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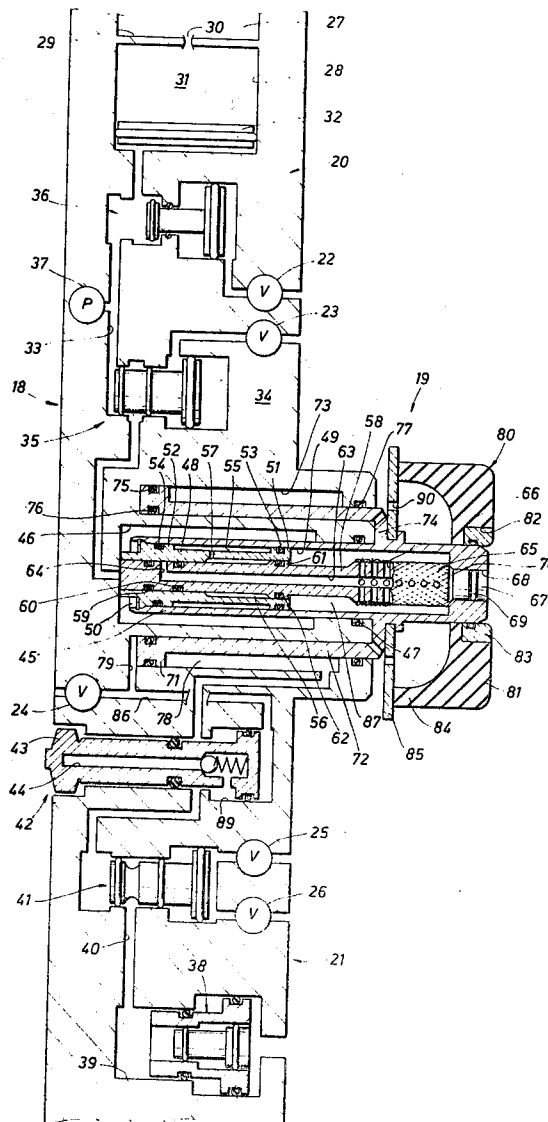
[54] **FORMATION-SAMPLING APPARATUS**
13 Claims, 4 Drawing Figs.

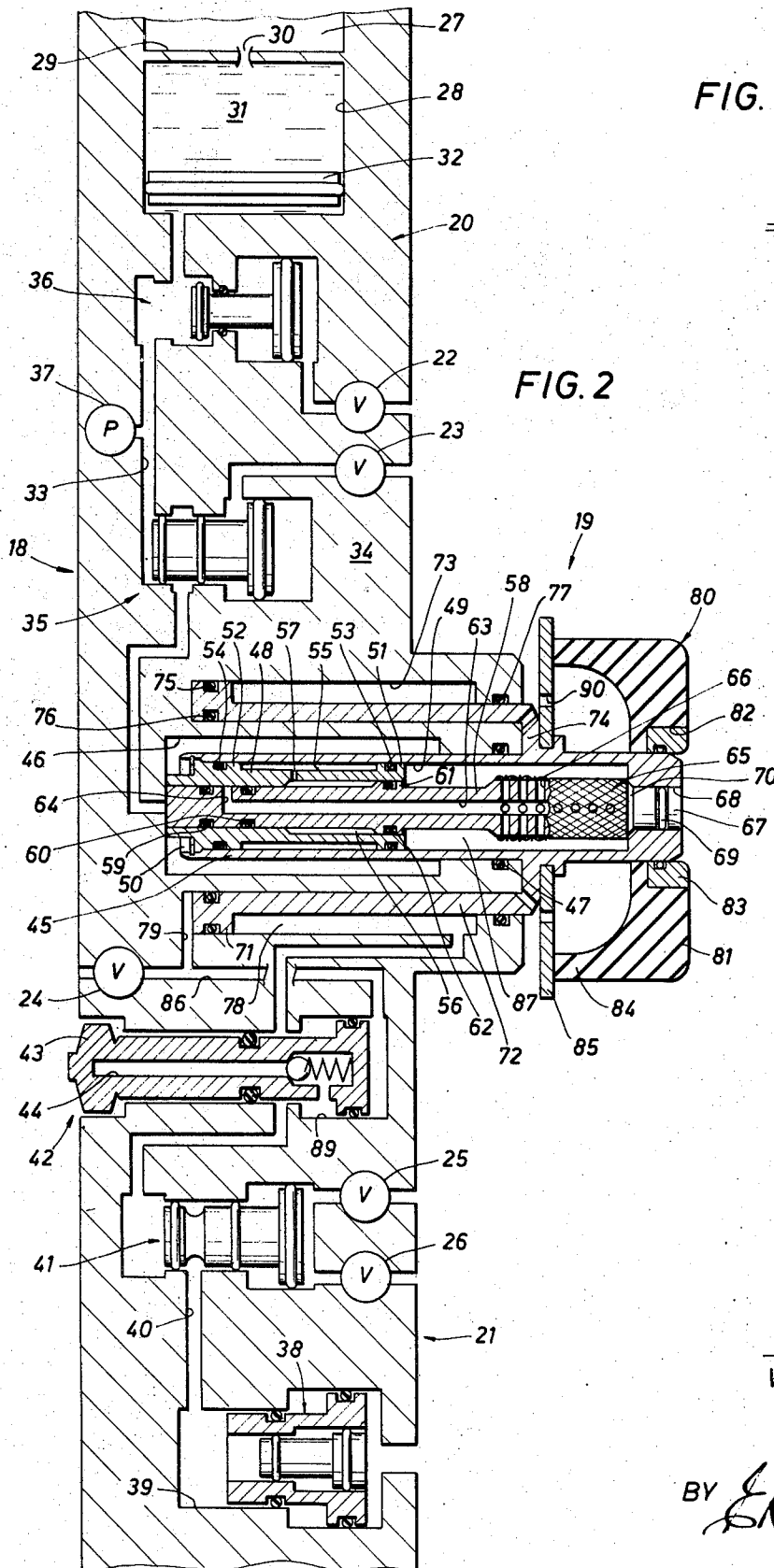
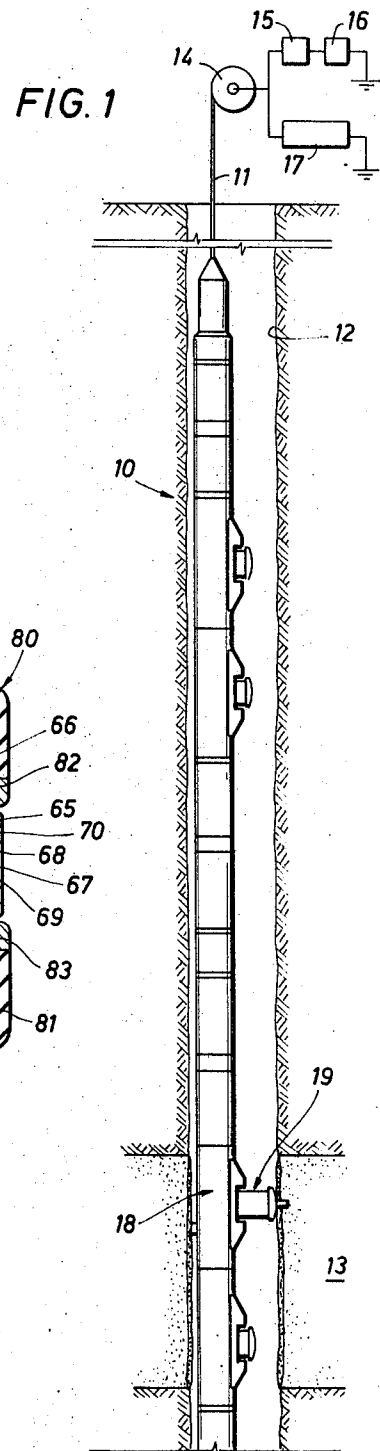
[52] U.S. Cl. 166/100
[51] Int. Cl. E21b 49/00
[50] Field of Search 166/55.1,
100; 175/4.52

