial No. 211,980, filed July 24, 1962. While the set passageway 49 and dump passageway 58 are shown in phantom lines outside the boundaries of the body 10, this is for clarity of illustration only and it will be understood that in actual practice such passages are positioned within the other boundaries of the body 10. The electrical connections for operating the dump valve 47 and set valve 48 have been omitted for clarity of illustration.

After the piston elements 26 and 27 have been laterally projected to engage the casing 14 and to move the body 10 laterally to bring the fluid inlet elements 17 into contact with the casing 14, the jet charges 22 are fired to perforate the casing within each of the ring pads 21. Well fluid from the formation then passes through the perforations thus formed into the cavity 18 within the barrel member 16. The formation fluid then passes through the outlet passage 61 in the end member 19 and through the tubular sealing plug 62 and through passageway 63 in the body 10. This passage 63, like the upper ends of passageways 49 and 58, is positioned within the body 10, but for clarity of illustration is illustrated in phantom lines.

As shown in FIGURE 2, the upper end of passage 63 communicates with port 64 in the sleeve 65, forming a part of the body 10. A stationary valve part 66 is fixed to the body sleeve 65 by means of threads 67. An annular groove 68 in the valve part 66 establishes communication between the port 64 in the body sleeve 65 and the port 69 in the stationary valve part 66. The movable valve part 70 is fixed on the upper body portion 11 and has a port 71 communicating with a central bore 72. When the parts are in the position shown in FIGURE 2, the port 69 is aligned with the port 71, so that flow of formation fluid from the passage 63 passes through the aligned ports and into the longitudinal bore 72 in the tubular member 73. This bore 72 is shown diagrammatically in FIGURE 1 and extends through the normally open electrically operated valve 74 to the sample chamber 75. A floating piston 76 in the sample chamber 75 moves upward when well fluid enters the lower end of the sample chamber 75. Upward movement of the floating piston 76 forces clean liquid in the chamber 75 above the piston to pass through the restriction 77 and into the upper chamber 78. When the piston 76 reaches the upper end of its stroke within the sample chamber 75, the electrically operated valve 74 is closed to shut in the formation fluid within the sample chamber 75. The construction and operation of the valve 74 is similar to that described in connection with valves 47 and 48.

Means are provided for plugging the casing perforations with cement, after the sample of well fluid has been received within the sample chamber 75 and shut in by means of the valve 74. As shown in the drawings, the means for plugging the casing perforations with cement include a container 81 attached to the lower end of the body 10 by means of the threaded part 82. A pipe 83 communicates at its lower end through fitting 84 with the interior 85 of the container 81. This pipe 83 is mounted outside the body 10 in the region of the hydraulic intensifier 31, and the upper end of the pipe is connected by fitting 86 to the lower end member 20 of the barrel member 16.

An electrically operated valve 87 is provided in the end member 20 of the barrel member 16. This valve is normally closed to prevent flow into or out of the lower end of the barrel member 16. When it is desired to introduce unset cement or other fluid from the container 81 through the pipe 83 and into the cavity 18 within the barrel member 16, an electrical signal is sent down

the wire line 13 to ignite an explosive charge 88, and this serves to fracture a frangible sleeve 89 to drive the movable valve part 90 into the cavity 18, carrying the plug 91 with it. The cavity 18 within the barrel member 16 is then in communication via the pipe 83 with the upper end of the container 81.

A floating piston 94 is mounted to slide within the cylindrical bore 95 of the container 81, and the chamber 96 above the floating piston 94 is filled with a fluid. In a typical case, the fluid is unset cement and its purpose is to plug the perforations formed in the casing 14 by the jet charge devices 22. When cement is the fluid to be injected, only one floating piston is employed, and hence the floating piston 97 is omitted. The hydrostatic pressure of fluid within the casing 14 enters the interior of the container 81 through ports 98 and 99 and acts on the lower surface of the floating piston 94. Since the pressure due to the hydrostatic head of fluid in the casing is greater than the well-formation pressure existing in the cavity 18, the floating piston 94 moves upward to expel unset cement through the pipe 83 and into the cavity 18 and through the perforations in the casing 14.

