

Dec. 20, 1960

E. F. BRIEGER ET AL

2,965,176

FORMATION TESTERS

Filed March 5, 1958

4 Sheets-Sheet 1

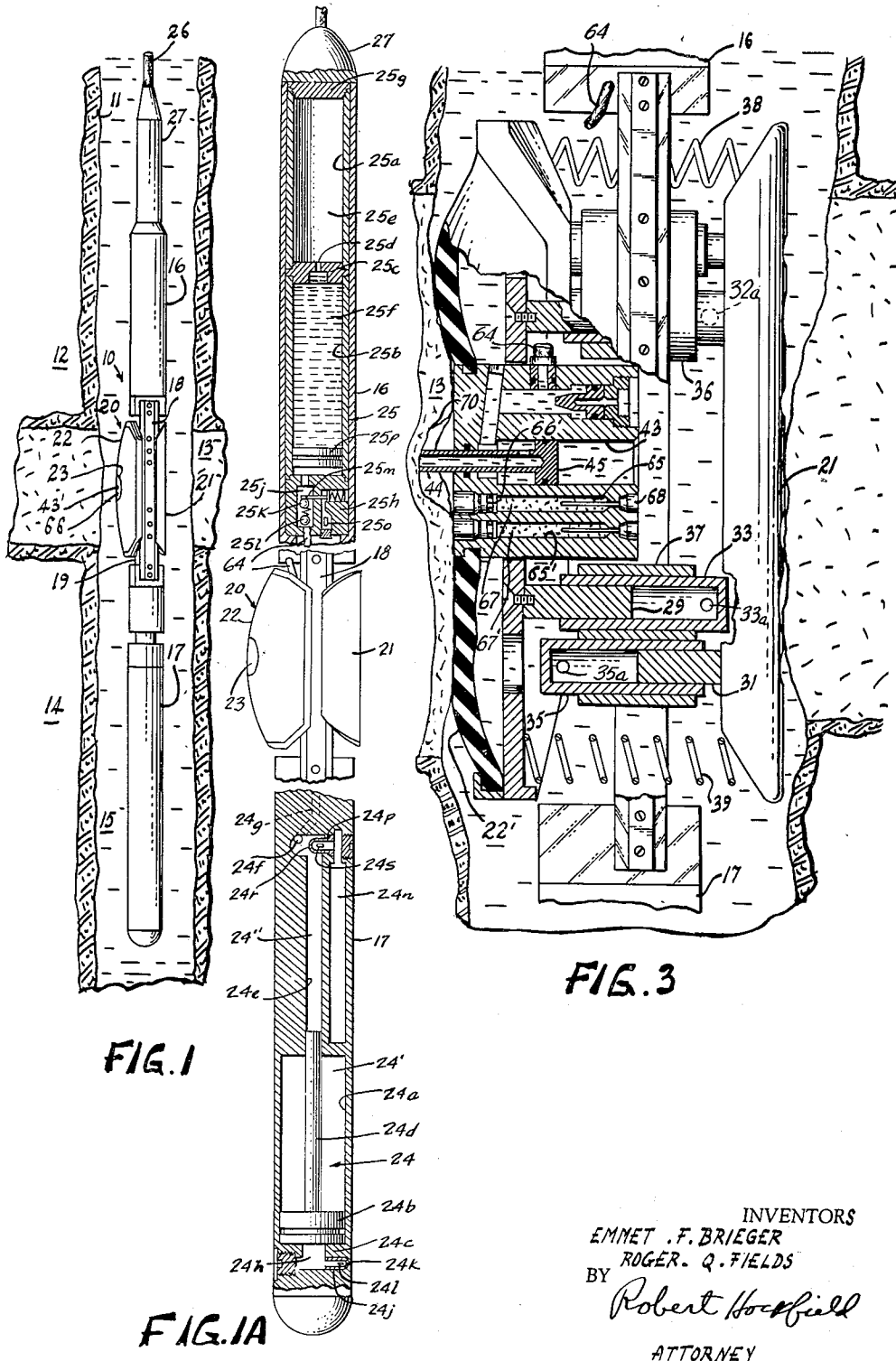


FIG. 3

FIG. 1

FIG. 1A

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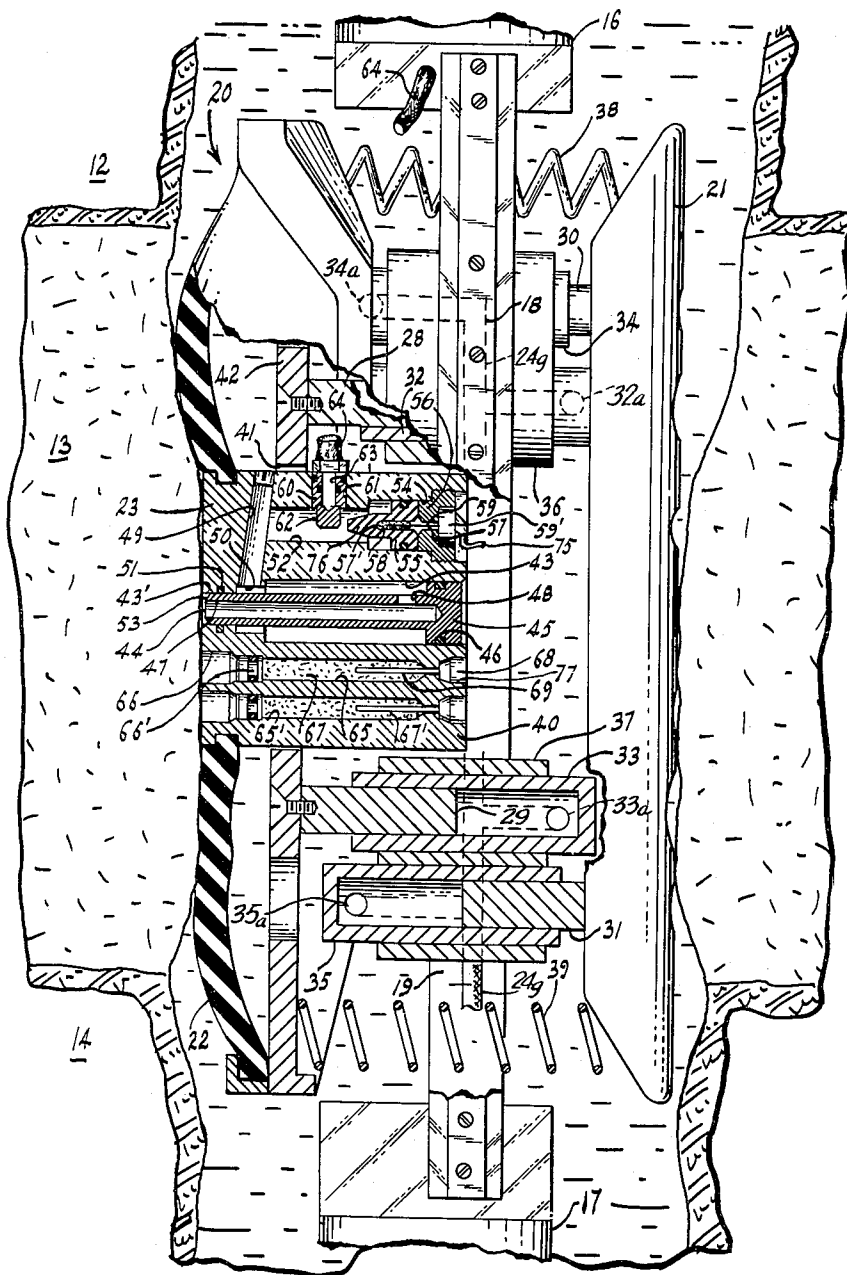