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ABSTRACT: In each of the several embodiments of the new and improved fluid-sampling apparatus disclosed herein, sample-admitting means adapted to be selectively advanced therefrom include a sealing pad uniquely arranged around the forward end of a tubular sampling member so that, upon contacting a borehole wall, the wall-engaging face of the sealing pad will effect firm sealing engagement therewith. Thereafter, continued advancement of the sample-admitting means will longitudinally compress the sealing pad rearwardly in relation to the sampling member to enable the forward end of the tubular member to penetrate at least the layer of mudcake lining the surface of the borehole wall. Means are further provided for urging the sealing pad against the borehole wall to insure that the projected forward end of the sampling member is isolated from borehole fluids.





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FIG. 3

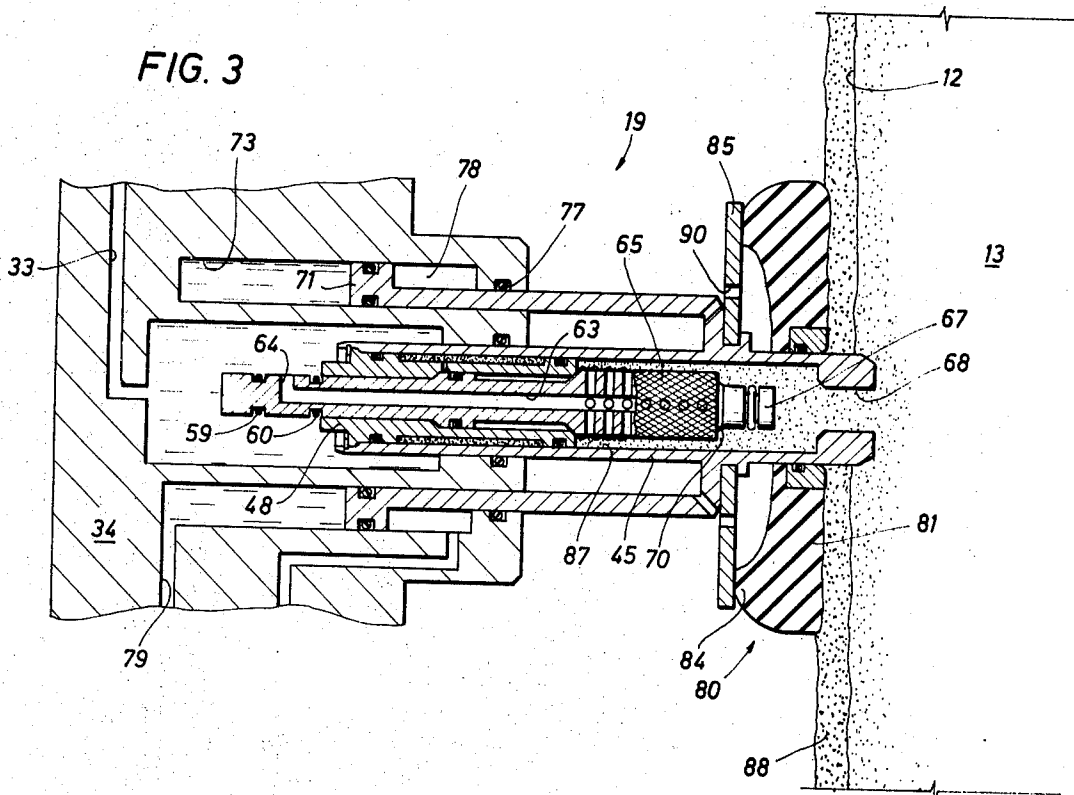
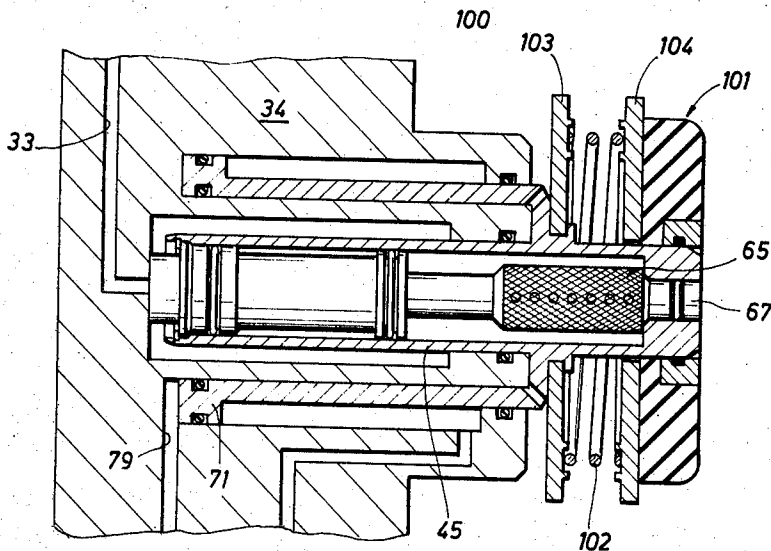