Means are provided for equalizing the pressure on opposite sides of the floating piston 94 when it reaches the end of its stroke. As shown on the drawings, this means includes a valve 100, mounted on the floating piston 94 and held in closed position by means of the pressure differential and by means of the spring 101. When the floating piston 94 reaches the upper end of its stroke, the lateral-extending pins 102 on the valve 100 strike the stationary shoulder 103 on the container 81, and further upward movement of the floating piston 94 serves to compress the spring 101 and to open a passageway 104 which equalizes the pressure above and below the floating piston 94. The pressure within the cavity 18 and within the ring pads 21 of the fluid inlet elements 17 is then equal to the pressure corresponding to the hydrostatic head of fluid within the casing 14. The pressure across the fluid inlet elements 17 is thus equalized, thus facilitating subsequent removal of the well tool from sealing contact with the casing, following retraction of the piston elements 26 and 27.

A well tool embodying this invention may be used for injecting well-treating fluids into the well formation in open-hole operations or through the perforations formed in the casing, and without first taking a sample of well fluid. If used within casing, the tool has the form of barrel 16 and fluid inlet seals 17 shown in the drawings. The outlet passage 61 in the end member 19 of the barrel member 16 is plugged. If a single fluid, such as, for example an acidizing fluid, is to be injected through the perforations, a single floating piston 94 is employed in the manner described above. For certain well-treating operations, however, such as injection of well-treating fluid for sand consolidation, it is desirable to inject two separate fluids sequentially. In the latter case, a second floating piston 97 is employed in the same container barrel. A first fluid, for example, liquid plastic material, is placed in the first chamber 96 between the floating piston 94 and the upper end of the container 81. A second fluid, for example a chemical hardener, is placed in the container barrel between the floating pistons 94 and 97. These floating pistons are substantially duplicates, except that the lower one may be provided with an indicator extension 105, projecting through the port 99. When the electrically operated valve 87 is opened, the pressure due to the hydraulic head of fluid in the casing acting over the lower face of the floating piston 97 causes both floating pistons to move upward in the container 81. The well-treating fluid in the chamber 96 passes into the cavity 18 through the pipe 83 and then passes into the well formation through the perforations produced by the jet charges 22. When the floating piston 94 reaches the upper end of its stroke, the pins 102 engage the stationary shoulder 103, thereby opening the

valve passage 104 through the floating piston 94. Continued upward movement of the floating piston 97 then forces well-treating fluid in the lower chamber 106 to pass through the floating piston 94 and to be delivered through pipe 83 into the cavity 18 and into the formation through the casing perforations. When the valve 107 on the lower floating piston 97 engages the lower surface of the valve 100 on the upper floating piston 94, the passage 108 through the lower floating piston 97 equalizes the pressure across the floating piston 97. Since the passages 103 and 104 are both open at that time, the pressure inside the cavity 18 is equalized with the pressure of the hydrostatic head within the casing 14.

If the tool is to be used in open hole for injection of treating fluids into the formation, a different type of inlet fluid seal is preferably used to isolate a section of the well formation. A suitable inlet fluid seal for open-hole operations is shown in the copending application of Brown et al., Serial No. 192,234, filed May 3, 1962, for Formation Fluid Sampler System and Method. The container 81 and floating pistons 94 and 97 operate in the same manner described above.

Means are provided for removable mounting the barrel member 16 on the body 10, and as shown on the drawings this means includes walls forming a lateral window opening 110 on the body 10. The barrel member 16 may be inserted and withdrawn laterally through this opening 110. The upper end of the end member 19 is received within a socket 111, and the lower end is carried on a support member 112, having a threaded stem 113, received within a threaded bore 114 on the body 10. Lateral openings 115 are provided on the member 112 for reception of a tool, not shown, for turning the support member 112 with respect to the body 10. The action of the threads 113, 114 is such as to clamp the barrel member 116 between the support member 112 and the body shoulder 116, forming a part of the stocket 111. The upper portion of the end member 19 is preferably rounded off, as shown at 117, to permit the lower end of the barrel member 16 to be swung laterally through the window opening 110, prior to lowering the barrel member 16 sufficiently to move out of the socket 111. In operative position, the fluid inlet elements 117 project through the lateral opening 110, as shown in FIGURE 6. The set conduit 49 and the dump conduit 58 are mounted in the annular space 118 between the outer surface of the barrel member 16 and the concentric inner wall 119 of the body 10. Electrical conduits for operating the set valve 48 and the dump valve 47 also pass through the annular space 118, but are omitted from the drawings for clarity of illustration.

