Oct. 3, 1967 U. E. VOETTER 3,344,860

SIDEWALL SEALING PAD FOR BOREHOLE APPARATUS

Filed May 17, 1965 2 Sheets-Sheet 1

Fig. 2

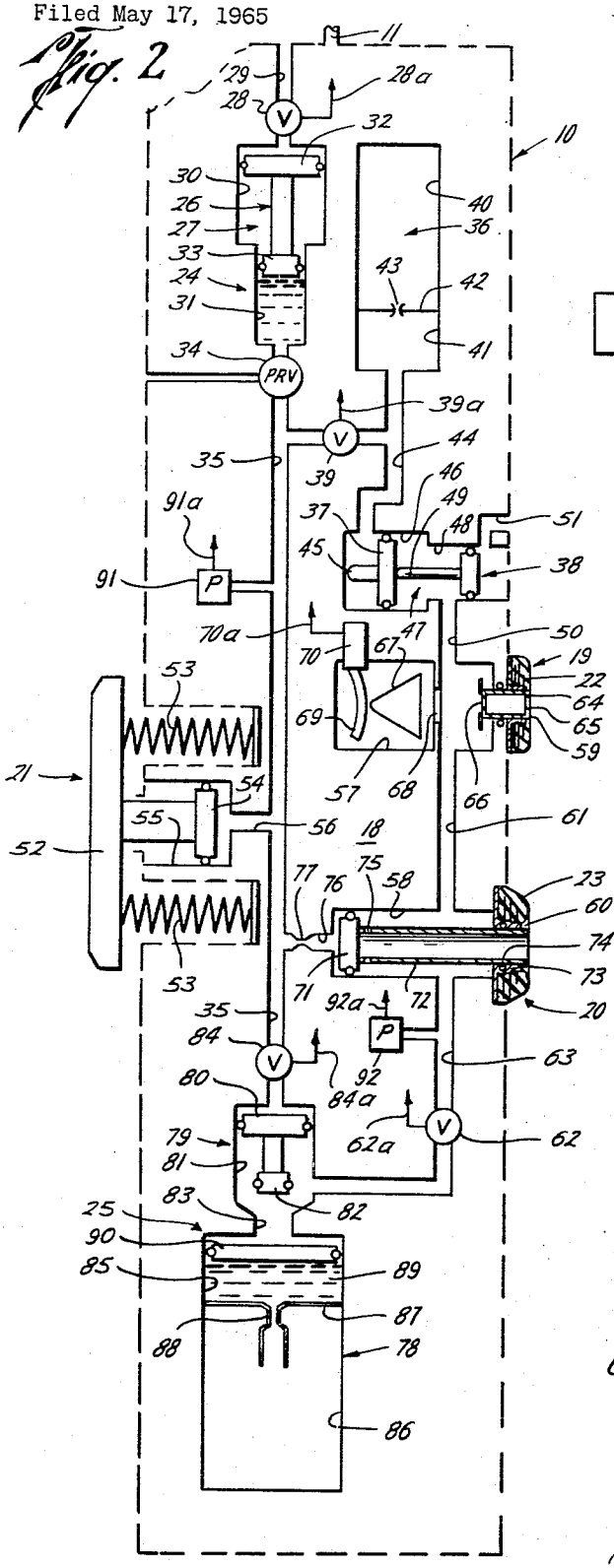
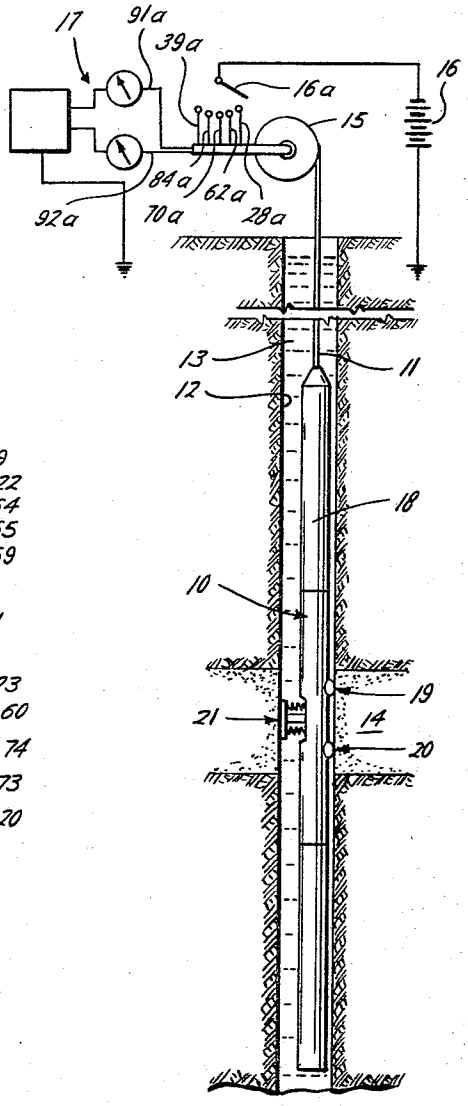