FIG. 4



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FORMATION-SAMPLING APPARATUS

Although the new and improved fluid-sampling tools disclosed in U.S. Pat. No. 3,385,364 have generally been highly successful, there have nevertheless been occasion where at least one of the several testing units on such a tool did not effect satisfactory fluid communication with an earth formation to obtain a fluid sample therefrom. For example, in some instances, one or more of the wall-engaging sealing pads on these tools may not make a satisfactory sealing engagement with the borehole wall where the formations being investigated are relatively unconsolidated. The problem here is attributed to the inability of the pad members to remain in sealing engagement with the borehole wall since such unconsolidated formation materials will tend to be rapidly eroded away from under the face of the pad as a fluid sample is being withdrawn.

To reduce the rate at which these unconsolidated formation materials are washed away, fluid-sampling tools have typically included means for regulating the flow rate at which fluid samples are admitted. In one manner of accomplishing this, a slidable piston is operatively arranged within the sample-receiving chamber of each testing unit to slowly displace a quantity of water contained therein through an orifice into an adjacent atmospheric chamber as the pressured fluid sample is admitted into the sample chamber on the opposite side of the piston.

Although this and other measures have improved the odds of obtaining fluid samples from unconsolidated formations, there are still some problems arising in the use of such apparatus. For example, where the flow rate at which a sample is obtained must be greatly limited, the fluid-sampling tool often must be held in position for perhaps an hour. Such long waits generally make it necessary to continually reciprocate the suspension cable to prevent it from becoming stuck in the well as by differential sticking of key-seating. Moreover, extended testing cycles will expend valuable rig time as well as reduce the number of operations that can be conducted during an allotted time. It will also be recognized that the overall length of each testing unit must be increased simply to accommodate the volume of water or so-called "water cushion" carried in the sample chamber.

Attempts have also been made to limit the flow rate by locating small orifices and the like in the sample passages. This has not been successful, however, since fluent materials, such as mudcake and loosened formation particles, entering the sampling apparatus frequently plug these necessarily-small restrictors. It has also been found that filters ahead of such flow restrictors are readily plugged by such fluent materials. As a result, the aforementioned water cushion is still the most-reliable arrangement for fluid-sampling tools of this nature.

Accordingly, it is an object of the present invention to provide new and improved fluid-sampling apparatus operatively arranged for reliably effecting fluid communication with various types of borehole surfaces and formation materials.

Another object of the present invention is to provide new and improved fluid-sampling apparatus that is capable of taking fluid samples at rapid flow rates without disrupting fluid communication with the formation.

Still another object of the present invention is to provide a new and improved fluid-sampling apparatus that does not necessarily require a space-consuming water cushion in its sample-receiving chamber.

These and other objects of the present invention are attained by new and improved fluid-sampling apparatus having sample-admitting means including a tubular sampling member adapted to be placed in fluid communication with a selected surface of a borehole wall. To isolate the forward end of the tubular member from the borehole fluids, packing means are uniquely mounted around the tubular member and adapted to be urged into sealing engagement with the borehole wall for isolating the selected surface. Means are provided for strongly urging the forward end of the sampling member in relation to the sealing member so that the forward end of the tubular

member will penetrate at least the layer of mudcake on the borehole wall. The sample-admitting means further includes means for limiting the entrance of unconsolidated formation particles as well as mudcake from the borehole wall or other unwanted debris or fluent matter that might otherwise tend to impede or halt the fluid-sampling operation.

The novel features of the present invention are set forth with particularity in the appended claims. The invention, together with further objects and advantages thereof, may be best understood by way of the following exemplary apparatus employing the principles of the invention as illustrated in the accompanying drawings, in which:

FIG. 1 depicts fluid-sampling apparatus of the present invention as it might appear within a borehole;

FIG. 2 is a somewhat-schematic representation of one preferred embodiment of the apparatus depicted in FIG. 1;

FIG. 3 is a partial view similar to FIG. 2 but illustrating the apparatus at a subsequent stage of typical testing operation; and

FIG. 4 depicts an alternative embodiment of fluid-sampling apparatus also employing the principles of the present invention.

Turning now to FIG. 1, fluid-sampling apparatus 10 incorporating the principles of the present invention is shown suspended from a multiconductor cable 11 in a well bore such as a borehole 12 containing a well control fluid. The apparatus 10 has been positioned adjacent a particular formation interval 13 for collecting a sample of producible fluids from that formation. The cable 11 is spooled in the usual manner from a winch 14 at the earth's surface, with some of its conductors being connected to a switch 15 for selective connection to a power source 16 and others being connected to typical indicating-and-recording apparatus 17. To permit a number of tests to be made during a single trip into the borehole 12, the fluid-sampling apparatus 10 is comprised of a corresponding number of tandemly-arranged sampling units, as at 18, that are each capable of independent operation and respectively include extendible sample-admitting means 19 (or 100) spatially disposed along one side of the sampling apparatus. As illustrated in FIG. 1, one of the sample-admitting means 19 (or 100) has been extended into fluid communication with the exposed face of the formation 13 for obtaining a sample of connate fluids therefrom.