FIG. 2

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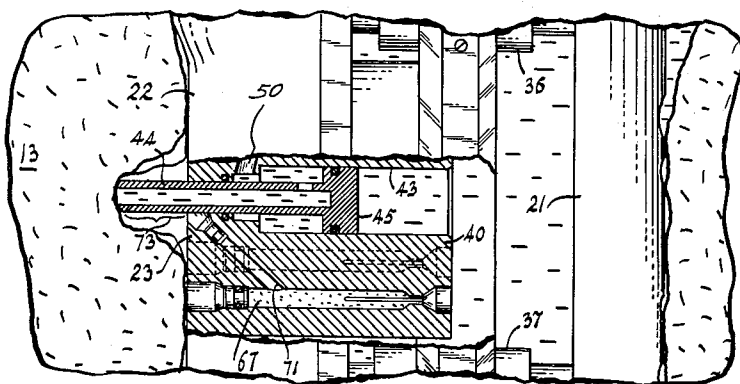


FIG. 4

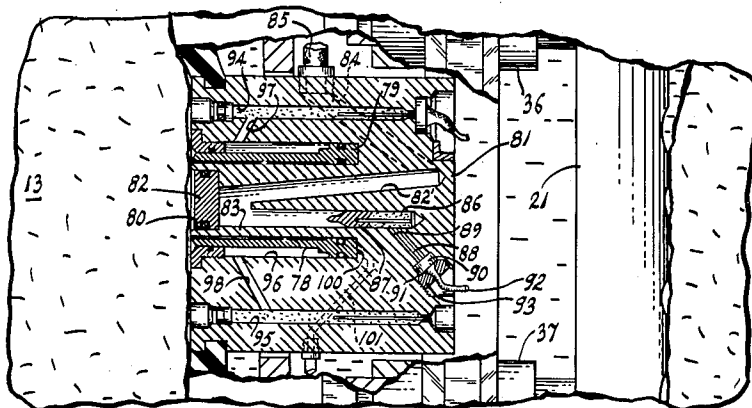


FIG. 5

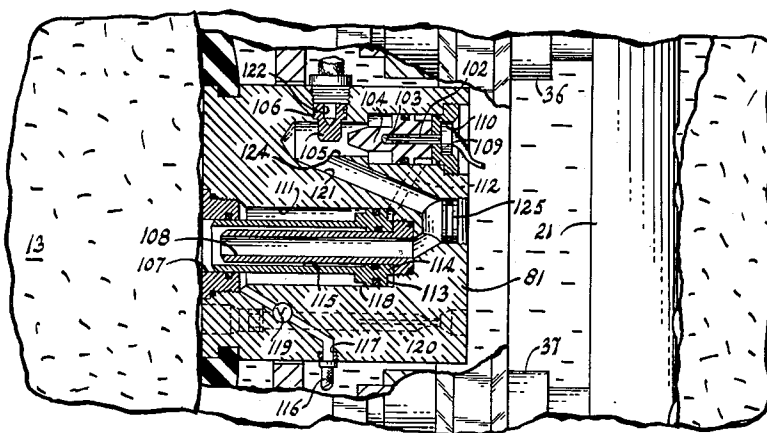


FIG. 6

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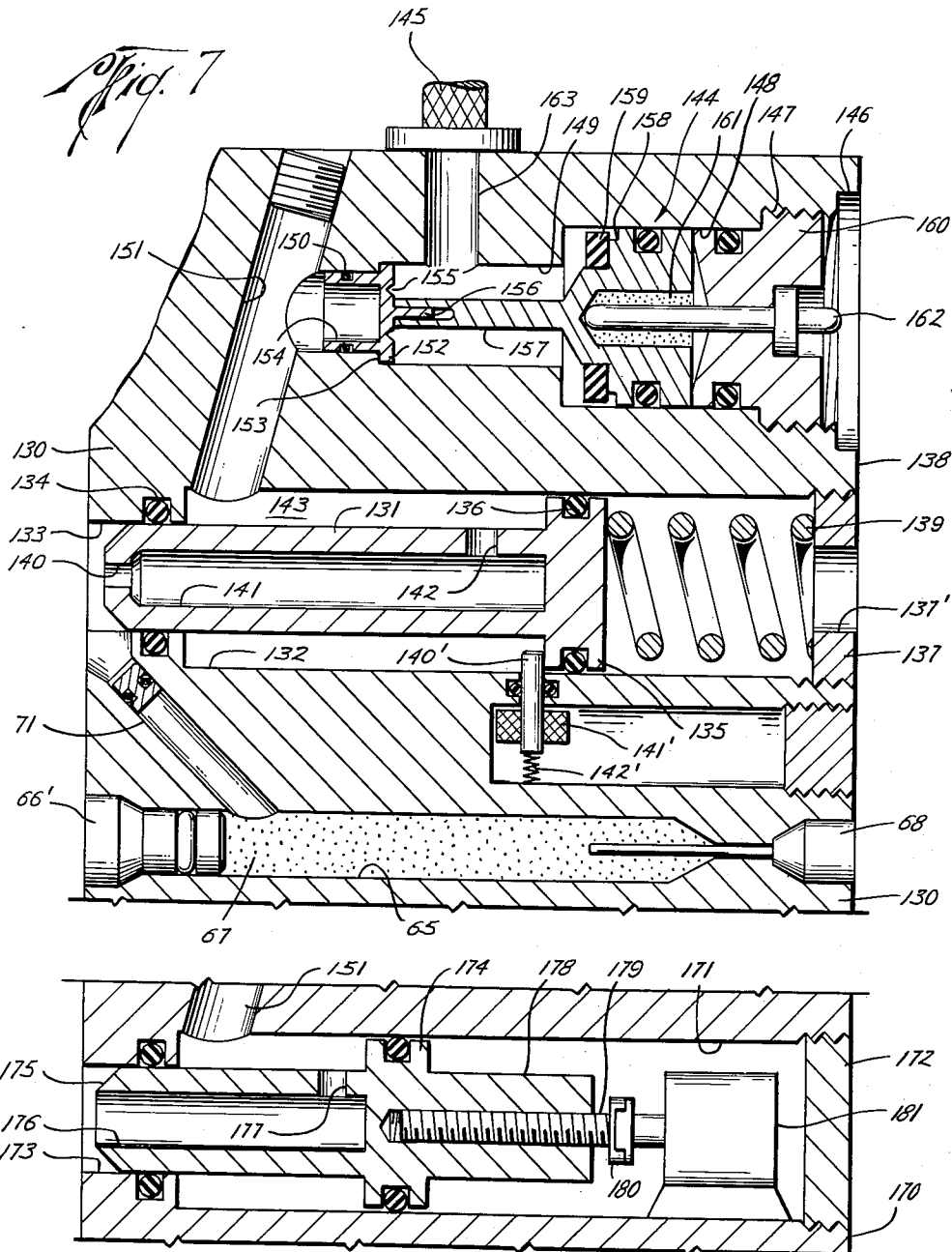
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4 Sheets-Sheet 4



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2,965,176

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16 Claims. (Cl. 166—100)

The present invention relates to apparatus for investigating earth formations traversed by a borehole and pertains more particularly to fluid samplers which may be lowered into boreholes for obtaining fluid samples from subsurface formations.