Fig. 1



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SIDEWALL SEALING PAD FOR BOREHOLE APPARATUS

Filed May 17, 1965 2 Sheets-Sheet 2

Fig. 3

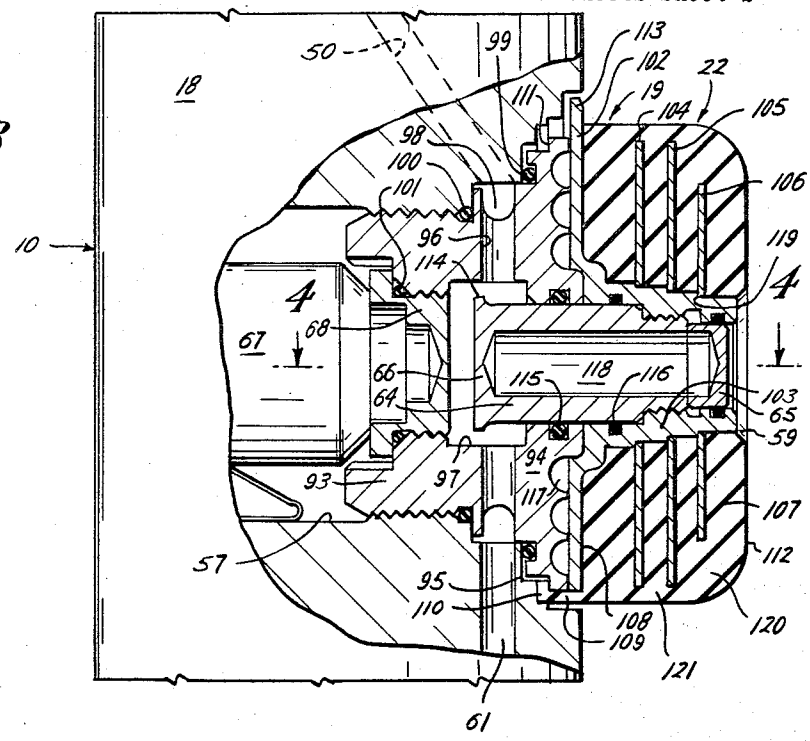
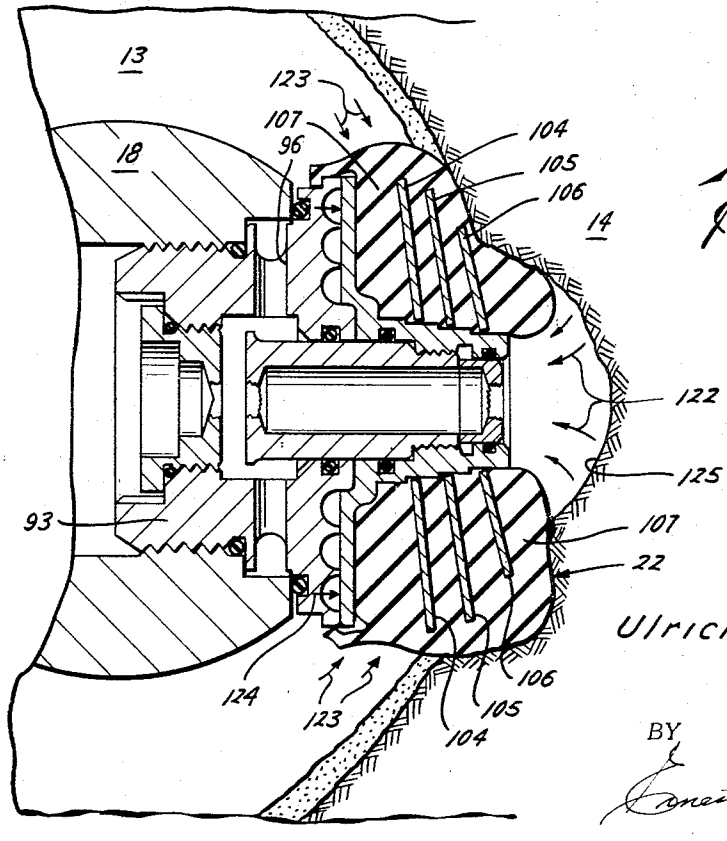


Fig. 4



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SIDEWALL SEALING PAD FOR BOREHOLE APPARATUS

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7 Claims. (Cl. 166—100)

ABSTRACT OF THE DISCLOSURE

This application discloses a sealing member for use with formation testers adapted for obtaining samples of connate fluids from the walls of a borehole. More particularly, the application discloses an annular elastomeric sealing member that is mounted on a rigid tubular member. A plurality of flat plates are embedded in the sealing member to support the elastomeric material against pressure forces otherwise sufficient to damage the elastomeric material during its use.

Accordingly, as will subsequently become more apparent, this invention relates to new and improved pack-off shoes for formation fluid-sampling apparatus; and, more particularly, to sealing members ideally suited for maintaining an effective seal with the wall of a borehole while a sample of connate fluid is being obtained from particularly soft earth formations.

When it is desired to obtain fluid samples from particularly soft or unconsolidated earth formations, fluid-sampling apparatus such as those disclosed in either the Brieger Patent No. 2,965,176 or the Whitten Patent No. 3,261,402, are usually employed. The tool described in the Brieger patent includes an elastomeric sealing member that is selectively urged against the wall of the borehole and held there in sealing engagement to isolate a portion of the wall. Upon command from the surface, a movable tubular probe or so-called "snorkel" is then extended through an opening in the engaged sealing member and urged against the formation. By opening a selectively operable valve in the tool, a discrete volume of whatever recoverable connate fluids there may be in the formation is expelled by formation pressure through the snorkel and into a low-pressure sample-receiving chamber carried on the tool. Then, after it is believed that an adequate amount of fluid sample has been obtained, a second valve in the tool is actuated to close the sample-receiving chamber and the snorkel is retracted. The tool is then retrieved to the surface of the ground where the fluid sample is examined.