As illustrated schematically in FIG. 2, each testing unit 18 of the fluid-sampling apparatus 10 is basically comprised of the selectively-extendible sample-admitting means 19 for obtaining samples of formation fluids, sample-collecting means 20 for recovering such samples, and selectively-operable means 21 for retracting the sample-admitting means. To operate these several means 19-21, a number of selectively-operable, normally-closed valves 22-26 are operatively arranged for selectively admitting well control fluids from the borehole 12 to their respectively associated pressure-responsive means to utilize the hydrostatic pressure of the borehole fluids as a source of motivating power.

Generally speaking, the several means 20-26 of the apparatus of the present invention are arranged similarly to their respective counterparts shown in U.S. Pat. No. 3,385,364 to employ the hydrostatic pressure of the fluids in the borehole 12 for operation of the apparatus 10. Thus, as will subsequently be described, the valves 22-26 are normally closed; and as the valves are successively opened in response to electrical signals from the surface, the well control fluids are selectively directed to the particular pressure-responsive means 19 (or 100) as well as 20 and 21 that each valve is controlling. Accordingly, these several means 20-26 are illustrated only schematically in FIG. 2 and need to be described only as is necessary to understand their functions in the new and improved tool 10 of the present invention.

The sample-collecting means 20 include a sample receiver which, as illustrated, may in some circumstances be divided into upper and lower chambers 27 and 28 separated from one another by a partition 29 having a flow restriction or orifice 30

therein. When these dual chambers 27 and 28 and interconnecting orifice 30 are employed, a liquid cushion 31 (such as water) is initially disposed in the lower chamber 28 and isolated therein by a floating piston 32. Since the upper chamber 27 is initially empty and at a low or atmospheric pressure, formation fluids (at whatever the formation pressure is) entering the sample chamber 28 will move the piston 32 toward the partition 29 at a rate regulated by the discharge of the water cushion 31 through the orifice 30. As previously discussed, however, elimination of the water cushion 31 will reduce the overall length of each testing unit 18. Thus, as will subsequently be appreciated, the success of the present invention does not depend upon the water cushion 31 and it has been illustrated here only to show that it may be used, if desired, with the new and improved formation-sampling apparatus 10 of the present invention.

To conduct fluid samples from the sample-admitting means 19 (or 100) to the sample-collecting means 20, passage means are included such as a fluid passage 33 in the body 34 of the apparatus 10 that is serially divided by a pair of pressure-actuated valves 35 and 36 operatively arranged so that the first valve 35 is selectively opened to admit a fluid sample to the sample chamber 28 and the second valve 36 is selectively closed to trap the sample therein. A pressure transducer 37 is connected to an intermediate portion of the passage 33 between the valves 35 and 36 and adapted to provide representative signals that are transmitted through the cable 11 to the indicating-and-recording apparatus 17 at the surface.

As fully described in the aforementioned patent, the retracting means 21 are comprised of one or more pressure-developing pistons 38 operatively arranged in a hydraulic chamber 39 that is coupled by way of an outlet passage 40 and a normally-closed pressure-actuated valve 41 to an emergency release apparatus 42 and the sample-admitting means 19 (or 100). Whenever the hydraulic valve 41 is opened, a pressured hydraulic fluid is operatively employed for retracting the sample-admitting means 19 (or 100). It will be understood, of course, that so long as the hydraulic valve 41 remains closed, the hydraulic pressure developed by the pressure-developing pistons 38 will be inoperative. To actuate the hydraulic valve 41, one, or preferably two, control valves, as at 25 and 26, are arranged for selective operation in response to signals from the surface. By arranging the control valves 25 and 26 in parallel, should one valve fail to open, the other control valve will provide a second opportunity for opening the hydraulic valve 41.

Should some malfunction in the retracting means 21 prevent the retraction of the sample-admitting means 19 (or 100), the emergency release apparatus 42 is arranged to selectively admit the borehole fluids into the apparatus 10 for equalizing the pressure differential across the sample-admitting means. As described in U.S. Pat. No. 3,385,364, the emergency release apparatus 42 is associated with an extendible wall-engaging piston member 43 that (upon opening of the control valve 24) is adapted to displace the tool body 34 away from one wall of the borehole 12 as the sample-admitting means 19 (or 100) are being extended in the opposite direction toward the other wall of the borehole. Ordinarily upon opening of the hydraulic valve 41, the wall-engaging piston 43 will be retracted along with the sample-admitting means 19 (or 100). However, should there be some malfunction, borehole fluids will be admitted into the passage 40 once the outer end of the extendible wall-engaging member 43 is broken to open an enclosed axial passage 44 therein.

In the sample-admitting means 19 shown in FIG. 2, an elongated tubular member 45 is slidably disposed for longitudinal movement within a lateral bore 46 formed in the body 34 of the testing unit 18 and fluidly sealed in relation thereto as by an O-ring 47 coaxially mounted around the forward portion of the lateral bore. In the preferred arrangement of the sample-admitting means 19, a tubular body 48 is coaxially mounted in the rearward portion of the axial bore 49 of the tubular

member 45 and secured against longitudinal movement therein. As seen generally at 50 in one manner of preventing this movement the rearward end of the tubular body 48 is slightly enlarged and secured within a complementary counterbore formed in the rearward end of the outer tubular member by a snap ring.

Enlarged-diameter shoulders 51 and 52 on the forward and rearward ends of the tubular body 48 are fluidly sealed by O-rings 53 and 54 within the outer tubular member to define an enclosed annular space 55 between the O-rings and the tubular members 45 and 48 that is initially at atmospheric pressure. In its preferred form, the forward portion of the tubular body 48 is counterbored, as at 56, and a restricted lateral passage 57 is arranged through the wall of the body for communicating the rear of the counterbore with the annular space 55.