Although the invention has utility in a variety of applications, it is particularly suited for use in association with sidewall formation fluid sampling apparatus of the particular type disclosed in Patent No. 2,674,313 to L. C. Chambers. For convenience, it will be described in this connection.

The fluid sampler disclosed in the above-mentioned patent is provided with a pack-off shoe that seals a portion of the sidewall of the borehole at the level of a formation of interest. Fluid from the formation may then flow to a sample-receiving chamber. After a desired amount of fluid is obtained, the sample-receiving chamber is closed and the shoe retracted. The entire housing may then be withdrawn from the borehole so that the sample can be examined.

While this fluid sampler operates efficiently and reliably and has achieved a good measure of commercial success, occasionally in soft formations the surge of fluid into the sample taker may produce a cavity in the formation adjacent to the pad. Such a cavity sometimes reduces the effectiveness of the fluid seal formed by the pack-off shoe, and the sample obtained may not be entirely representative of formation fluid.

It is, therefore, an object of the present invention to provide new and improved apparatus for investigating earth formations of the foregoing type having increased reliability and efficiency in operation.

Another object of the invention is to provide a new and improved fluid sampler especially suited for use in obtaining a sample from soft formations.

Yet another object of the invention is to provide a new and improved fluid sampler for use in a borehole drilled into the earth and having a sealing member which secures a better degree of isolation than heretofore possible between an earth formation to be tested and the borehole fluid.

These and other objects of the invention are attained by providing a support adapted to be passed through a borehole. The support carries a pack-off shoe adapted to be forced against the sidewall of the borehole and seal a portion of the sidewall from any drilling fluid present in the borehole. The shoe is provided with an entry port through which a testing probe is adapted to be projected into an adjacent formation.

The novel features of the present invention are set forth in the appended claims; additional objects and ad-

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vantages will become apparent from the following detailed description taken in conjunction with the accompanying drawings, in which:

Fig. 1 is an elevational view of a formation fluid sampler embodying the present invention shown in a borehole and in one condition of operation;

Fig. 1A is a side view of portions of the apparatus illustrated in Fig. 1 drawn to a larger scale, certain parts thereof being shown cut-away and in section to reveal interior details;

Fig. 2 is a side view of a portion of the apparatus illustrated in Fig. 1 drawn to an enlarged scale, certain parts thereof being shown cut-away and in section to reveal interior details, and representing another condition of operation;

Fig. 3 is a view of the same apparatus shown in Fig. 2 and illustrating still another condition of operation;

Fig. 4 represents another embodiment of the present invention;

Fig. 5 is a cross-sectional view of a portion of the formation fluid sampler comprising a modification of the form shown in Fig. 2, and

Fig. 6 is a cross-sectional view of a portion of a formation fluid sampler comprising another modification of the form shown in Fig. 2.

Fig. 7 is a cross-sectional view of a portion of the formation fluid sampler comprising a modification of the form shown in Fig. 2 and

Fig. 8 is a cross-sectional view of a portion of the formation fluid sampler comprising a modification of the form of the probe actuating means.

In Fig. 1 of the drawings, the fluid sampler there shown includes a pressure resistant housing or support 10 adapted to pass through a borehole 11 traversing earth formations 12, 13 and 14, and containing a column of drilling fluid 15, usually exhibiting a hydrostatic pressure higher than the formation fluid pressure. Housing 10 may, for convenience, be divided into a plurality of separate sections 16 and 17 connected together in longitudinally spaced relation by a pair of side rails 18 and 19. These side rails 18 and 19 are transversely spaced from one another to provide a place for supporting an actuating mechanism for a pack-off shoe 20 and a back-up shoe 21 shown in retracted positions. Pack-off shoe or packing means 20 includes a flexible sealing face 22 provided with a rigid central insert 23 having longitudinally spaced apertures 43' and 66, the function of which will be described hereinafter. Pack-off shoe 20 may, for example, be of the type described in copending application Serial No. 418,650, filed March 25, 1954, now Patent No. 2,821,256, in the name of H. B. Boller and assigned to the present assignee.

To position pack-off shoe 20 opposite the selected formation 13, housing 10 is lowered or raised through borehole 11 by means of a winch (not shown) located at the surface and which spools a cable 26 connected to head 27 of housing 10.

To bring pack-off shoe 20 and back-up shoe 21 in close contact with the sidewall of the borehole, these elements are respectively coupled to a pair of pistons 28, 29 and 30, 31 as shown in Fig. 2. Hydraulic cylinders 32 and 33 receive pistons 28 and 29, respectively, and hydraulic cylinders 34 and 35 receive pistons 30 and 31, respectively. Secured between side rails 18 and 19

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are a pair of housings 36 and 37 which receive the cylinders and pistons just described.

In order to impart motion to the pistons, cylinders 32, 33, 34 and 35 are fluidly connected to a hydraulic actuator 24 (Fig. 1A) disposed in housing section 17. Tension springs 38 and 39 connected to opposite end portions of pack-off shoe 20 and back-up shoe 21 maintain the two shoes in retracted positions when the tool is lowered or raised through the borehole, as shown in Fig. 1.

Hydraulic actuator 24, for example, may be of the type disclosed in the aforesaid Chambers patent and includes a hollow cylinder 24a preferably filled with air 24' at atmospheric pressure, which is insulated by the walls of the housing section 17 from the high pressure borehole fluid. A piston 24b adapted to move under pressure through cylinder 24a, normally rests at the base 24c of this cylinder. A piston rod 24d is connected at one end to piston 24b, the other end being slidably mounted in chamber 24e, which is preferably filled with a substantially incompressible liquid, such as oil 24''. The movement of rod 24d by means of piston 24b through cylinder 24a therefore tends to increase the pressure of oil 24'' therein.

From a port 24f in the upper end of cylinder 24e, an oil-filled channel 24g passing through housing section 17 provides a liquid path to openings 32a, 33a, 34a and 35a in the rear of a plurality of cylinders 32, 33, 34 and 35, respectively. Hence an increase in pressure of oil 24'' in cylinder 24e and channel 24g will, in turn, increase the pressure behind pistons 28, 29, 30 and 31 thus force the shoes 21 and 22 away from housing 10.

From the base 24c of low pressure cylinder 24a, a channel 24h communicates with a port 24j in the exterior of housing section 17 which is normally blocked by a frangible plug 24k so that borehole fluid cannot enter cylinder 24a. In close proximity to frangible plug 24k is placed a small explosive charge 24l containing a conventional electrical igniter (not shown) connected for operation in a well-known manner.

When the tool is lowered to a desired point, the igniter is detonated rupturing plug 24k and since air in cylinder 24a is at a substantially lower pressure than borehole fluid, the borehole fluid will pass through channel 24h into cylinder 24a below piston 24b driving it up into the cylinder. Piston rod 24d will, in turn, force the oil 24'' in cylinder 24e through channel 24g at great pressure forcing pistons 28, 29, 30 and 31 to thrust shoes 21 and 22 against the wall of the borehole.