The sample-taking apparatus disclosed in the Whitten patent is comprised of a combination of sample-admitting means, with each employing conventional annular sealing members. One of these sample-admitting means includes a snorkel similar to that of the Brieger patent and the other sample-admitting means employs a shaped charge to provide an entrance into a formation.

As connate fluids are expelled from a particularly soft or unconsolidated formation, formation particles, such as sand, will be continually washed away from around the forward face of the sealing member. Eventually so much of the formation face will be cut away that the sealing member will be no longer able to maintain an effective seal. In both the Brieger and Whitten apparatus, this undesirable action is minimized by progressively advancing the snorkel into the formation as particles are washed out thereby reinforcing the loose formation. It will be appreciated, however, that once the snorkel has advanced to its outer limit of travel, the continued washing away of formation particles will quickly create a large cavity that will soon extend beyond the periphery of the sealing member. Once this occurs, the sealing member will no longer be sealed against the formation and the well control fluids will be admitted through the snorkel to the sample-receiving chamber.

Another approach that has been proposed for maintaining an effective seal is to mount an annular sealing member around the forward end of a movable tubular member. Then, as more fully described in Patent No. 3,295,615 to Emmet F. Brieger and Ulrich E. Voetter, as the formation particles are washed away, the sealing member itself is progressively advanced into the cavity so created to maintain a seal around the so-called "follower tube."

Although these and other measures have greatly improved the odds of obtaining fluid samples from unconsolidated formations, there are still some problems encountered in the use of such equipment. For example, the so-called "follower-type packer" disclosed in the aforementioned Brieger and Voetter patent may prematurely lose its seal should the formation face be non-homogeneous and the cavity develop eccentrically away from the central axis of the follower tube toward the periphery of the sealing member. Thus, a disproportionate amount of the elastomeric material of the sealing member will be displaced in this direction and either lose sealing contact with the formation prematurely or cause the elastomeric member to rupture. Similarly, where a shaped charge is employed as described in the Whitten patent to gain access into a formation, in some instances the entrance to the perforation will be greatly enlarged. Thus, the central portion of the sealing member is unsupported and will usually be extruded by the hydrostatic pressure of the well control fluids into the somewhat frusto-conical perforation.

Accordingly, it is recognized by those skilled in the art that it is highly essential to the success of a fluid-sampling operation that an effective seal be maintained between the earth formation and sample-admitting means as long as possible. Moreover, as a fluid sample is being admitted through the central opening of the sealing member, the pressure on the forward face of the sealing member will be no greater than the formation pressure and usually drops to a very low value upon opening of the sample-receiving chamber. When this occurs, the differential acting across the sealing member may nearly equal the hydrostatic pressure of the well control fluids, which pressure is often substantially in excess of 10,000-p.s.i.g. Thus, to maintain an effective seal as long as possible, the sealing member must have (1) sufficient resiliency and displaceable volume to move into the cavity as it develops in the formation in front of the sealing member, (2) sufficient strength to withstand excessively high differential pressures, and (3) sufficient toughness to withstand abrasion against the roughened walls of the borehole.

Accordingly, it is an object of the present invention to provide new and improved sealing members for maintaining an effective seal against the sidewall of a borehole as connate fluids are being withdrawn from adjacent soft or unconsolidated earth formations.

This and other objects of the present invention are provided by arranging resilient sealing means around a rigid central member projecting forwardly from a rigid base member and one or more rigid lateral members spaced fowardly of the base member.

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

FIG. 1 depicts sample-taking apparatus employing the

sealing means of the present invention as it might appear within a borehole;

FIG. 2 is a simplified, schematic representation of the sample-taking apparatus illustrated in FIG. 1;

FIG. 3 is a cross-sectional view in elevation of a portion of the apparatus of FIG. 1 and an embodiment of a sealing member arranged in accordance with the present invention; and

FIG. 4 is a cross-sectional view in plan of the apparatus shown in FIG. 3 and illustrating a typical condition of its operation.

Turning now to FIG. 1, fluid-sampling apparatus **10** incorporating the principles of the present invention is shown suspended from a multi-conductor cable **11** in a borehole **12** containing well control fluids **13** and positioned adjacent a particular earth formation **14** for collecting a sample of connate fluid therefrom. The cable **11** is spooled from a winch **15** at the earth's surface, with some of its conductors being connected to a switch **16***a* for selective connection to a conventional power source **16***b* and others being connected to conventional indicating-and-recording apparatus **17**. The fluid-sampling apparatus **10** is comprised of an elongated body **18**, which, to facilitate manufacture and assembly, may be arranged to include tandemly connected sections. Longitudinally spaced, sample-admitting means **19** and **20** arranged in accordance with the principles of the present invention are mounted along one side of the body **18** and extendible wall-engaging means **21** are mounted on the opposite side. In the position illustrated in FIG. 1, the wall-engaging means **21** have been extended to laterally shift the fluid-sampling apparatus **10** in the borehole **12** and sealingly couple the sample-admitting means **19** and **20** with the exposed face of the formation **14** in preparation for obtaining a sample of connate fluids therein.

Inasmuch as the particular details of its various components are not necessary for a full understanding of the present invention, the fluid-sampling apparatus **10** is shown only schematically in FIG. 2 to illustrate the overall relation of its other components to the sample-admitting means **19** and **20** and their respective sealing members **22** and **23** arranged in accordance with the present invention. Accordingly, these other components may well be those described in greater detail in the aforementioned Whitten and Brieger patents; and their descriptions will therefore be limited to only that necessary for understanding their basic operation and general relation to one another and to the present invention.