An elongated valve member such as a cylindrical body 58 is slidably disposed in the tubular member 45 and provided with a pair of closely-spaced O-rings 59 and 60 on its rear portion sealingly engaged within the reduced bore at the rear of the tubular body 48. An enlarged-diameter shoulder 61 near the midportion of the valve member 58 carries an external O-ring 62 that is sealingly received within the counterbore 56 at the forward end of the tubular body 48. An axial bore 63 extending rearwardly from near the forward end of the cylindrical body 58 is terminated at a lateral passage 64 through the wall of the body between the spaced O-rings 59 and 60 thereon. The forward portion of the cylindrical body 58 is preferably enlarged and is covered with a suitable filtering member of finely-meshed screen 65 that covers a plurality of small apertures or lateral holes 66 in the enlarged extension. The cylindrical forward end 67 of the valve member 58 is adapted for complementary reception in an axial bore 68 defining the entrance of the tubular member 45 and is sealingly engaged therewith by means such as an O-ring 69 carried on this forward end portion.

It will, of course, be recognized that the shoulder 70 formed by the junction of the reduced forward end 67 of the valve member 58 and the enlarged portion thereof carrying the screen 65 will prevent forward movement of the valve member in relation to the tubular member 45. Moreover, in the preferred manner of securing the valve members 58 against rearward movement with the sample-admitting means 19 in the illustrated retracted position, the rear end of the valve member is adapted to be abutted against the rear wall of the housing bore 46. It will be realized, therefore, that although the hydrostatic pressure of borehole fluids will be acting on the forward end 67 of the valve member 58, the valve member cannot shift rearwardly so long as the sample-admitting means 19 are retracted.

To selectively extend the sample-admitting means 19, piston means, such as an enlarged annular piston member 71 having a tubular forward extension 72, are slidably disposed in an enlarged annular bore 73 formed coaxially in the tool body 34 around the lateral bore 46 and coupled, as at 74, to the forward portion of the tubular member 45. O-rings, as at 75 and 76, are appropriately arranged around and within the piston member 71 for fluidly sealing the piston member within the enlarged coaxial bore 73; and an O-ring 77 is coaxially mounted around the forward end of the enlarged bore for fluidly sealing the tubular piston extension 72 in relation to the tool body 34 and defining an enclosed annular space 78 ahead of the piston that is initially at atmospheric pressure. Accordingly, it will be appreciated that upon introduction of borehole fluids through a passage 79 into the rear of the enlarged annular bore 73 behind the piston member 71, the sample-admitting means 19 will be urged forwardly in relation to the tool body 34 and toward an adjacent wall of the borehole 12.

An elastomeric packing element 80 is coaxially mounted on the forward end of the tubular member 45 and uniquely arranged to be longitudinally compressed in relation to the tubular member as the sample-admitting means 19 are advanced

into sealing engagement with a borehole wall. In the preferred manner of accomplishing this, the packing element 80 is symmetrically arranged in relation to the tubular member 45 and includes a transverse forward portion 81 having a central opening 82 carrying a tubular sealing member 83 coaxially disposed for movement over the tubular member 45 and a rearwardly-directed peripheral skirt portion 84. By securing the skirt portion 84 of the packing element 80 to a rigid, transverse supporting plate 85 secured to an intermediate portion of the sampling tube 45 and leaving the forward transverse portion 81 free to move axially in relation to the tubular member, it will be appreciated that as the wall-engaging forward face of the elastomeric member engages a borehole wall, the elastomeric element will compress and move rearwardly in relation to the sampling tube.

To obtain a fluid sample from a selected formation, the formation-sampling apparatus 10 is positioned as shown in FIG. 1 in the borehole 12 opposite the formation 13. As this point, however, the various elements of the apparatus 10 will still be in their initial positions substantially as shown in FIG. 2. Then, once the apparatus 10 is in position, the control valve 24 is selectively opened to admit well control fluids into the body passages 79 and 86 for simultaneously extending the piston 71 and the extendible wall-engaging member 43 in opposite lateral directions. Once the outer end of the extendible wall-engaging member 43 (or, perhaps, the rear face of the apparatus 10) engages the rear wall of the borehole 12, continued forward movement of the piston member 71 will firmly urge the forward end of the tubular sampling member 45 against the adjacent surface of the borehole with a substantial force that is equal to the hydrostatic pressure of the well control fluids multiplied by the cross-sectional area of the piston 71 through O-rings 75 and 77.

Once, however, the sample-admitting means means 19 move forwardly and the rear end of the slidable valve member 58 is displaced from the rear wall of the housing bore 46, the rearwardly-acting pressure forces on the slidable member 1 will begin urging it rearwardly in relation to the advancing tubular member 45 and the tubular body 48. It will, therefore, be recognized that once the valve member 58 moves only a short distance away from the rear wall of the housing bore 46, the forward valve portion 67 will be free to move out of the axial bore 68 and open the enclosed space 87.

Accordingly, means are provided for selectively delaying this rearward movement of the valve member 58 so as to enable the sealing member 80 to first be sealingly disposed against the borehole wall before the forward valve portion 67 is opened. In the preferred manner of accomplishing this, the annular space defined in the counterbore 56 in the tubular body 48 and between the O-rings 60 and 62 is initially filled with a viscous fluid or some suitable fluent material such as a silicone grease or other deformable plastic materials. Thus, the time required for the valve member 58 to shift rearwardly from its initial position (FIG. 2) to its final position (FIG. 3) will be governed by the time required for the effective force of the hydrostatic pressure acting rearwardly on the valve member 58 to displace the viscous fluid from the space member 58 to displace the viscous fluid from the space 56 through the restricted passage 57, and into the atmospheric space 55.