To retract the shoes 21 and 22 from the wall of the borehole, a cylinder 24m containing air 24n at atmospheric pressure is provided in the housing section 17. An opening 24p between cylinder 24m and cylinder 24e is normally blocked by a frangible plug 24r. An explosive igniter and charge 24s is disposed in the plug 24r so that ignition of the charge opens the channel 24p permitting the oil 24'' under pressure in cylinder 24e to flow into cylinder 24n. Once the pressure behind pistons 28, 29, 30 and 31 is relieved, springs 38 and 39 retract shoes 21 and 22 to their initial position.

Central insert 23 is integral with a member 40, herein-after referred to as a gun block, and both are movable in a horizontal direction through a central opening 41 of a driving plate 42. The driving plate 42 is included in shoe 20 and is attached to piston 28 and 29.

To maintain an effective seal with the formation under test, a hollow, cylindrical test probe 44 is movably positioned in a central bore or cylinder 43 in gun block 40 and extends between the front and the rear surfaces of the gun block 40. Probe 44 has a diameter in transverse cross section smaller than cylinder 43. The fore end of the probe 44 has a peripheral beveled edge 53 for cutting into the formation, and its rear end is provided with an enlarged piston head 45, the probe and

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piston head being slidable within cylinder 43, but fluidly sealed to the wall of the cylinder 43 by an O ring 46. The piston 45 thus is responsive to any difference in pressure between the pressure of the mud in the borehole and the pressure of formation fluids. Gun block 23 has an aperture 43' of lesser diameter than cylinder 43 which is provided within an O ring 51 to maintain an effective fluid seal with the outer surface of cylindrical probe element 44.

A longitudinal channel 47 extending through probe element 44, but terminating short of piston head 45, communicates through a port 48 at the rear of the probe with the annulus between cylinder 43 and probe 44 to allow fluid flow therethrough. The annulus in turn is connected for fluid flow to a sample fluid passageway 49 having an opening 50 at the annulus.

From sample fluid passageway 49, a bore 52 extends parallel to cylinder 43 through gun block 40. The bore 52 has an enlarged bore 54 at the rear section in which a hammer pin 55 is slidably mounted. A fluid resistant plug 56 is threadedly connected into the rear section and has a central opening 57 aligned with an opening 57' in hammer pin 55. Opening 57' contains a small explosive charge 58 associated with an electrical igniter needle 59 extending through openings 57 and 57' and having a head portion 59' seated in an enlarged rear section of opening 57. Gun block 40 is made of metal and head portion 59' of electrical igniter needle 59 has an insulated conductor 75 attached thereto which electrically connects the one terminal of the igniter to an energizing circuit (not shown) at the surface. The circuit is completed by a return electrical connection (not shown) to gun block 40. Igniter needle 59 may, for example, be of the type illustrated in Patent No. 2,681,701 to M. Schlumberger.

A break valve 60 is appropriately sealed in a bore 61 extending through gun block 40 transversely to and intersecting bore 52. A free, end portion 62 of break valve 60 projects partially into bore 52 and terminates at a position adjacent end 76 of hammer pin 55. A central bore 63 extends through break valve 60 through part of end portion 62. This bore 63 is in communication with a flexible tube 64 which is connected to a fluid sample-receiving chamber 25 in upper housing section 16.

Sample-receiving chamber 25 (Fig. 1A), for example, may be of the type disclosed in the aforesaid Chambers patent and includes an upper low pressure cylinder 25a and a lower cylinder 25b separated by a plate member 25c having a small diameter connecting orifice 25d. Upper cylinder 25a is preferably filled with air 25e at atmospheric pressure while lower cylinder 25b is filled with a substantially incompressible liquid such as water 25f. The upper end of cylinder 25a threadedly receives a removable cap member 25g while the lower end of cylinder 25b is attached to a ball valve device or seal valve 25h. Separating the fluid 25f from the seal valve 25h is a piston 25p which rests upon the seal valve 25h and is slidable in an upward direction upon the receipt of a fluid sample under pressure to force fluid 25f through orifice 25d into cylinder 25a. Valve device 25h has a passageway 25j in fluid communication with flexible tube 64 which contains a pair of balls 25k, 25l separated by a spring, the lower ball 25l normally blocking fluid flow into tube 64 but permitting fluid flow from tube 64. Upper ball 25k is in contact with a rod and piston 25m which permits formation fluid to bypass ball 25k until such time as the rod and piston 25m are moved to the right thereby permitting ball 25k to block the passageway 25j. The piston portion of the rod and piston 25n is contained in a chamber having an explosive charge 25o, the detonation of which serves to drive the piston and rod 25m to the right thereby sealing off the passageway 25j from fluid flow in either direction.

As the seal secured by face 22 may be so effective that shoe 20 cannot be retracted after a fluid sample is ob-

tained, there is provided in gun block 40 a release mechanism, for example, of the type described in copending application Serial No. 418,644, filed March 25, 1954, by Clyde C. Chivens and Roger Q. Fields, entitled "Release Mechanism for a Pack-Off Shoe," and assigned to the present assignee, now Patent No. 2,851,107. As shown in Fig. 2, this release mechanism includes a channel 65 extending through gun block 40 and central insert 23 parallel to bore 43. The forward end 66 of channel 65 is blocked by a seal element or plug 66'. Channel 65 is filled with an explosive charge 67, such as gun powder, for example, and its rear end 77 receives an insert 68 carrying an igniter needle 69. Another channel 65' similarly arranged as channel 65 is also shown.

In operation, the borehole apparatus 10 of Fig. 1 is lowered in the borehole 11 and positioned with pack-off shoe 20 and back-up shoe 21 opposite the formation 13 to be tested. The hydraulic actuator 24 for the shoes 20 and 21 is operated to extend the shoes into engagement with respective sidewall portions of the borehole as shown in Fig. 2 and the testing apparatus is ready to begin the fluid sample extracting operation.

Current is passed through igniter needle 59 to detonate explosive charge 58. The resulting explosion propels the hammer pin 55 forward, thus shearing free end portion 62 and opening break valve 60. Formation fluids may then flow through the testing cylinder or probe 44, through port 48 into the annulus between bore 43 and probe 44, through fluid channels 49 and 52, through break valve 60 and through the sample tubing 64 to the sample chamber in housing section 16 of the formation tester. The sample chamber may be, for example, of the type described in the aforesaid Chambers patent.

As the formation fluid flows into the probe 44, the flow may occur at relatively high velocity. Consequently, if the formation 13 is soft, as may be the case in sands, sand particles from the formation 13 may be carried along, and a small cavity 70 may start to form just ahead of testing element 44 as shown in Fig. 3. It is evident that the hydrostatic pressure of the mud in the borehole acts on the right-hand surface of piston 45 while, because of the seal effected by member 22, only formation pressure acts on the left-hand side of the piston. Since the mud pressure is usually higher than the formation pressure, a net force is developed which drives the piston toward the wall of the borehole. The piston, in turn, carries the probe 44 out of cylinder 43, and after entering cavity 70, the probe engages or penetrates the formation 13. This effectively reinforces the formation and prevents any further widening and collapse of the wall around the small cavity 70. In other words, the fluid seal provided by sealing face 22 is effectively extended into the cavity 70, thereby to maintain the seal and assure good fluid coupling between the formation under test and the sample-receiving chamber 25 of the tool via probe 44. Thus, the seal effected by the pack-off shoe 20 with the borehole wall is maintained and a truly representative sample of the formation fluid is collected in the sample chamber.