In the event that the tool body 10 should become stuck in the casing 14 because of electrical failure or any other reason, emergency means are provided for insuring retraction of the piston elements 26 and 27 and of equalizing the pressure across the fluid-inlet elements 17. The emergency valve device shown in FIGURES 2 and 2A serves to accomplish this purpose. The tubular member 73, which carries the movable valve part 70 on its lower end, is attached to the upper body portion 11, which in turn is connected to the wire line 13. A coil spring 121 encircles the tubular member 73 and rests on the shoulder 122 and enclosing sleeve 123 is fixed at its lower end to the member 65 and has a downward facing 124 engaged by the upper end of the coil spring 121. The parts 73 and 123 are thus telescopically mounted, and the weight of the lower body member and all of its parts and attachments are carried on the coil spring 121.

In the event that the well tool should become stuck in the casing, additional tension is placed on the wire line 13, causing the parts 73 and 70 to move upward relative to the parts 123 and 66, compressing the coil spring 121. The spring-urged dogs 125 move outward into the recess 126, to lock the parts in extended telescopic position. The emergency valve parts 70 and 66 are then in the position shown in FIGURE 2A. In this position, the port 64 connected to the sample-fluid passage 63 is vented to the interior of the casing through ports 69, groove 127, port 128, groove 129, and body port 130. At the same time, the upper ends of conduits 49 and 58 are placed in communication through port 149, groove 150, port 151, groove 152, port 153, and port 154.

Venting of the fluid-sample port 64 to the interior of the casing 14 has the effect of equalizing the pressure within the cavity 18 with the pressure within the casing 14, thereby eliminating any pressure drop across the fluid-inlet elements 17. Connecting the upper end of the set conduit 49 with the dump conduit 58 insures retraction of the piston elements 26 and 27, because it reduces the pressure of the hydraulic fluid which actuates them to the very low value of the pressure in the dump chamber 25. This pressure is substantially below that of the hydrostatic head existing in the casing 14, with the result that the pressure of the hydrostatic head forces the piston elements 26 and 27 to retract its position. Continued tension on the wire line 13 then lifts the entire tool out of the casing 14.

In operation, the tool is normally transported to and from location in disassembled portions of convenient weight and length, usually comprising no more than two adjacent sections. These sections are assembled at the well location, and the tool is hoisted into the derrick by means of the wire line 13 extending from a drum on a logging truck. When the tool is suspended just above the floor of the derrick, a number of preliminary steps may be performed. These steps include redressing operations necessitated because of prior sampling or treating operations, for example, replacing the barrel member 16, replacing spent electrically operated explosive valves, and final checking of equipment in electrical calibration check.

The tool 10 is then lowered into the casing 14 by means of the wire line 13. As the tool is being lowered, the pressure of the fluid in the casing increases in proportion to depth, and this increasing pressure applied to the intensifier 31 raises the pressure of the hydraulic fluid in the chamber 41. The hydrostatic pressure in the casing also acts on the floating piston or pistons within the container 81 to pressurize the well-treating fluid or cement therein.

As the tool 10 approaches the desired depth, signals from the conventional casing-collar locater are monitored at the surface, and the proper final depth of the tool is accurately regulated. The set valve 48 is then electrically operated, causing high pressure of oil from the intensifier 31 to project the piston elements 26 and 27 laterally against the casing 14 and thereby move the body 10 in the opposite direction to bring the ring pads 22 of the fluid-inlet element 17 into sealing engagement with the inner surface of the casing 14. The primer cord 24 is then electrically ignited to fire the jet charges 22, causing them to blast perforations through the wall of the casing 14 and into the well formation, thereby establishing a plurality of communication channels between the interior of the barrel member 16 and the well formation. Formation fluid then flows through these communication channels within the fluid-inlet elements into the cavity 18 and through the sample conduit 63 and into the sample chamber 75. Upward movement of the floating piston 76 in the sample chamber 75 is limited by action of the restriction 77, through which cleaning fluid passes from the chamber 75 to the chamber 78. The differential pressure which causes the flow of fluid from the formation is that between the formation-fluid pressure and the pressure within the chamber 78, which is initially atmospheric pressure.