As illustrated in FIG. 2, the fluid-sampling apparatus **10** is basically comprised of a hydraulic system **24** which utilizes the hydrostatic pressure of the well control fluids **13** to develop an increased hydraulic pressure for actuating the apparatus, sample-admitting means **19** and **20** employing the sealing members **22** and **23**, and a sample-collecting system **25** for obtaining a sample of connate fluids.

After the apparatus **10** has been positioned adjacent the formation **14**, the hydraulic system **24** is activated from the surface. The wall-engaging means **21** are extended to laterally shift the apparatus **10** and sealingly engage the sealing members **22** and **23** against the exposed face of the formation **14** for obtaining a fluid sample. Once a sample has been collected in the sample-collecting system **25**, the pressure in the hydraulic system **24** is relieved to disengage the wall-engaging means **21** and sample-admitting means **19** and **20** for retrieval of the apparatus **10**.

The hydraulic system **24** may, for example, be generally of the type described in U.S. Patent No. 3,011,554 granted to Robert Desbrandes and includes a master piston **26** slidably mounted in a stepped cylinder **27** in the body **18**. An electrically actuated "mud" valve **28** (such as shown in FIG. 4 of the Desbrandes patent) is selectively operable to admit the well control fluids **13** through a passage **29** into an enlarged-diameter portion **30** of the cylinder **27** above the piston **26**. Thus, whenever the mud valve **28** is opened, the hydrostatic pressure of the well control fluids **13** will drive the master piston **26** inwardly to develop a somewhat greater hydraulic pressure in a reduced-diameter portion **31** of the cylinder **27** below the piston. This developed hydraulic pressure will, of course, be equal to the product of the hydrostatic pressure multiplied by the ratio of the areas of the enlarged end **32** and the reduced end **33** of the piston **26**.

A pressure-regulating valve **34** (such as the one shown in FIGS. 8 and 8*a* of the Desbrandes patent) responds to the hydrostatic pressure of the well control fluids **13** to maintain the hydraulic pressure in an outlet conduit **35** downstream of the valve **34** at a predetermined differential above the hydrostatic pressure.

The hydraulic system **24** also includes a hydraulic fluid "dump" chamber **36** that is connected to a hydraulic actuator **37** of a normally-closed, pressure-equalizing valve **38** and via a normally-closed, electrically-actuated valve **39** (such as shown in FIG. 7 of the Desbrandes patent) to the main hydraulic conduit **35**. Dump chamber **36** is normally at atmospheric pressure and is divided into larger and smaller compartments **40** and **41** by a partition **42** in which an orifice **43** is mounted. When it is desired to retrieve the apparatus **10**, the electrically-actuated valve **39** is opened to admit hydraulic fluid from the main conduit **35** into the smaller compartment **41** of the dump chamber **36** and, via conduit **44**, to the actuator piston **37** of the pressure-equalizing valve **38**. Although the hydraulic pressure in the main conduit **35** is immediately reduced somewhat when valve **39** is opened, the lower compartment **41** and orifice **43** are suitably sized to enable the hydraulic actuator **37** to open the equalizing valve **38** before the hydraulic pressure has dropped to its final level.

The pressure-equalizing valve **38** is actuated by the actuator piston **37** which has a protruding stop **45** and is slidably received within an enlarged-diameter portion **46** of a stepped cylinder **47**. The reduced-diameter portion **48** of the cylinder **47** receives the slidable pressure-equalizing valve **38** which has a rearwardly extending projection **49** that is normally engaged against the forward face of the actuator piston **37**. In its normal position as illustrated in FIG. 2, the valve member **38** blocks fluid communication between a conduit **50** leading to the sample-admitting means **19** and **20** and a conduit **51** opening to the exterior of the apparatus **10**. Thus, it will be appreciated that whenever hydraulic fluid is admitted through valve **39** to the dump chamber **36**, the actuator piston **37** will shift the equalizing valve **38** outwardly to open fluid communication between conduits **50** and **51**.

The extendible wall-engaging means **21** on the opposite side of the body **18** from the sample-admitting means **19** and **20** are arranged to shift the apparatus **10** laterally in a borehole prior to taking fluid samples. The hydraulically actuated wall-engaging means **21** is comprised of an extendible back-up shoe **52** which is normally held in a retracted position by springs **53** against the body **18**. A piston actuator **54** is slidably received within a hydraulic cylinder **55** that is connected by a conduit **56** to the main hydraulic conduit **35**. Thus, whenever the mud valve **28** is opened, the increased pressure in the main hydraulic conduit **35** will urge the piston actuator **54** outwardly to extend the back-up shoe **52** against the adjacent exposed face of the formation.

Two different types of sample-admitting means **19** and **20** have been shown in FIG. 2 to illustrate two typical embodiments of sample-admitting means that may employ sealing members arranged in accordance with the present invention. The sample-admitting means **19** and **20** include longitudinally spaced lateral chambers **57** and **58** within the body **18**, with the chambers being open at one end and having the annular, elastomeric sealing members **22** and **23** mounted outside of the body around these openings to provide central openings **59** and **60** for

admitting fluid samples into the chambers. The chambers 57 and 58 are interconnected by a conduit 61 and connected via a normally-closed, electrically-actuated valve 62 and conduit 63 to the sample-collecting system 25.