After the sample chamber 25 is filled, it is closed by a conventional seal valve 25h and the hydraulic pressure actuator 24 in housing section 17 is then operated to reduce the hydraulic pressure in the cylinders 32, 33, 34 and 35. The hydrostatic pressure of drilling mud 15 acting on the pistons 28, 29, 30 and 31 via the pack-off shoe 20 and the back-up shoe 21, together with the bias of springs 38 and 39, tends to displace the shoes toward their retracted position.

If difficulty is experienced in retracting sealing face 22 from the sidewall of the borehole, the release mechanism of explosive charges 67 and 67' in bores 65 and 65', respectively, is operated. By detonating charges 67, bore 65 is opened because plug 66' and insert 68 are blown clear of bore 65. This equalizes the pressure differential between the two surfaces of sealing face 22 and

enables the shoe 20 to be retracted. A similar result occurs for the case of bore 65'.

The borehole tool is then raised and if the testing element 44 is not withdrawn from cavity 70, it is broken and left in the formation. In either event, the tool can be brought to the surface where the sample-receiving chamber (not shown) can be removed from housing section 16 and the fluid sample therein may be measured and analyzed in any known manner.

To avert any difficulties in pulling away from the formation, an arrangement such as shown in Fig. 4 may be used. In this embodiment, the blast of the explosive charge 67 of the release mechanism is partly or totally diverted through a bore 71 whose axis intersects probe 44 in the vicinity of member 23. Accordingly, a sealing plug is blown out and extended portion 73 of the probe 44 is severed and remains in the formation. Preferably, probe 44 should be made of drillable material, such as high strength aluminum. Except for this modification, the embodiment of Fig. 4 is of the same construction and operates in the same manner as the embodiment of Fig. 2.

In another embodiment of the present invention, as shown in Fig. 5, a test probe 78, made of steel and with piston head 79 sliding within an annular chamber 96, surrounds a fluid sample port 80 in a gun block 81. The rear face of the annulus chamber 96 communicates through a port 100 and a channel 101 with a hydraulic pressure actuating means (not shown) which may be similar to the actuating means 24 described in connection with Fig. 1A. Port 80 is normally sealed with a frangible plug 82 capable of resisting the hydrostatic pressure in the borehole, and communicates with a fluid passageway 82' and a gun bore 83. Fluid passageway 82' is connected to a bore 84 communicating, through a flexible tubing 85, with a sample-receiving chamber (not shown) in housing section 16 similar to the sample-receiving chamber 25 as previously described. The rear portion of gun bore 83 contains an explosive charge 86 associated with a projectile 87 directed at plug 82. An electrical igniter needle 88 extending through an opening 89 is in close contact with explosive charge 86. Its head portion 90, seated in an enlarged rear section 91 of opening 89, is connected to an insulated conductor 92 passing through a plug 93 which seals opening 89 from the borehole mud.

A shoe release mechanism similar to the one described in detail in the embodiment of Fig. 2 includes channels 94 and 95 which communicate with annulus chamber 96 through lateral bores 97 and 98, the purpose of which will be explained hereinafter.

When the testing apparatus of Fig. 5 is ready to begin the fluid sample extracting operation, positioned as shown in Fig. 2, hydraulic pressure is applied through channel 101 to the right-hand surface of piston head 79; this pressure drives the piston head 79 forward inside the annulus chamber 96. The piston head 79, in turn, carries the probe 78 against the formation. An electric current is then passed through igniter 88 to detonate explosive charge 86, and projectile 87 ruptures frangible plug 82 and becomes embedded in the surrounding formation. Formation fluid may then flow through open port 80, passageway 82', bore 84 and through flexible tubing 85 to the sample chamber (not shown) in housing section 16 of the formation tester.

To retract the probe 78 after the sampling operation is completed, the hydraulic pressure applied against piston 79, through channel 101, is relieved. The shoe release mechanism is then energized as previously described. However, in the present embodiment the blasts of the explosive charges in channels 94 and 95 are partly diverted through lateral bores 97 and 98 to exert a high pressure upon the left-hand surface of piston head 79. Hence, test probe 78 is pulled out of the formation and forced back into gun block 81. Shoes 20 and 21 are

retracted as the pressure is equalized on both sides of the sealing member 22 and the apparatus is then raised to the surface of the borehole to enable examination of the fluid sample.

Fig. 6 shows another embodiment of a gun block which has a somewhat different arrangement for ejecting and retracting the test probe. In this case the gun block 81 includes a test probe 115 having a central axial insert having an axial passageway 108 therein, the complete probe assembly being movably mounted in a cylindrical bore or chamber 111. The test probe also includes a piston head 114 having a suitable sealing ring associated therewith. The right-hand end of chamber 111 which is coaxial with the probe passageway 108 also communicates with fluid passageways 121 and 124, the latter being closed to borehole fluids by an assembly including an igniter pin 102, explosive charge 103, and hammer pin 104. A plug 125 prevents borehole fluids from flowing directly into the right-hand end of chamber 111.

A fluid passageway which is initially blocked by a break valve 106 serves to connect the left-hand side of passageway 124 to the fluid sample chamber contained in housing section 16 similar to the sample-receiving chamber 25 previously described. The right-hand end of passageway 124 also communicates directly with the right-hand side 113 of piston head 114 by way of a fluid passageway or channel 112.

For retracting the test probe 115, the chamber formed between the wall of chamber 111 and probe 115 is connected by way of a fluid conduit or channel 117 and a flexible tubing 116 to a surface-controlled hydraulic pressure source (not shown) similar to hydraulic actuating means 24 previously described. Channel 117 includes a conventional check valve 119 for controlling the fluid pressure applied to the left-hand side 118 of piston head 114.

In operation after the shoes have been made to engage the borehole wall, an electrical current is passed through igniter 102. The resulting explosion of the charge 103 propels hammer pin 104 forward, thus shearing free the end portion 105 and opening break valve 106. Formation fluid may then flow through port 107 testing probe passageway 108, passageway 121 and bore 122 to the sample chamber (not shown). Simultaneously, the blast of explosive charge 103 expels igniter head portion 109 from rear section 110 and allows mud pressure to enter annulus chamber 111 through fluid channel 112. This mud pressure acts on the right-hand surface 113 of piston head 114 which, therefore, carries the probe 115 out of chamber 111 and toward the wall of the borehole.

To retract the probe 115 from the formation, a hydraulic pressure, controlled from the surface, is applied through flexible tubing 116 and fluid channel 117, to the left-hand side 118 of piston head 114. Thus, piston head 114 is moved back in the annulus chamber 111 and probe 115 is pulled out of the formation. During the retracting movement of the piston 114, the mud fluid contained in the annulus chamber section limited by the right-hand surface 113 of the piston head 114 is discharged back into the borehole through fluid channel 112. When the probe 115 is completely retracted, the hydraulic pressure in fluid channel 117 is relieved. Just before this, however, the check valve 119 which is positioned across fluid channel 117 is activated by suitable control means (not shown) so as to close channel 117 and, thus, maintain on piston head 114 the fluid pressure necessary to keep the probe 115 in a retracted position. A shoe release mechanism 120 is then actuated and the apparatus is raised to the surface of the borehole.