When the sample chamber 75 has been filled, the pressure of sample fluid in the conduit 63 will rise to a value equal to well-formation pressure. Suitable apparatus in the measurement and control section of the tool (not shown) telemeters the pressure reading to the surface,

and this increase in pressure serves as an indicator to show that the sample chamber has been filled. An electrical signal is then transmitted from the surface to close the normally open electrically operated valve **74**, thereby closing in the sample of formation fluid within the sample chambers **75**.

The electrically operated valve **87** is then opened to permit flow of unset cement from the container **81** through the pipe **83** into the interior of the barrel member **16**, and out through the fluid-inlet elements into the perforations in the casing. When the single-floating piston in the container **81** reaches the end of its stroke, the valve within the floating piston opens, equalizing the pressure across the fluid inlet element **17**, and thereby facilitating subsequent removal of the tool from the wall of the casing. The tool remains in position for a time sufficient to permit the cement to harden in the perforations, and then the electrically operated dump valve **47** is opened to dump the high-pressure hydraulic fluid from chamber **41** into the flow-pressure dump chamber **45**. Retraction of the piston elements **26** and **27** ensues by virtue of the differential pressure between the hydrostatic pressure in the casing and the atmospheric pressure initially existing in the dump chamber **45**. The tool may then be withdrawn upwardly by applying tension to the wire line **13**. If the tool should stick in the casing, additional tension in the wire line serves to change the porting of the valve parts **70** and **66**, thereby venting the interior of the barrel **16** to the casing, and connecting the high-pressure set conduit **49** to the low-pressure dump conduit **58**, as described above.

The operation of the tool when used for injecting well-treating fluids into the formation, is similar to that described above, except that no sample of fluid is taken from the formation, and, instead, two or more floating pistons may be employed in the air container **81** to inject different fluids sequentially through the perforations formed in the casing **14**. If desired, the last of the series of fluids so injected may comprise unset cement, in order to plug the perforations in the casing following injection of well-treating fluids into the formation.

Having fully described my invention, it is to be understood that I am not to be limited to the details herein set forth, but that my invention is of the full scope of the appended claims.

I claim:

1. In a well fluid sampling tool adapted to be lowered into a well casing on a wire line, the combination of: a tool body having a lateral opening, the tool body having a sample-receiving chamber, a barrel member insertable into said lateral opening into operative position on the body, releasable means for securing said barrel member to the body, the barrel member being provided with fluid sample inlet elements which project through said lateral opening in the body when the barrel member is secured in operative position, each element having a jet charge for perforating the casing and admitting well fluid through said fluid inlet elements into the interior of said barrel member, conduit means on the body connecting the interior of said barrel member with said sample-receiving chamber, and laterally extendible means on the body adapted to move the body laterally and to hold said fluid inlet elements in contact with the casing.

2. In a well fluid sampling tool adapted to be lowered into a well casing on a wire line, the combination of: a tool body having a lateral opening, the tool body having a sample-receiving chamber, a barrel member insertable into said lateral opening into operative position on the body, releasable means on the body for securing said barrel member thereto, the barrel member being provided with fluid sample inlet elements which project through said lateral opening in the body when the barrel member is secured in operative position, each element having a jet charge for perforating the casing and admitting well fluid through said fluid inlet elements into the

interior of said barrel member, conduit means on the body connecting the interior of said barrel member with said sample-receiving chamber, and a pair of separate laterally extendible elements on the body above and below said barrel member adapted to move the body laterally and to hold said fluid inlet elements in contact with the casing.

3. In a well fluid sampling tool adapted to be lowered into a well casing on a wire line, the combination of: a tool body having a lateral opening, the tool body having a sample-receiving chamber, an elongated barrel member insertable into said lateral opening into operative position on the body, releasable means on the body at one end of the barrel member for securing said barrel member to the body, the barrel member being provided with a longitudinal row of fluid sample inlet elements which project through said lateral opening in the body when the barrel member is secured in operative position, each element having a jet charge for perforating the casing and admitting well fluid through said fluid inlet elements into the interior of said barrel member, conduit means on the body connecting the interior of said barrel member with said sample-receiving chamber, and laterally extendible means on the body above and below said barrel member adapted to move the body laterally and to hold said fluid inlet elements in contact with the casing.