It will, of course, be understood that even upon application of a substantial forwardly-directed pressure force on the sampling tube 45 as illustrated in FIG. 3, the forward end of the tubular sampling member can penetrate the adjacent formation (as at 13) only so far as is permitted by the nature of the particular formation materials. Thus, should the formation 13 be fairly competent, the forward end of the tubular member 45 will, most likely, still be incapable of making a significant penetration into the formation. However, at any rate, this forwardly-acting pressure force will cause the forward end of the sampling member 45 to penetrate at least the so-called "mudcake" (as at 88) that typically lines the wall of the borehole traversing a potentially-productible earth formation, as at 13.

As depicted in FIG. 3, therefore, forward movement of the piston 71 upon opening of the control valve 24 will, therefore, successively extend and compress the sealing member 80 into sealing engagement with the mudcake-lined face of the formation 13 and then drive the nose of the tubular sampling member 45 forwardly through the mudcake layer 88 and at least into contact with the formation. It should be noted at the so-called "flow-line" valve 35 is still closed at this point in the operating cycle.

Accordingly, in keeping with the objects of the invention, as the forward end of the sampling member 45 penetrates the mudcake (as at 88) on the borehole wall and forward valve member 67 is opened, the resulting cylindrical plug of mudcake driven into the nose of the tubular member will be forcibly driven (by formation pressure rearwardly into the enlarged annular space 87 to the rear of the filtering screen 65. Similarly, should the sampling member 45 penetrate an unconsolidated producible formation, any formation particles carried into the sample-admitting means 19 by the flow of connate fluids will also be received within the momentarily-voided annular space 87. Ultimately, however, formation fluids as well as the mudcake plug (and possibly at least some loosened formation particles) will have filled the voided annular space 87 to equalize the momentary pressure differential created by the initial forward movement of the sample-admitting means 19. Thus, once the initial forward movement of the sampling tube 45 is halted, any plug of the mudcake 88 that would otherwise have blocked the filtering screen 65 will be safely disposed in the annular space 87 to the rear of the screen. Similarly, should there also be any formation materials displaced after the plug of mudcake is removed, these too will be disposed behind the mudcake plug in the forward portion of the annular space 87. Although the displaced mudcake plug and perhaps some, if any, of such initially-displaced formation materials will be rather impermeable at least a substantial portion of the forward end of the screen 65 will be free of foreign matter so as to not materially impede the subsequent flow of formation fluids through the filtering screen. It will be understood, of course, that the screen 65 is selectively sized to strain out such loosened formation particles.

It should be appreciated as well that the rearward travel of the forward valve portion 67 is operative to open the reduced entrance 68 in the nose of the sampling member 45 before the O-ring 59 closing the lateral passage 64 in the rear of the cylindrical valve member 58 clears the rearward end of the tubular body 48. Thus, with the sample-admitting means 19, only the minor momentarily-voided space 87 is initially opened for receiving any plug of the mudcake 88 and loosened formation materials entering the sampling tube 45. As seen in FIG. 3, therefore, this mudcake plug will be disposed well behind the filtering screen 65 within the annular space 87. Then, after this initial quantity of mudcake enters the sample-admitting means 19, the passage 64 will open as the valve member 58 continues moving toward its rearwardmost position to establish communication with the additional voided spaces in the rear of the housing bore 46 and the open portion of the passage 33. The flow-line valve 35 is, of course, still closed at this point.

Accordingly, the significantly-reduced volume of the initially-voided space 87 (in relation to the volume of the bore 46) will allow the sampling tube 45 to make at least a slight advancement into the formation 13 before the large volume of the housing bore is opened. It is believed, therefore, that if the nose of the sampling tube 45 can be first embedded into an unconsolidated formation before the passage 64 is opened, there will be a correspondingly reduced chance that the borehole fluids will channel through the mudcake 88 and contiguous formation wall supporting the forward face of the pad 80. It will also be appreciated that since only the voided space 87 is initially opened, all of the mudcake plug will be drawn into this space and, since there is no flow through the filtering screen, greatly minimize any coating over the screen 65.

In some instances, it is believed desirable to fill the passage 63 with a viscous fluid, such as grease or the like, before the apparatus 10 is lowered into the borehole 12. When this is done, it will be appreciated that upon opening of the forward valve portion 67, there is no tendency at all for the mudcake plug to be drawn onto the screen 65 since there is not pressure differential across the screen until the rearward valve means defined by the O-ring 59 and body 48 open.

Accordingly, at this point in the operating cycle of the tool 10, the sample-admitting means 19 will have established fluid communication with the formation, as at 13, being tested before a fluid sample is taken. By selectively displacing the plug of mudcake as well as any formation particles that may initially enter the sample-admitting means 19 into the voided space 87, at least a substantial portion of the filtering screen 65 will be available for straining fluid samples upon opening of the flow-line valve 35. Thus, a formation fluid sample is obtained by simply opening the flow-line valve 35; and then, once the transducer 37 indicates that the sample chamber 28 is filled, closing the seal valve 36.

Once the flow-line valve 35 is opened, there will be a substantial pressure differential between the formation fluids and the upper chamber 27 that will promote flow of the connate fluids into the sample-admitting means 19 at a regulated rate as, for example, might be determined by the orifice 30. If, for example, the formation 13 is fairly competent, there will be little or no erosion of the formation materials. On the other hand, should the formation 13 be unconsolidated, it will be recognized that unless the space 87 is already filled, the connate fluids can carry, at best, only a selectively-limited quantity of formation particles into the sampling tube 45 once the flow-line valve 35 is opened.

These loosened formation particles will rapidly fill whatever volume remains in the selectively-limited annular space 87 as the connate fluids pass on through the filtering screen 65 and into the sample chamber 28. The limited volume of the annular space 87 will, however, be quickly filled with a packed, but permeable, column of the loosened particles. Once this occurs, it will be appreciated that no further movement of loosened formation materials can take place since the packed column will be fully supported within the sample-admitting means 19. Thereafter, only connate fluids can flow into the sample-admitting means 19 with this packed column of clean formation materials serving as a filtering media that is well supported by the screen 65. It will be recognized, therefore, that once the erosion of formation materials is halted, the sealing member 80 will be capable of retaining effective sealing engagement against the borehole wall for the entire operation.