A tubular member 64 is slidably and sealingly mounted within the forward portion of the chamber 57 and projects from the open end of the chamber. The forward end of the tubular member 64 is sealingly engaged within the central opening 59 through the sealing member 22. Thin-walled closure members 65 and 66 are mounted at opposite ends of the tubular member 64 to block flow through the central opening 59 and tubular member.

A shaped charge 67 is disposed in the rear of the upper chamber 57, with a thin-walled closure member 68 being mounted in front of the shaped charge to fluidly seal it within the rearward portion of the chamber. Thus, so long as it has not been detonated, the shaped charge 67 will be isolated from the sample-collecting system 25 and fluid can enter the apparatus body 18 only by way of sample-admitting means 20. The shaped charge 67 is connected to electrically responsive igniter means, such as a detonator cord 69 and a blasting cap 70, that are ignitable from the surface via a conductor 70*a* in the cable 11.

Sample-admitting means 20 in the lower chamber 58 include an actuator piston 71 that is sealingly and slidably mounted in the rear of the chamber and adapted to urge a tubular probe 72 forwardly in the chamber and through an annular member 73 mounted within the central opening 60 in the sealing member. This "snorkel" tube 72 may, for example, be generally arranged as shown in FIG. 3 of the aforementioned Whitten patent. An O-ring 74 in the annular member 73 fluidly seals the forward end of the snorkel tube 72. Thus, fluids must enter the open forward end of the snorkel tube and enter the chamber 58 by way of a lateral port 75 in the tube.

For delaying the operation of the sample-admitting means 20 until the wall-engaging means 21 has shifted the apparatus 10 against the formation, a conduit 76 having an orifice 77 therein connects the main hydraulic conduit 35 to the enclosed space behind the actuator piston 71 at the rear of the chamber 58.

The sample-collecting system 25 includes a sample-receiving chamber 28 which has a normally-open, hydraulically-actuated, closure or seal valve 79 (such as shown in FIG. 10 of the Desbrandes patent). The seal valve 79 is comprised of an actuator piston 80 slidably disposed in a cylinder 81 and carrying a valve member 82 adapted to move into engagement with a complementary valve seat 83 at the entrance of the sample-receiving chamber 78 to block flow communication with the main fluid conduit 63.

The seal valve 79 is normally held open but, once it has been actuated, it will be latched in a closed position. A normally-closed, electrically actuated valve 84 connects the upper portion of the cylinder 81 to the main hydraulic conduit 35. Thus, to shut off fluid flow from the main fluid conduit 63, opening of the valve 84 will admit hydraulic fluid into the cylinder 81 above piston 80 and shift the valve member 82 downwardly into sealing engagement with the valve seat 83.

The sample-receiving chamber 78 generally includes upper and lower compartments 85 and 86 separated by a partition 87 having a flow restriction or orifice 88. A liquid cushion 89, such as water, is disposed in the upper compartment 85 and isolated from the upper portion thereof by a floating piston 90 which is sealingly engaged within the upper compartment. Since the lower compartment 86 is empty, the connate fluids entering the sample-receiving chamber 78 from conduit 63 move the piston 90 downwardly at a rate regulated by the flow of water 89 through the orifice 88.

Pressure transducers 91 and 92 are provided to continuously monitor the pressure in the hydraulic system 24 and sample-collecting system 25. These transducers 91 and 92 may, for example, be of the type shown in FIG. 9 of the Desbrandes patent and are connected by electrical leads 91*a* and 92*a* to the pressure indicating-and-recording apparatus 17 (FIG. 1) at the surface of the earth. Thus, by observing the variations in these pressure measurements, a skilled operator will be advised of each step in the operating cycle of the fluid-sampling apparatus 10.

To operate the sample-taking apparatus 10 illustrated in FIGS. 1 and 2, the apparatus is positioned in a borehole 12 adjacent a particular formation 14 of interest. Then, by connecting the power source 16*b* through switch 16*a* to cable conductor 28*a*, the mud valve 28 will be opened to admit well control fluids 13 from the passage 29 into the upper portion 30 of the master cylinder 27. This will drive the master piston 27 downwardly and develop a substantially greater hydraulic pressure in the reduced-diameter portion 31 of the cylinder 27. The pressure-regulating valve 34 will operate to admit hydraulic fluid into the main hydraulic conduit 35 and maintain the pressure therein at a substantially constant differential above the hydrostatic pressure of the well control fluids 13.

Since the other normally-closed valves 39 and 84 are not yet opened, the hydraulic fluid will be admitted initially only to conduits 56 and 76 leading to the wall-engaging means 21 and the sample-admitting means 20, respectively. However, in view of the restrictive effect of the orifice 77 in conduit 76, the piston actuator 54 will operate first and extend the back-up shoe 52 against one face of the borehole 12 to shift the apparatus 10 laterally in the opposite direction. Once the apparatus 10 has been shifted laterally, the annular sealing members 22 and 23 will be sealingly engaged against the opposite face of the borehole 12.

Once the hydraulic pressure in the conduit 76 downstream of the orifice 77 has risen above the hydrostatic pressure, it will be realized that the actuator piston 71 will move outwardly to urge the forward end of the snorkel tube 72 against the formation 14. Thus, it will be appreciated that the orifice 77 will delay the operation of the sample-admitting means 20 until the sealing member 22 and 23 are sealingly engaged against the exposed face of the formation 14. It will be understood also that by monitoring pressure transducer 91, the operator can determine when the sealing members 22 and 23 have been fully engaged.