Fig. 7 shows another embodiment of a gun block which has a somewhat different arrangement for ejecting the test probe with a modified form of the test probe and a modified form of the break valve. In this arrangement the gun block 130 includes a test probe 131 which is movably positioned in a central bore or cylinder 132 in

the gun block. The fore end of probe 131 has a diameter in transverse cross section smaller than cylinder 132 and extends through an aperture 133 in the gun block and is fluidly sealed with respect to the aperture by an O ring 134. The rear end of the probe is provided with a piston 135 which is slidably mounted within the cylinder 132 and fluidly sealed by means of an O ring 136. A plug 137 is threadedly connected to the cylinder 132 at the rear surface 138 on the gun block and a resilient means such as a spring 139 is positioned under compression between the rear face of the piston 135 and the plug 137. Plug 137 also has an opening 137' to admit the fluid pressure of the formation. A latching means such as a bar 140' extends transversely into the cylinder 132 and serves to hold the probe in a retracted position. The bar when retracted from the cylinder 132 releases the probe 131 and the action of the spring 139 serves to insert the probe into the formation. Means to retract the bar such as a solenoid 141' may be employed together with a biasing spring means 142' to return the bar into the cylinder 132 when the solenoid is de-actuated. The electrical connections are not shown but it will be readily apparent that the solenoid may be actuated by a current to retract the bar and upon discontinuance of the current the spring 142' will return the bar to its initial position.

Returning now to the fore end of the probe 131, a cylindrical opening 140 at the end of the probe extends into a somewhat larger cylindrical opening 141 which extends to a point near the body of the piston and a port 142 is provided through the probe 131 to allow fluid flow through the cylindrical openings 140, 141 and port 142 to the open annular space 143 between the probe 131 and cylinder 132. The outermost end of the probe 131 is somewhat conical tapered so that the smaller opening and tapered end portion tend to prevent clogging of the probe.

The break valve shown generally at 144 serves to close the sample fluid passageway 145 until the tool is properly in position and is located in a cylindrical opening having decreasing stepped diameters 146-150 which are connected to a fluid passageway 151 which is, in turn, connected to the annular space 143. Positioned and fluidly sealed in the diameter portion 150 by means of an O ring seal, is a breakable cap 152 having a flanged portion 153 extending into the diameter section 149 and the stepped surface between diameter portions 149, 150 serve to provide an abutment surface for the flange portion 153. The cap has a bore 154 extending from the end portion of the cap in diameter 150 to a point near the other end of the cap and in the other end surface is a circular weakening groove 155 of the same or slightly less diameter than the bore 154. Extending from the end portion within the diameter of the groove is a pin 156 which is located in a corresponding bore in the hammer pin 157 which, in turn, is of less diameter than the groove 155. The hammer pin has an end piston body 158 slidable within the diameter portion 148 and fluidly sealed by means of an O ring. A shock absorbing member 159 is located adjacent the piston body and adapted to abut with the step surface formed between the diameter portions 148 and 149. A fluid resistant plug 160 is threadedly connected to diameter portion 147 and also extends into diameter portion 148 to abut with the piston body 148. A small explosive charge 161 associated with an electrical igniter needle 162 is located in the piston body 158 and the igniter needle 162 is connected to an energizing circuit at the surface (not shown). The cylinder portion 149 is connected by means of a passageway 163 to the fluid sample passageway 145.

The release mechanism including channel 65, explosive charge 67 and bore 71 is similar in arrangement to the mechanism of Fig. 4.

In operation after the shoes have been made to engage the borehole wall, an electrical current is passed through the solenoid 141' to retract the bar 140' from the cylinder

der 132 and the probe 131 is then spring biased against the formation. The penetration of the probe is dependant upon the spring pressure and the pressure of the drilling fluid so that the probe reinforces the formation and reduces the formation of a cavity. When the break valve 144 is opened, the differential pressure across piston 135 will add to the spring pressure to force the probe into the formation. An electrical current is then passed through igniter 162 and the explosion of the charge 161 propels the hammer pin 157 forward thus shearing the circular grooved portion of the cap 152 and opening break valve 144. The shock absorbing means 159 limits the forward movement of the piston body 158 and the severed portion of the cap will be retained with the hammer pin 157 by the pin 156 of the cap in the bore of the hammer pin. Fluid flow from the formation will now occur through the bores 140, 141, port 142, annular space 143, passageway 151, bore 150, 149, 163 to the fluid sample passageway 145. The annular portion of plug 152 will slip over the circular hammer pin 157 and thus it will be appreciated that both the sheared portions of the cap 152 are retained with the hammer pin 157. Hence, the probability of clogging of the bores in the block is reduced.

In Fig. 8 a modified arrangement of the probe actuating means is shown wherein the gun block 170 is provided with a bore or cylinder opening 171 having a fluid sealing cap 172 threadedly connected to one end and a bore opening 173 of smaller diameter at the other end. A test probe has a piston body portion 174 slidably and fluidly sealed in the bore 171 which serves as a guide for the probe. A probe portion 175 extending from the piston through the bore opening 173 is fluidly sealed therewith. A bore 176 extends partially through the probe portion and is fluidly connected to the annular space between the probe portion and the cylinder 171 by means of a port 177.

On the other side of the piston body 174, an extending portion 178 of the probe is threadedly connected by means of a threaded member 179 and a slipping clutch 180 to a reversible motor 181. The motor is operatively connected to control means so that, dependant upon the direction of rotation of the motor 180, the probe will be moved either into or out of the formation.

While in the drawings of the various embodiments the testing probes have been represented by a cylindrical sleeve having a completely open fore end, such fore end may, where desired, include an appropriate filtering member to reduce the amount of sand entering the tool. Likewise, to obtain a better seal with the wall of the cavity formed in the formation, the fore end of the probe may be provided also with a sealing means such as a sealing lip constructed of a deformable material.

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. Therefore, the aim of the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

We claim:

1. An apparatus for operating in a borehole comprising: a support adapted for passage through a borehole; packing means mounted on said support and including a front surface adapted to engage and isolate a portion of the sidewall of the borehole opposite a selected formation, said packing means having a port extending through said front surface; actuating means on said support operatively connected to said packing means for moving said front surface into contact with the wall of the borehole; a probe member movable through said port into an earth formation adjacent to said front surface; and means operatively connected to said probe member to permit movement of said probe into the selected formation through said port.

2. In a sidewall packing apparatus for use in a borehole containing a fluid, the combination of: a support adapted for passage through a borehole; a pack-off shoe mounted on said support; sealing means mounted on said pack-off shoe and including a front surface adapted to engage and isolate a selected portion of the borehole, said sealing means having a port extending through said front surface; means operatively connected to said pack-off shoe for moving said sealing means into contact with the sidewall of the borehole; probing means movable through said port; and means for utilizing the fluid pressure in the borehole whereby said probing means is caused to be driven through said port into the selected portion of the borehole adjacent to said front surface.

3. In a well testing apparatus for use in a borehole containing a column of liquid at a pressure higher than the fluid pressure of an adjacent earth formation, the combination of: a housing adapted for passage through a borehole; means forming a fluid sample chamber in said housing; a sealing member mounted on said housing and including a front surface adapted to engage and isolate a portion of the borehole, said sealing member having a port extending through said front surface; means operatively connected to said sealing member for moving said sealing member into contact with the sidewall of the borehole; and probing means movable through said port and responsive to the pressure difference between the fluid pressure in the borehole and the fluid pressure in the formation whereby said probing means is caused to penetrate into the formation after said sealing member has engaged said portion of the borehole, said probing means having a fluid channel; means defining a fluid passageway between said probing means and said fluid sample chamber, whereby fluid from said formation may enter said fluid sample chamber.

4. In a well testing apparatus for use in a borehole containing a column of liquid at a pressure higher than the fluid pressure of an adjacent earth formation, the combination of: a housing adapted for passage through a borehole; means forming a fluid sample chamber in said housing; a sealing member mounted on said housing and including a front surface adapted to engage and isolate a portion of the borehole; said sealing member having a port extending through said front surface; means operatively connected to said sealing member for moving said front surface into contact with the sidewall of the borehole; probing means movable through said port and responsive to the difference in pressure between the fluid pressure in the borehole and the fluid pressure in the formation whereby said probing means is caused to penetrate into the formation after said sealing member has engaged said portion of the borehole, said probing means having a fluid channel; means defining a fluid passageway between said probing means and said fluid sample chamber, whereby fluid from said formation may enter said fluid sample chamber; and means for closing off said fluid passageway after a desired sample of fluid has entered said sample chamber.

5. In a sidewall fluid sample taker to be used in a borehole containing a column of liquid at a pressure higher than the fluid pressure of an adjacent earth formation, the combination of: a housing adapted for passage through said borehole; said housing having a fluid sample chamber; pack-off means mounted on said housing and including a front surface adapted to engage and isolate a portion of a soft formation selected along the sidewall of the borehole; said pack-off means having a port extending through said front surface; actuating means in said housing operatively connected to said pack-off means for moving said front surface into contact with the wall of a borehole; a tubular member adapted to be projected through said port into said soft formation, movement of said tubular member being responsive to the difference in fluid pressures in the borehole and the formation; and fluid conduit means in said tubular member; means

defining a fluid passageway between said fluid conduit means and said fluid sample chamber, whereby fluid from said soft formation adjacent to said pack-off means and said tubular member may enter said fluid sample chamber.

6. In a well testing apparatus for use in a borehole, the combination of: a housing adapted for passage through a borehole; means forming a fluid sample chamber in said housing; a sealing member mounted on said housing and including a front surface adapted to engage and isolate a portion of the borehole, said sealing member having a port extending through said front surface; means operatively connected to said sealing member for moving said front surface into contact with the sidewall of the borehole; probing means movable through said port after said sealing member has engaged said portion of the borehole in response to the difference in fluid pressures in the boreholes and the formation, said probing means having a fluid channel; means defining a passageway between said probing means and said fluid sample chamber, whereby fluid from said formation may enter said fluid sample chamber; means for closing off said fluid passageway after a desired sample of fluid has entered said sample chamber; and means for facilitating retraction of said sealing member by equalizing the pressure differential on said sealing member and for severing the portion of said probing means protruding from said front surface.

7. In a sidewall fluid sample taker to be used in a borehole containing a column of liquid at a pressure higher than the fluid pressure of an adjacent earth formation, the combination of: a housing adapted for passage through a borehole; said housing having a fluid sample chamber; pack-off means mounted on said housing and including a front surface adapted to engage and isolate a portion of a soft formation selected along the sidewall of the borehole, said pack-off means having a port extending through said front surface; actuating means operatively connected to said pack-off means for moving said front surface against said selected soft formation; probe means responsive to the difference in the fluid pressure in the borehole and the fluid pressure in the formation mounted for movement transversely through said port and laterally outward towards said selected portion of the formation; fluid conduit means in said slidable probe means; means forming a normally closed channel connecting said fluid conduit means in said slidable probe means to said fluid sample chamber; and means for opening said normally closed channel to the fluid from the formation adjacent said front surface of said pack-off means.

8. In a sidewall fluid sample taker to be used in a borehole containing a fluid at a pressure higher than the fluid pressure of an adjacent earth formation, the combination of: a pressure resistant housing adapted for passage through a borehole; said housing having a fluid sample chamber; a pack-off shoe mounted on said housing and including a surface portion adapted to engage and isolate a portion of the wall of the borehole, said pack-off shoe having a port extending through said surface portion, said pack-off shoe further having a rigid insert having a guide aligned with said port which extends in a direction transverse to said surface portion; actuating means operatively connected to said pack-off shoe for moving said surface portion against a selected formation; a probe movable along said guide and through said port, said probe being responsive to the difference between the fluid pressure in the borehole and the fluid pressure in the formation to move through said port in an earth formation adjacent to said surface portion; fluid conduit means in said movable probe; means forming a channel connecting said fluid conduit means to said fluid sample chamber; a frangible plug disposed in said channel for normally closing said channel to fluid flow; and explosively operable means in said channel for rupturing said

frangible plug to open a fluid path between said probe and said fluid sample chamber.

9. Borehole apparatus comprising: a support adapted for passage through a borehole and including wall-engaging means having a sealing face adapted to engage and isolate a substantially continuous zone on the sidewall of the borehole and means forming an opening in said sealing face; actuating means operatively connected to said wall-engaging means for moving said sealing face into contact with the sidewall of the borehole; means forming an extension of said opening, said means being movable relative to said sealing face in a direction toward the sidewall of the borehole independently of said actuating means after said sealing face is in contact with the bore hole wall in response to the difference in fluid pressures in the borehole and the formation; sample receiving means in said support; and means for fluidly coupling said extension to said sample-receiving means.

10. In a sidewall fluid sample taker to be used in a borehole, the combination of: a housing adapted for passage through a borehole; said housing having a fluid sample chamber; a pack-off shoe mounted on said housing and including a surface portion adapted to engage and isolate a portion of the wall of the borehole, said pack-off shoe having a port extending through said surface portion, said pack-off shoe further including a rigid insert having a guide extending in a direction transverse to said surface portion; actuating means operatively connected to said pack-off shoe for moving said surface portion against a selected formation; a probe movable along said guide and through said port into the formation adjacent to said surface portion; means for moving said probe along said guide and towards said selected formation; fluid conduit means in said probe; means forming a channel connecting said fluid conduit means to said fluid sample chamber; a frangible plug disposed in said channel for normally closing said channel to fluid flow; explosively operable means in said channel for rupturing said frangible plug to open a fluid path between said probe and said fluid sample chamber; and explosively operable means in said rigid insert for facilitating retraction of said pack-off shoe from the sidewall of the borehole.