To retrieve the fluid-sampling apparatus 10, the control valve 25 (or 26) is actuated to open the normally-closed hydraulic valve 41. By opening the valve 41, the high-pressure hydraulic fluid is admitted through the passage 40 into the enclosed annular spaces 78 and 89 (ahead of the pistons 71 and 43) that were initially at atmospheric pressure. Since the hydraulic pressure is greater than the hydrostatic pressure of the borehole fluids, as the hydraulic fluid enters these spaces 78 and 89, the piston 71 and extendible member 43 are normally returned to their initial positions. Once these members 43 and 71 have been returned, the fluid-sampling apparatus 10 can, of course, be either retrieved from the borehole 12 or repositioned therein.

Should there be some malfunction in the retracting system 21, as, for example, sticking of the hydraulic valve 14, the fluid-sampling apparatus 10 can still nevertheless be retrieved by the emergency release apparatus 51. Thus, should the necessity arise, the outer end of the extendible wall-engaging member 43 can be quite simply broken by picking up on the apparatus 10. Then, once the outer end of the axial passage 41 is opened, there the borehole fluids will be admitted into the spaces 78 and 89.

By comparing FIGS. 2 and 3, it will be appreciated that once the forward face of the sealing pad 80 engages the layer of mudcake 88, the outwardly-acting force of the piston 71

will readily compress the skirt portion 84 of the sealing member to cause the central portion 81 thereof to move rearwardly in relation to the advancing tubular member 45. Accordingly, by virtue of the unique arrangement of the sealing member 80, a major portion of the thrust from the piston 71 will be effective to force the nose of the tubular member into at least the mudcake 88. This, however, does not mean that an effective sealing engagement is not achieved by the sealing pad 80 since the resiliency of the compressed elastomeric skirt portion 84 and central portion 81 will be urging the forward face of the sealing member firmly against the mudcake 88. Moreover, by assuring fluid communication (as through ports 90 or the like through the plate 85) between the borehole fluids and rear surface of the central portion 81, the pressure differential between the hydrostatic pressure in the borehole 12 and the formation pressure will also be highly effective in maintaining tight seal around the central opening 82 of the sealing member 80.

Accordingly, instead of dissipating a significant proportion of the outwardly-directed force of the piston 71 in compressing the elastomeric sealing member 80, almost all of this force is imposed on the tubular member 45 to effect a penetration of the mudcake 88 and, quite possibly, a portion of the formation 13. Thus, since the nose of the tubular sampling member 45 will be at least embedded into the mudcake 88 before the forward valve portion 67 opens, and only the limited quantity of mudcake actually confined in the bore 68 can enter the annular space 87.

Turning now to FIG. 4, an alternative embodiment of sample-admitting means 100 is shown. It will be realized, of course that the principal difference between the sample-admitting means 19 and 100 is that the elastomeric sealing element 101 for the sample-admitting means is resiliently biased by a coaxially-disposed compression spring 102 instead of the elastomeric skirt portion 84 used for biasing the sealing member 80. To secure the several elements, the compression spring 102 is secured to a transverse supporting plate 103 secured on the sampling member 45 and to a rigid plate 104 on the rear of the elastomeric element 101. It will be recognized, of course, that the spring 102 is adapted so that, upon compression, it will urge the forward face of the pad member 101 against the wall of the borehole 12 with sufficient force to effect a sealing engagement therewith.

Those skilled in the art will appreciate that irrespective of whether a water cushion, as at 31, is or is not employed, when a fluid sample is being taken there will be substantial pressure differential existing between the connate fluids entering the forward portion of the sample-admitting means 19 (or 100) and the enclosed sample chamber 28 which is initially at atmospheric pressure. This extreme pressure differential must, of course, be accommodated in either instance. Thus, if the water cushion 31 and the other chamber 27 are employed, most of this pressure differential will be taken across the orifice 30 so that only a minimal pressure drop will occur in the sample-admitting means 19 (or 100). On the other hand, if the water cushion 31 is not employed in the tool 10, the pressure drop will be primarily accommodated across the filtering screen 65 and the apertures 66. If need be, additional flow restriction can be provided by arranging suitable orifices or the like (not shown) in either the passage 63 or flow line 33.

In any event, there are, of course, widely-different types of formations from which samples are to be taken. In those situations where the formations are fairly competent, it is not at all likely that the performance of the sample-admitting means 19 (or 100) would be affected by elimination of the water cushion 31. On the other hand, the water cushion 31 may assure a more-reliable operation with the sample-admitting means 19 (or 100) where a particularly uncemented granulated formation material is anticipated. The choice is, therefore, best determined by actual operating experience in each particular oil field.

Accordingly, it will be appreciated that the present invention has provided new and improved formation-sampling ap-

paratus adapted for reliably establishing and maintaining fluid communication with various types of borehole surfaces and formation materials. Thus, although changes and modifications may be made in the principles of the invention as set out in the claims, by limiting the entrance of mudcake and any unconsolidated formation materials into the formation-sampling apparatus, greater assurance is had that satisfactory fluid samples will be obtained.

I claim:

1. Apparatus adapted for use in a borehole and comprising: a support; a unitary tubular sampling member on said support and having an end portion adapted to penetrate a borehole surface; a resilient sealing member having a longitudinally-compressible portion with a transverse forward face and a longitudinal opening therethrough loosely receiving said end portion of said tubular member, and sealing means adapted for fluidly sealing between said tubular member and said compressible portion upon rearward displacement thereof in relation to said tubular member; first means on said support adapted for forcing said end portion of said tubular member against a borehole surface to effect at least a slight penetration thereof; and biasing means mounted on said tubular member and responsive to penetration of said end portion thereof into a borehole surface for urging said forward face of said sealing member into sealing engagement against such a borehole surface as said compressible portion thereof is compressed and slidably displaced rearwardly along said tubular member to at least partially protrude said end portion thereof in advance of said forward face.