Once the hydraulic pressure behind piston 71 has built up to a sufficient magnitude to extend the snorkel tube 72 through the central opening 60 of the sealing member 23, the forward end thereof will be engaged against the formation 14. Should there be a recoverable and flowable connate fluid therein and the formation 14 is unconsolidated, upon opening of the flow-line valve 62, the sampling tube 72 will be forced by the hydraulic pressure into the formation as the fluids and loose formation particles flow into the tube. Should, however, the formation 14 be so well consolidated that no particles are washed away, the tube 72 will still remain against the formation and the connat fluids will flow into the sampling tube and on into the sample-receiving chamber 78. It should be noted that although well control fluids 13 will enter the sample-admitting means 20 before it is actuated, their total volume will be known. Thus, since this known volume of fluids 13 is so small relative to the volume of chamber 78, their negligible effect can be corrected when analyzing the fluids trapped in the chamber.

It will be appreciated, of course, that whenever the flow-line valve 62 is opened, the pressure in the main fluid conduit 63 will be immediately reduced. Thus, by monitoring pressure transducer 92, a skilled operator can determine that a fluid sample has entered the sample-receiving chamber 78.

Should there be no fluid sample collected by sample-admitting means 20, the operator will then connect the

power switch 16*a* to cable conductor 70*a* to detonate the shaped charge 67 of the alternate sample-admitting means 19. Upon detonation of the shaped charge 67, the thin-walled closure members 65, 66 and 68 will be punctured and the perforating jet will perforate the formation 14. Accordingly, should there be recoverable connate fluids that can flow into the resultant perforation, they will enter sample-admitting means 19 and flow into the sample-receiving chamber 78 by way of conduits 61 and 63.

Whenever pressure measurements indicate that the sample-collecting chamber 78 is most likely full, the power switch 16*a* is connected to cable conductor 84*a* to open valve 84. Opening of valve 84 will admit hydraulic fluid from the main conduit 35 to the piston actuator 80 of the seal valve 79 and close off the sample-receiving chamber 78.

To recover the apparatus 10, the power switch 16*a* is connected to conductor 39*a* to open valve 39 to relieve the hydraulic pressure holding the wall-engaging means 21 in position. Opening of valve 39 will admit hydraulic fluid to the lower compartment 41 of the dump chamber 36 as well as to the rear of cylinder 46 behind the piston actuator 37 of the pressure-equalizing valve 38. As previously explained, however, the hydraulic pressure in conduit 44 will decrease slowly so that the actuator 37 will be able to first shift the equalizing valve 38 outwardly from its flow-blocking position between conduits 50 and 51. Once the well control fluids 13 are admitted from conduit 51 into the sample chambers 57 and 58, the fluid pressure across the sealing members 22 and 23 will be equalized. Finally, as the hydraulic pressure drops in the main conduit 35, the hydrostatic pressure of the well control fluids 13 will, with the assistance of springs 53, retract the back-up shoe 52 to free the apparatus 10 and allow it to be retrieved.

Turning now to FIG. 3, a partial cross-sectional view in elevation is shown of a portion of the body 18 and sample-admitting means 19 employing a preferred embodiment of the sealing member 22 arranged in accordance with the present invention.

Sample-admitting means 19 include a tubular body member 93 that is threadedly engaged in the forward end of the lateral chamber 57 in the apparatus 10, with an enlarged-diameter forward portion 94 of the member being received within a counterbored recess 95 in the body 18 at the forward end of the chamber. A plurality of transverse passages 96 through the wall of the body member 93 provide fluid communication from its axial bore 97 to a circumferential groove 98 around the member. O-rings 99 and 100 on both sides of the circumferential groove 98 fluidly seal the body member 93 in the lateral chamber 57 and isolate the forward portion of the chamber that is in communication with the branch conduit 50 and interconnecting conduit 61 to the other sample-admitting means.

The shaped charge 67 is disposed in the rear of the lateral chamber 57, with the forward end of the shaped charge being coaxially aligned and directed toward the axial bore 97 of the body member 93. The thin-walled closure member 68 is threadedly secured at the rear of the axial bore 97 of the body member 93 and fluidly sealed therein by means of an O-ring 101.

The sealing member 22 is arranged in accordance with the principles of the present invention and is comprised of a rigid support member having an enlarged-diameter base portion 102 and a generally tubular, reduced-diameter, central portion 103 projecting forwardly therefrom. A plurality of flat, annular, disc-like members 104–106 are spaced apart and mounted around the projecting central portion 103. An elastomeric material 107 is molded around the central member 103 and spaced support plates 104–106 and bonded against the forward face 108 of the base portion 102. A plurality of rearwardly extending projections 109 from the elastomeric material 107 are provided with inwardly directed lips 110 that are received within an annular groove 111 around the periphery of the enlarged forward portion 94 of the tubular body member 93. The forward face 112 of the elastomeric material 107 in sealing member 22 is curved at least in the horizontal plane so as to generally conform to the curvature of a borehole. A laterally projecting lug 113 from the base portion 102 is received within a complementary groove in the body 18 to align the sealing member 22 properly.

Although it will be appreciated that when used with other types of sample-admitting means (such as at 20) the sealing member (such as at 23) may be secured against the body 18, in this illustrative embodiment of typical sample-admitting means 19, the sealing member 22 travels forwardly a limited distance during the operation of the sample-admitting means.