11. In a sidewall fluid sample taker to be used in a borehole, the combination of: a housing adapted for passage through a borehole; said housing having a fluid sample chamber; a pack-off shoe mounted on said housing and including a surface portion adapted to engage and isolate the wall of the borehole, said pack-off shoe having a port extending through said surface portion said pack-off shoe further including a rigid insert having a guide extending in a direction transverse to said surface portion; actuating means operatively connected to said pack-off shoe for moving said surface portion against a selected formation; a probe movable along said guide and through said port; means for moving said probe along said guide and towards said selected formation; fluid conduit means in said probe; means forming a channel connecting said fluid conduit means to said fluid sample chamber; a frangible plug disposed in said channel for normally closing said channel to fluid flow; explosively operable means in said channel for rupturing said frangible plug to open a fluid path between said probe and said fluid sample chamber; and explosively operable means in said rigid insert and including first means for facilitating retraction of said pack-off shoe by equalizing the pressure differential on said pack-off shoe and second means for severing said probe within the formation, said first and second means being adapted to operate simultaneously.

12. In a well testing apparatus for use in a borehole, the combination of: a housing adapted for passage through a borehole; means defining a fluid sample chamber in said housing; a sealing member mounted on said housing and including a front surface adapted to engage

and isolate the wall of the borehole, said sealing member having a central port extending through said front surface; means operatively connected to said sealing member for moving said front surface into contact with the sidewall of the borehole; a rigid member extending axially of said front surface and said central port; a normally closed axial bore extending transversely through said rigid member; first means forming a fluid communication path extending from said axial bore and having a rear end portion fluidly connected to said fluid sample chamber; second means forming a conduit extending from said axial bore and including explosive means to open said bore to formation fluid flow; said rigid member having a cylindrical chamber spaced about said axial bore; probing means slidably mounted within said cylindrical chamber for axial outward motion towards the formation adjacent to said front surface; means including a fluid conduit for applying hydraulic pressure to said probing means whereby said probing means is caused to penetrate into the formation; and explosively operable means including first means for facilitating retraction said pack-off shoe by equalizing the pressure differential on said sealing member and second means, coupled to said first means, for retracting said probing means into said cylindrical chamber, said first and second means being adapted to operate simultaneously.

13. In a well testing apparatus for use in a borehole containing a column of fluid at a pressure higher than the fluid pressure of an adjacent earth formation the combination of: a pressure resistant housing adapted for passage through a borehole; said housing having a fluid sample chamber; a sealing member mounted on said housing and including a front surface adapted to engage and isolate a portion of the wall of the borehole, said sealing member having a port extending through said front surface; means operatively connected to said sealing member for moving said sealing surface into contact with the sidewall of the borehole; said sealing member further provided with a rigid insert having a cylindrical chamber aligned with said central port and extending transversely therefrom, first means forming a fluid communication path extending into said rigid insert from the side opposite said front surface and connecting with an interior end of said cylindrical chamber; second means forming a channel fluidly connecting said first means to said fluid sample chamber; a frangible plug disposed in said channel for normally closing said channel to fluid flow; cylindrical probing means slidably mounted within said cylindrical chamber for axial outward motion towards said formation adjacent said front surface; third means forming a fluid passageway connecting the rear end of said probing means to the exterior end of said first means, whereby said cylindrical probing means is responsive to the difference between the fluid pressure in the borehole and the fluid pressure in the formation; explosively operable means in said first means intermediate said second and third means for rupturing said frangible plug to open simultaneously said first and second means to formation fluid flow, and said third means to the fluid pressure in the borehole whereby said probing means is caused to penetrate into the formation; means including a fluid conduit for selectively applying hydraulic pressure to said probing means to retract said probing means into said cylindrical chamber; and a check valve disposed in said fluid conduit and arranged to maintain said hydraulic pressure against said probing means, and explosively operable means for facilitating retraction of said pack-off shoe.

14. In a sidewall fluid sample taker to be used in a borehole containing a column of liquid, the combination of: a housing adapted for passage through said borehole; said housing having a fluid sample chamber; pack-off means and wall-engaging means disposed on opposite sides of said housing and mounted on said housing for relative movement therebetween, said pack-off means

including a front surface adapted to engage and isolate a portion of a formation selected along the sidewall of the borehole, said pack-off means having a port extending through said front surface and aligned therewith, a cylinder of larger diameter opening to said port and to the column of liquid; actuating means in said housing operatively connected between said pack-off means and said wall-engaging means for moving said front surface of said pack-off means and said wall-engaging means into contact with the wall of a borehole; a tubular member having a forward portion adapted to be projected through said port into said soft formation and a rearward piston portion adapted to be received in said cylinder whereby movement of said tubular member is achieved by difference in fluid pressure in the borehole and the formation; and fluid conduit means in said tubular member; means defining a fluid passageway between said fluid conduit means and said fluid sample chamber, whereby fluid from said soft formation adjacent to said pack-off means and said tubular member may enter the fluid sample chamber.

15. In a sidewall fluid sample taker to be used in a borehole containing a column of liquid, the combination of: a housing adapted for passage through said borehole; said housing having a fluid sample chamber; pack-off means and wall-engaging means disposed on opposite sides of said housing and mounted on said housing for relative movement therebetween, said pack-off means including a front surface adapted to engage and isolate a portion of a formation selected along the sidewall of the borehole, said pack-off means having a port extending through said front surface and aligned therewith, a cylinder of larger diameter opening to said port and to the column of liquid; actuating means in said housing operatively connected between said pack-off means and said wall-engaging means for moving said front surface of said pack-off means and said wall-engaging means into contact with the wall of a borehole; a tubular member having a forward portion adapted to be projected through said port into said soft formation and a rearward piston portion adapted to be received in said cylinder whereby movement of said tubular member is achieved by difference in fluid pressure in the borehole and the formation; and fluid conduit means in said tubular member; means defining a fluid passageway between said fluid conduit means and said fluid sample chamber, whereby fluid from said soft formation adjacent to said pack-off means and said tubular member may enter the fluid sample chamber; means for facilitating retraction of said pack-off means including a chamber in said housing enclosing an explosive arranged to open said chamber between said front surface and the borehole liquid to equalize the pressure differential on the pack-off means.

16. In a sidewall fluid sample taker to be used in a borehole containing a column of liquid, the combination of: a housing adapted for passage through said borehole; said housing having a fluid sample chamber; pack-off means and wall-engaging means disposed on opposite sides of said housing and mounted on said housing for relative movement therebetween, said pack-off means including a front surface adapted to engage and isolate a portion of a formation selected along the sidewall of the borehole, said pack-off means having a port extending through said front surface, and aligned therewith, a cylinder of larger diameter opening to said port and to the column of liquid; actuating means in said housing operatively connected between said pack-off means and said wall-engaging means for moving said front surface of said pack-off means and said wall-engaging means into contact with the wall of a borehole; a tubular member having a forward portion adapted to be projected through said port into said soft formation and a rearward piston portion adapted to be received in said cylinder whereby movement of said tubular member is achieved by difference in fluid pressure in the borehole and the formation; and fluid conduit means in said tubular member; means

defining a fluid passageway between said fluid conduit means and said fluid sample chamber, whereby fluid from said soft formation adjacent to said pack-off means and said tubular member may enter the fluid sample chamber; and means for facilitating retraction of said pack-off means including a chamber in said housing enclosing an explosive arranged to open said chamber between said front surface and by borehole liquid to equalize the pressure differential on the pack-off means; said chamber being arranged to open adjacent to said tubular member to sever said tubular member upon detonation of the explosive.

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