4. In a well fluid sampling tool adapted to be lowered into a well casing on a wire line, the combination of: a tool body having a lateral opening, the tool body having a sample-receiving chamber and having an upper portion provided with mechanical and electrical connections for the wire line, an elongated barrel member insertable into said lateral opening into operative position on the body, releasable means on the body for securing said barrel member thereto, said releasable means including a threaded part on the body engageable with one end of the barrel member to clamp it against the body at the other end of the barrel member, the barrel member being provided with fluid sample inlet elements which project through said lateral opening in the body when the barrel member is secured in operative position, each element having an electrically fired jet charge for perforating the casing and admitting well fluid through said fluid inlet elements into the interior of said barrel member, conduit means on the body connected to the end of the barrel member remote from said threaded part for establishing communication between the interior of said barrel member and said sample-receiving chamber, and laterally extendible means on the body above and below said barrel member adapted to move the body laterally and to hold said fluid inlet elements in contact with the casing.

5. In a well fluid sampling tool adapted to be lowered into a well casing on a wire line, the combination of: a tool body having a sample-receiving chamber, means on the body providing a cavity, the body having a generally cylindrical section with an annular wall and a lateral opening in the annular wall, a barrel member insertable into said lateral opening into operative position on the body, releasable means for securing the barrel member to the body, the barrel member in operative position defining a clearance space within said annular wall, the barrel member having fluid sample inlet elements adapted to contact the casing, each element having a jet charge for perforating the casing and admitting well fluid through said fluid inlet elements into the interior of the barrel member conduit means on the body for establishing communication between the interior of said barrel member and said sample-receiving chamber, laterally extendible means on the body adapted to contact the casing to move the body laterally and to hold said fluid inlet elements in contact with the casing, and hydraulic means including a conduit extending through said clearance space for actuating the laterally extendible means.

6. In a well fluid sampling tool adapted to be lowered into a well casing on a wire line, the combination of: a

tool body having upper and lower portions, the upper portion having mechanical and electrical connections for the wire line and having a sample-receiving chamber therein, the lower body portion having a barrel member provided with fluid sample inlet elements, each element having an electrically fired jet charge for perforating the casing and admitting well fluid through said fluid inlet elements into the interior of said barrel member, conduit means connecting the interior of said barrel member with said sample-receiving chamber, laterally extendible means on the lower body portion adapted to move the body laterally and to hold said fluid inlet elements in contact with the casing, and means for venting the interior of said barrel member to the interior of the casing to equalize the pressure across said fluid inlet elements, said means including valve means on said upper body portion operable upon increase in wire line tension to connect said conduit means to the interior of said casing.

7. In a well fluid sampling tool adapted to be lowered into a well casing on a wire line, the combination of: a tool body having upper and lower portions, the upper portion having mechanical and electrical connections for the wire line and having a sample-receiving chamber therein, the lower body portion having a barrel member provided with fluid sample inlet elements, each element having an electrically fired jet charge for perforating the casing and admitting well fluid through said fluid inlet elements into the interior of said barrel member, conduit means connecting the interior of said barrel member with said sample-receiving chamber, piston means on the lower body portion above and below said barrel member and adapted to extend laterally into contact with the casing to move the body laterally and to hold said fluid inlet elements in contact with the casing, the lower body portion having a high-pressure chamber, means for delivering fluid under pressure from said high-pressure chamber to extend said piston means, means for venting said piston means to said low-pressure chamber, and means for venting the interior of said barrel member to the interior of the casing to equalize the pressure across said fluid inlet elements, said means including valve means on said upper body portion operable upon increase in wire line tension to connect said conduit means to the interior of said casing.

8. In a well fluid sampling tool adapted to be lowered into a well casing on a wire line, the combination of: a tool body having upper and lower portions, the upper portion having mechanical and electrical connections for the wire line and having a sample-receiving chamber therein, the upper portion having a port in a wall thereof communicating with the interior of the casing, the body portions having telescoping parts mounted for limited axial movement, the lower body portion having a barrel member provided with fluid sample inlet elements, each element having an electrically fired jet charge for perforating the casing and admitting well fluid through said fluid inlet elements into the interior of said barrel member, conduit means connecting the interior of said barrel member with said sample-receiving chamber, piston means on the lower body portion above and below said barrel member and adapted to extend laterally into contact with the casing to move the body laterally and to hold said fluid inlet elements in contact with the casing, the lower body portion having a high-pressure chamber and a low-pressure chamber, means for delivering fluid under pressure from said high-pressure chamber to extend said piston means, means for venting said piston means to said low-pressure chamber, and means for venting the interior of said barrel member to the interior of the casing to equalize the pressure across said fluid inlet elements, said means including valve means on said telescoping parts operable upon relative axial movement thereof to connect said conduit means to said port.

9. In a well fluid sampling tool adapted to be lowered into a well casing on a wire line, the combination of: a tool body having upper and lower portions, the upper portion having mechanical and electrical connections for the wire line and having a sample-receiving chamber therein, the upper portion having a port in a wall thereof communicating with the interior of the casing, the body portions having telescoping parts mounted for limited axial movement, the lower body portion having a barrel member provided with fluid sample inlet elements, each element having an electrically fired jet charge for perforating the casing and admitting well fluid through said fluid inlet elements into the interior of said barrel member, conduit means connecting the interior of said barrel member with said sample-receiving chamber, hydraulically actuated piston means on the lower body portion above and below said barrel member and adapted to extend laterally into contact with the casing to move the body laterally and to hold said fluid inlet elements in contact with the casing, the lower body portion having a high-pressure chamber containing hydraulic fluid and a low-pressure chamber containing a compressible fluid, means including a first electrically operated valve for delivering hydraulic fluid under pressure from said high-pressure chamber to actuate said piston means, means including a second electrically operated valve for venting said piston means to said low-pressure chamber, and means for venting the interior of said barrel member to the interior of the casing to equalize the pressure across said fluid inlet elements, said means including valve means on said telescoping parts operable upon relative axial movement thereof to connect said conduit means to said port.

10. In a well fluid sampling tool adapted to be lowered into a well casing on a wire line, the combination of: a tool body having a sample-receiving chamber, the tool body also having means forming a cavity therein, said means having fluid sample inlet elements adapted to contact the casing, each element having a jet charge for perforating the casing to establish communication between the well and said cavity, conduit means extending from said cavity to said sample-receiving chamber, laterally extendible means on the body above and below said cavity adapted to contact the casing to move the body laterally and to hold said elements in contact with the casing, the body having a cylindrical container with a floating piston therein forming a first fluid chamber and a second fluid chamber, passage means including a valve connecting the first fluid chamber to said cavity, means for pressurizing the second fluid chamber, and means on the floating piston for connecting said chambers upon predetermined travel of said floating piston.

11. In a well fluid sampling tool adapted to be lowered into a well casing on a wire line, the combination of: a tool body having a sample-receiving chamber, a barrel member removably mounted on the body and having a cavity therein, said barrel member having fluid sample inlet elements adapted to contact the casing, each element having a jet charge for perforating the casing to establish communication between the well and said cavity, conduit means extending from said cavity to said sample-receiving chamber, laterally extendible means on the body above and below said barrel member adapted to contact the casing to move the body laterally and to hold said elements in contact with the casing, the body having a cylindrical container with a floating piston therein forming a first fluid chamber and a second fluid chamber, passage means including a valve connecting the first fluid chamber to said cavity, means for pressurizing the second fluid chamber, and means on the floating piston for connecting said chambers upon predetermined travel of said floating piston.

12. In a well tool adapted to be lowered into a well casing on a wire line, the combination of: a tool body having means forming a cavity therein, said means having elements adapted to contact the casing, each element having a jet charge for perforating the casing to estab-

lish communication between the well and said cavity, laterally extendible means on the body above and below said cavity adapted to contact the casing to move the body laterally and to hold said elements in contact with the casing, hydraulic pressure generating means on the body below said cavity for actuating said laterally extendible means, the body having a cylindrical container below the hydraulic pressure generating means, said container having a floating piston therein forming a first fluid chamber and a second fluid chamber, passage means including a pipe extending outside the hydraulic pressure generating means and connecting the first fluid chamber to said cavity, a valve controlling flow through said pipe, means for pressurizing the second fluid chamber,

and means for connecting said chambers upon predetermined travel of said floating piston.

References Cited by the Examiner

UNITED STATES PATENTS

2,688,369	9/1954	Broyles	166—100
3,104,712	9/1963	Whitten	166—100
3,115,932	12/1963	Reynolds	166—55.1
3,174,547	3/1965	Fields	166—100

CHARLES E. O'CONNELL, *Primary Examiner.*

J. A. LEPPINK, *Assistant Examiner.*