Accordingly, to employ the sealing member 22 as a "follower-type packer," the forward end of the slidable tubular member 64 is secured within the tubular central portion 103 and extends rearwardly therefrom into the forward portion of the axial bore 97 through the tubular body member 93. A peripheral flange 114 around the rearward end of the slidable tubular member 64 is provided to limit the extent of the forward travel of the tubular member and sealing member 22. O-rings 115 and 116 respectively mounted in the enlarged-diameter portion 94 of the tubular body member 93 and inner bore of the tubular central portion 103 fluidly seal the slidable tubular member 64 therein.

A plurality of circular grooves 117 interconnected by radial or transverse grooves (not shown) across the forward face of the enlarged-diameter portion 94 of the tubular body member 93 admit well control fluids 13 into the space defined thereby behind the rearward face of the enlarged-diameter base portion 102. The thin-walled closure members 65 and 66 may be arranged by closing the forward and rearward ends of the slidable tubular member 64 so as to provide a sealed chamber 118 therein until the shaped charge 67 is detonated. It will be appreciated that the chamber 118 within the slidable tubular member 64 will remain free of fluid until opened by the perforating jet. Thus, not only is the penetrating jet allowed to form without undue interference from liquids, but the central tubular portion 103 will not be swelled by explosive pressures from detonation of the shaped charge 67 that otherwise would occur should liquids be within the slidable tubular member 64.

The support plates 104–106 are preferably spaced apart by a corresponding number of forwardly directed shoulders, such as at 119, on the periphery of the central tubular portion 103. Thus, during the molding of the elastomeric material 107, the support plates 104–106 will be correctly positioned after the elastomeric material has been molded in place.

Although it is generally preferred that these support plates 104–106 be circular, they may also be made in other shapes. For example, since the forward face 112 of the sealing member 22 is preferably curved in the horizontal plane (not shown) to fit the curvature of a borehole, it will be appreciated that the plates 104–106 may be made somewhat elliptical with their length along their major axis being as shown in FIG. 3 and their length along their minor axis (perpendicular to the plane of FIG. 3) being somewhat reduced to maintain their periphery a short distance within the elastomeric material 107. Thus, by providing a slight clearance (such as at 120 and 121) in every radial direction around each of the support plates 104–106, the peripheral portions of the elastomeric material 107 will be relatively unrestrained and be capable of moving freely in any direction to fill an adjacent cavity in an earth formation.

Although the support plates 104–106 may be secured to the central tubular portion 103, for example as on shoulder 119, it is preferred that these plates remain free relative to the central portion 103. Thus, by allowing the plates

104–106 to remain free, they may move forwardly from their respective shoulders as the resilient material 107 is extruded toward an earth formation. Then, when the resilient material 107 returns to its normal position, the plate members 104–106 will be free to return to their normal position as shown in FIG. 2. Similarly, it will be realized that should pressure differentials tending to extrude the elastomeric material 107 be directed transversely to the central axis through the sealing member 22, the support plates 104–106 will be free to tilt relative to the central axis and thereby better equalize the load on the sealing member.

It will be further appreciated that although it is preferable that the elastomeric material 107 be wholly integral and bonded to most, if not all, surfaces of the support plates 104–106 and portions 102 and 103 of the support member, the hydrostatic forces normally encountered in deep boreholes will often tear the elastomeric material away from a metal surface to which it is bonded. Accordingly, it is within the scope of the present invention to mold the elastomeric material 107 in a unitary form as shown, with the support plates 104–106 being embedded therein. Then, this assembly could be snugly fitted over the central portion 103 of the support member. Similarly, the elastomeric material 107 could also be formed in individual annular sections with the support plates 104–106 being interspersed therebetween.

Accordingly, upon operation of sample-admitting means 19, it will be appreciated that after the shaped charge 67 has been detonated to puncture the closure members 65, 66 and 68, connate fluids will be admitted through the punctured forward closure member 65 and into the slidable tubular member 64. From there, the connate fluids will flow through the transverse passages 96 and conduit 61 to the main sample conduit 63 in the body 18.

As connate fluids are produced from an unconsolidated formation, the pressure within the central opening 59 will approach atmospheric pressure because of the sudden drop in pressure as connate fluids are first admitted into the sample-receiving chamber 78. The hydrostatic pressure of the well control fluids 13 will act through the transverse grooves and circular grooves 117 on the forward face of the body member 93 to urge the sealing member 22 and tube 64 outwardly toward the formation. It will be realized, of course, that as the adjacent formation crumbles, the sealing member 22 will be able to travel forwardly thereinto until its forward travel is arrested by the peripheral flange 114 at the rear of the slidable tubular member 64.

Turning now to FIG. 4, a cross-sectional view is shown in plan of the sealing member 22 illustrated in FIG. 3 as connate fluids are being withdrawn from the unconsolidated earth formation 14 in the direction of arrows 122. Pressure in front of the sealing member 22 will, of course, be no greater than formation pressure and will most likely be substantially less. Thus, it will be appreciated that the hydrostatic pressure of the well control fluids 13 will be acting as shown by arrows 123 and 124 against the exposed portions of the sealing member 22 and tend to extrude the elastomeric material 107 inwardly into the resulting cavity 125 in the formation. The support plates 104–106, however, not only serve as a bridge across the cavity 125 to support the elastomeric material 107, but will also serve to distribute the forces more evenly across the sealing member 22. Accordingly, although high differential pressures can urge the elastomeric material 107 so far forwardly into the cavity 125 that at least the forwardmost support plate 106 is beyond the forward end of the tubular central portion 103, the sealing member 22 will still be effective until the cavity has enlarged sufficiently to allow well control fluids 13 to bypass the sealing member at a circumferential point.