2. The borehole apparatus of claim 1 wherein said second means include yieldable biasing means spatially arranged around said tubular member between said support and said compressible portion.

3. The borehole apparatus of claim 1 wherein said biasing means include spring means spatially arranged around said tubular member between said support and said compressible portion, and a rigid backing member transversely arranged on said tubular member between said spring means and said compressible portion and adapted for engagement therewith.

4. The borehole apparatus of claim 1 wherein said biasing means include an annular elastomeric skirt portion of said sealing member extending rearwardly from the rear of said compressible portion thereof and spatially arranged around said tubular member, a rigid backing member arranged on said tubular member between said support and said skirt portion, and means securing said backing member to said skirt portion.

5. Fluid-sampling apparatus adapted for obtaining samples of connate fluids from earth formations traversed by a borehole and comprising: a support; sample-admitting means including a tubular sampling member movably mounted on said support and having a forward end adapted to penetrate a borehole surface; packing means including a sealing member having a transverse portion with a forward surface-engaging face and a central opening therethrough slidably receiving said tubular member, and sealing means adapted for fluidly sealing said tubular member to said sealing member upon rearward displacement of said transverse portion thereof in relation to said tubular member; piston means on said support adapted for bringing said forward end of said tubular member against a borehole surface with a force adapted to effect at least a slight penetration thereof; and biasing means mounted on said tubular member and operable upon engagement of said forward end with a borehole surface for urging said surface-engaging face of said sealing member forwardly against such a surface with a lesser force as said transverse portion thereof is slidably displaced rearwardly from said forward end of said tubular member.

6. Fluid-sampling apparatus adapted for obtaining samples of connate fluids from earth formations traversed by a borehole and having a layer of mudcake on the walls thereof, said fluid-sampling apparatus comprising: a support; sample-admitting means on said support and including a tubular sam-

pling member having a forward end adapted to effect fluid communication with such formations; sample-collecting means on said support including a sample chamber and passage means adapted for conducting such samples from said tubular member to said sample chamber; packing means including a resilient sealing member having an outer portion surrounding a compressible central transverse portion with a forward wall-engaging face and a longitudinal opening therethrough slidably disposed around said tubular member, sealing means coaxially arranged in said longitudinal opening and adapted for fluidly sealing said sealing member in relation to said tubular member upon rearward displacement of said central portion along said tubular member, and biasing means mounted on said tubular member and adapted for urging said outer portion of said sealing member into sealing engagement with a borehole wall without preventing rearward displacement of said central portion in relation to said tubular member; and means on said support adapted for forcing said forward end of said tubular member against a borehole wall to effect at least a penetration of a layer of mudcake thereon as said central portion of said sealing member is displaced rearwardly along said tubular member to advance said forward end thereof ahead of said wall-engaging forward face and into fluid communication with an earth formation.

7. The fluid-sampling apparatus of claim 6 wherein said biasing means include an annular rearwardly-directed extension from said outer portion extending coaxially around said tubular member toward said support, said rearward extension being of a resilient compressible material, and a rigid annular backing member secured to said tubular member and to said rearward extension for compressing said rearward extension for compressing said rearward extension as said forward end is urged against a borehole wall to develop sufficient biasing force for sealingly engaging said outer portion with such a borehole wall to develop sufficient biasing force for sealingly engaging said outer portion with such a borehole wall.

8. The fluid-sampling apparatus of claim 7 wherein said biasing means further include means for admitting borehole fluids to the rear surface of said central portion.

9. The fluid-sampling apparatus of claim 6 wherein said biasing means include a rigid annular backing member on the rear face of said outer portion, and spring means between said support and said backing member and adapted for compression therebetween upon rearward displacement of said central portion.

10. The fluid-sampling apparatus of claim 9 wherein said biasing means further include means for admitting borehole fluids to the rear surface of said central portion.

11. Fluid-sampling apparatus adapted for obtaining samples of connate fluids from earth formations traversed by a borehole and having a layer of mudcake on the walls thereof said comprising: a support; sample-admitting means including a tubular sampling member operatively arranged on said support for longitudinal movement between retracted and extended positions and having a forward end adapted to effect fluid communication with such formations upon extension of said tubular member; means on said support adapted for extending said tubular member to drive said forward end thereof against a borehole wall to effect at least a penetration of a layer of mudcake thereon; sample-collecting means on said support including a sample chamber and passage means adapted for conducting such samples from said tubular member to said sample chamber; and packing means including an elastomeric sealing member having an outer portion surrounding a compressible central portion with a forward wall-engaging face and a longitudinal opening therethrough slidably disposed around said tubular member, sealing means coaxially arranged in said longitudinal opening and adapted for fluidly sealing said sealing member in relation to said tubular member upon rearward displacement of said central portion along said tubular member, in relation to said tubular member upon rearward displacement of said central portion along said tubular member, and biasing means mounted on

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said tubular member and adapted for urging said outer portion of said sealing member into sealing engagement with a mudcake layer on a borehole wall without preventing rearward displacement of said central portion along said tubular member to advance said forward end thereof ahead of ahead of said wall-engaging forward face and through a mudcake layer in fluid communication with an earth formation upon extension of said tubular member.

12. The fluid-sampling apparatus of claim 11 further including: valve means normally closing said forward end of said tubular member to prevent entrance of borehole fluids therein;

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and means operatively associated with said tubular member and said valve means for opening said valve means upon extension of said tubular member from said support.

13. The fluid-sampling apparatus of claim 11 further including: valve means normally closing said forward end of said tubular member to prevent entrance of borehole fluids therein; and means operatively associated with said tubular member and said valve means for opening said valve means only after extension of said tubular member from said support.

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