Thus, when a sealing member formed in accordance with the principles of the present invention is employed with sample-admitting means, such as those shown at 19 and 20 in FIGS. 1 and 2, the sealing member will provide a more effective seal with the sidewall of the borehole than has heretofore been possible with conventional sealing members. Although the foregoing description has been specifically directed to a so-called "follower-type packer" such as described in the aforementioned Brieger and Voetter patent, the same principles may be employd with a sealing member that is fixed to the body of the fluid-sampling apparatus. In this latter instance, of course, it will be understood that the sealing member will be capable of maintaining an effective seal only so long as the resultant cavity in the earth formation has not progressed beyond the periphery of the sealing member.

Thus, it will be appreciated that the present invention has provided new and improved sealing means for use with fluid-sampling apparatus (such as at 10 in FIGS. 1 and 2) that is capable of maintaining an effective pressure seal against the sidewall of a borehole traversing a relatively soft or unconsolidated earth formation. By providing rigid support members, such as plates 104–106, within the elastomeric material, the sealing member of the present invention will be well supported to withstand the excessively high pressure differentials imposed by well control fluids in a deep well as well as be better able to carry such loads in view of the better distribution of forces thereon.

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

What is claimed is:

1. A sealing pad adapted for sealing against the wall of a well bore traversing earth formations comprising: a tubular member; reinforcing means extending laterally of said tubular member and movable relative thereto; resilient sealing means around said tubular member and reinforcing means, said resilient sealing means having a forward sealing surface adapted for sealing engagement with a wall of a well bore; and means for supporting the rearward portions of said tubular member and resilient sealing means.

2. A sealing pad adapted for sealing against the wall of a well bore traversing earth formations comprising: a tubular member; reinforcing means including at least one plate member disposed intermediate of the ends of said tubular member and extending laterally therefrom; resilient sealing means encompassing said reinforcing means and tubular member, said resilient sealing means having a forward sealing surface adapted for sealing engagement with a wall of a well bore; and means for supporting the rearward portions of said tubular member and resilient sealing means.

3. A sealing pad adapted for sealing against the wall of a well bore traversing earth formations comprising: a tubular member; reinforcing means including a plurality of plate members extending laterally of said tubular member at spaced intervals intermediate of the ends of said tubular member; resilient sealing means providing a forward sealing surface adapted for sealing engagement with a wall of a well bore, said sealing means encompassing said tubular member and extending laterally from between said plate members beyond their outer edges; and means for supporting the rearward portions of said tubular member and resilient sealing means.

4. A sealing pad adapted for sealing against the wall of a well bore traversing earth formations comprising: a rigid member having a rearward base portion and a central tubular portion projecting forwardly from said base portion; a plurality of rigid annular plate members mounted around said tubular portion at spaced intervals intermediate of the free end of said tubular portion and said base portion; and resilient sealing means extending for-

wardly of said base portion and providing a forward sealing surface adapted for sealing engagement with a wall of a well bore, said sealing means encompassing said tubular portion and said plate members.

5. A sealing pad adapted for sealing against the wall of a well bore traversing earth formations comprising: a rigid member having a rearward base portion and a central tubular portion projecting forwardly from said base portion and having a plurality of external shoulders at spaced intervals intermediate of the free end of said tubular portion and said base portion; a plurality of rigid annular plate members mounted around said tubular portion and disposed against said shoulders; and resilient sealing means extending forwardly of said base portion and providing a forward sealing surface adapted for sealing engagement with a wall of a well bore, said sealing means encompassing said tubular portion and said plate members.

6. For apparatus used in a well bore traversing earth formations and containing well control fluids and including means for sealing-off a portion of the wall of a well bore and for passing fluid between the earth formations and the interior of said apparatus, the improvement comprising: a sealing pad adapted for sealing against the wall of a well bore including; a rigid member having a rearward base portion mounted on said apparatus and a central tubular portion projecting forwardly from said base portion; a plurality of rigid annular plate members mounted around said tubular portion at spaced intervals intermediate of the free end of said tubular portion and said base portion; and resilient sealing means extending forwardly of said base portion and providing a forward sealing surface adapted for sealing engagement with a portion

of the wall of a well bore, said sealing means encompassing said tubular portion and said plate members.

7. For apparatus used in a well bore traversing earth formations and containing well control fluids and including means for sealing-off a portio of the wall of a well bore and for passing fluid between the earth formations and the interior of said apparatus, the improvement comprising: a sealing pad adapted for sealing against the wall of a well bore including; a rigid member having a rearward base portion mounted on said apparatus and a central tubular portion projecting forwardly from said base portion and having a plurality of external shoulders at spaced intervals intermediate of the free end of said tubular portion and said base portion; a plurality of rigid annular plate members mounted around said tubular portion and disposed against said shoulders; and resilient sealing means extending forwardly of said base portion and providing a forward sealing surface adapted for sealing engagement with a portion of the wall of a well bore, said sealing means encompassing said tubular portion and said plate members.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,344,860 October 3, 1967

Ulrich E. Voetter

It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

In the heading to the printed specification, lines 4 and 5, "Schlumberger Well Surveying Corporation" should read -- Schlumberger Technology Corporation --. Column 2, line 63, "fowardly" should read -- forwardly --. Column 6, line 43, "member" should read -- members --. Column 12, line 5, "portio" should read -- portion --.

Signed and sealed this 23rd day of September 1969.

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents