May 21, 1968 H. K. VAN POOLLEN 3,384,170

WELL-BORE SAMPLING DEVICE AND PROCESS FOR ITS USE

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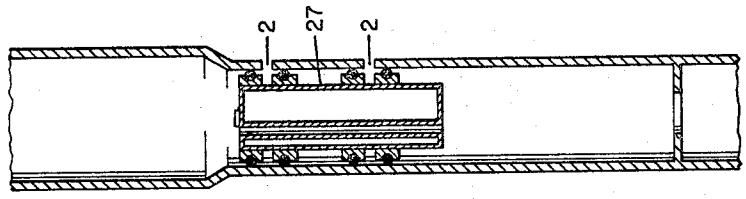


Fig. 4

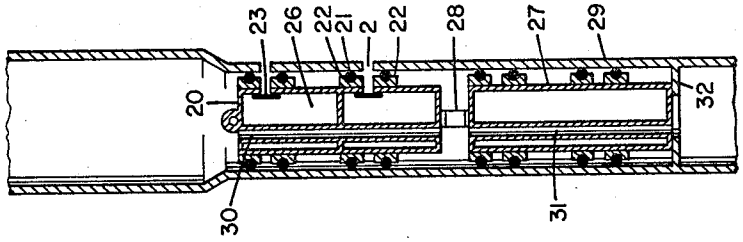


Fig. 3

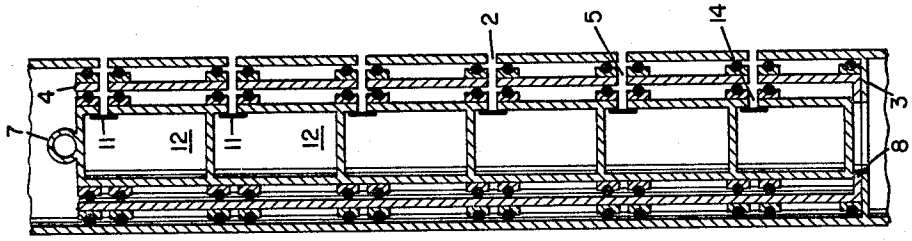


Fig. 2

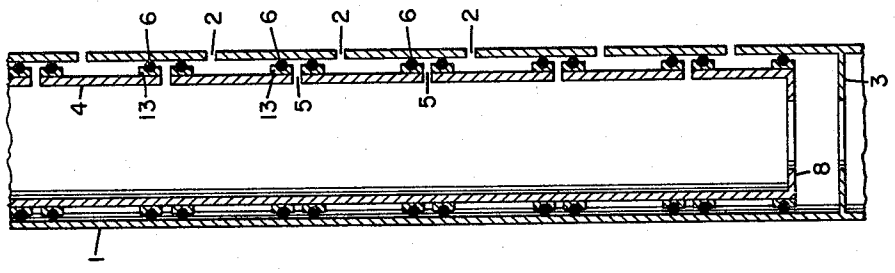


Fig. 1

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WELL-BORE SAMPLING DEVICE AND PROCESS FOR ITS USE

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The present invention relates to new devices and processes for the sampling of fluids within subterranean formations, and in particular relates to the sampling of such fluids from a plurality of elevations within well-bores.

In geological exploration, particularly in the logging of wells drilled for the discovery and recovery of petroleum from underground formations, it is often desirable to sample an observation well at several elevations within a reservoir. In most cases such sampling is preferably done simultaneously at a number of different levels, and is generally accomplished by first perforating the casing of the well-bore, e.g. with gun or other conventional perforating means. Such sampling provides clear indication of the fluids available at different elevations within the borehole.

Some sampling tools allow sampling at one perforation while the other perforations are in communication with each other. Such tools include the Schlumberger wire line formation tester and various types of straddle-packer arrangements. This communication between perforations at various levels causes a co-mingling of the fluids within the well-bore. In some circumstances, fluids from one perforation will flow into the well-bore and will flow outward through another perforation perhaps at lower elevation. Such cross flow requires large amounts of fluid to be withdrawn from any one perforation if a representative sample is to be obtained. Withdrawals of such large amounts of fluid is difficult in the relatively limited size of sampling device which can normally be conveniently dropped down hole on a wire line. In addition, with large amounts of fluid being withdrawn from a single perforation, spherical flow will take place in the reservoir and this will distort the fluid-fluid interfaces in immediate vicinity of the well-bore. Particularly large withdrawals will cause the observation well to become a "sink" and again the fluid fronts will be distorted.

This problem of co-mingling of fluids within the formation and its effect on the obtaining of a representative sample has been recognized and previous attempts have been made to overcome this difficulty. For example, in U.S. Patent 2,781,663 filed Jan. 16, 1956, and issued Feb. 19, 1957, it is mentioned that superimposed pressure may be applied to the casing to prevent well fluids from entering the same while the tool is being placed in position. The difficulty with such techniques is that a gas is not suitable for this pressurization since it will merely raise the total pressure within the well casing and in many cases will not prevent cross flow between the perforations in the casing. If a liquid is used, there is the difficulty of an additional pumping of the well-bore and the additional complication of contamination of the samples by the pressurizing liquid.

Also, any fluid which is used to pressurize the well-bore will, of necessity, have a greater pressure than that of the fluids in the formation and therefore will flow into the formation at least to some degree. This flow of a non-representative pressurizing fluid into the formation can distort the equilibrium within the formation and cause samples which are later taken, to be non-representative.

All such detrimental effects can be avoided by the use of the sampling devices of the present invention. Through their use only substantially horizontal flow will take place and samples may be drawn simultaneously at a number of

perforations. By keeping the well-bore closed off at other times, only very small amounts of fluid will have to be withdrawn from the formation in order to obtain representative formation fluid samples.

The sampling devices of the present invention comprise sampling chambers preferably disposed vertically one over the other, each such chamber having at least one aperture equipped for sealing in communication with a perforation in the well casing. Valves, or other means for closing the apertures, are preferably provided. In addition, the present invention comprises sealing means for sealing the perforations in the well casing at those times when the sampling device is not in position for withdrawing samples. These sealing means can be any of a variety of devices, including among the particularly preferred embodiments, a cylindrical sleeve which seals the perforations and into which the sampling device can be slid, the sleeve having openings which can be brought into alignment with the perforations in the well casing when sampling is to be accomplished, or can be moved away from the perforations in the well casing when the sampling device is withdrawn from the sleeve.

In another preferred embodiment the sealing means is a dummy sampling device which is suspended below the actual sampling device by a detachable wire line or electrically operated hook. When the sampling container is lowered into the well it displaces the dummy downward so that the sampling device can communicate with the perforations of the well-bore. When the sampling device is withdrawn the dummy is pulled upward until it seals off the perforations in the well-bore and the dummy is then disconnected so that the sampling device can be withdrawn from the well-bore. The invention will be more fully understood by reference to the descriptions of the specific embodiments which follow.

FIGURE 1 is a schematic diagram of the device of the present invention in which the perforations are sealed by a hollow sleeve.

FIGURE 2 shows the sealing device of FIGURE 1 deflected to the sampling position and containing a sampling device.

FIGURE 3 shows a second embodiment of the invention in which a dummy sampling device is used to seal off the perforations in the well-bore casing at times when the actual sampling device is not in position for sampling. FIGURE 3 shows the sampling device in sampling position with the dummy hanging underneath.

FIGURE 4 shows the embodiment of FIGURE 3 with the sampling device in the process of being raised to the surface and the dummy in position to seal the perforations in the casing.

In FIGURE 1 the well casing **1** has been cemented in place in the well-bore and contains perforations produced by conventional perforation techniques in such manner that no significant burrs are present on the inside of the casing. This may be accomplished by the use of permeaters or abrasive jet perforation or bullets or one of the various shaped charges which are commercially available and which leave essentially no burr. The casing has been equipped with a no-go shoulder **3** to facilitate alignment of the sampling devices with the perforations. Any of a number of stops can be used in place of the no-go shoulder. For example, inflatable packers, removable expansion rings or even a stud welded to the inside wall of the casing, may be utilized or careful calibration of the wire line can be used to position the sampling devices. A series of apertures **5** extend through the wall of the casing and are so spaced as to be capable of coinciding with the perforations **2** in the casing. However, in FIGURE 1 the sleeve **4** is displaced so that the apertures **5** do not communicate with the perforations **2**. A series of seals **6** seal the apertures **5** against the casing **1** and are

capable of sealing the apertures in communication with the perforations 2, when the sleeve 4 is suitably aligned. The O-rings 6 extend circumferentially around the sleeve 4 forming a girth seal and these O-rings are held in place by bands 13 which extend around the sleeve 4 and partially confine the O-rings. The sleeve assembly can be forced down the well-bore as necessary by having, for example, a 200 pound or larger sinker bar. Various other refinements, including retraction mechanism for retracting the seals until the sleeve is in place, may be employed. Well pipe of a larger diameter may be used from the formation to the surface and centralizers may be added to the sleeve in order to keep the seals from rubbing against the hydraulic plate, as the sleeve is lowered down the well-bore. In FIGURE 1 no substantial flow into the well-bore occurs from the perforations 2 and virtually no cross flow between the perforations is possible.

FIGURE 2 shows the sleeve 4 of FIGURE 1 with the sampler 7 in place in the sampling position. The sampler consists of a number of fluid chambers 12 each having an aperture 14 equipped with a check valve 11 to prevent flow outward from the chambers. The apertures 14 on the sample chamber are isolated by a series of O-rings 15 and retaining rings 16 similar to those used on sleeve 4. When the sampling device 7 is lowered into the sleeve 4 the bottom of the sample device strikes a no-go shoulder 8 in the sleeve. This displaces the sleeve downward until it strikes the no-go shoulder 3 inserted in the well-bore. As mentioned above, this no-go shoulder 3 may be replaced by a stud, packer, slack wire line or other means for stopping the downward travel of sleeve 4 when the apertures 5 are in alignment with the perforations 2 in the well casing. Similarly, other alignment devices may be used in place of the no-go shoulder 8 to align the apertures 14 in the sampling device 7 with the apertures 5 in the sleeve.

The sample containers may be conventionally evacuated or vented to perimt fluids to flow freely into them. Because the casing perforations 2, the sleeve apertures 5, and the sampling container apertures 14 are all in alignment, fluids flow from points in the formation into sampling chambers at approximately the same elevation as the points from which the fluids leave the formation.

The embodiment shown in FIGURE 2 and the other embodiments of the invention are adaptable to a wide variety of conventional modifications and auxiliaries including, for example, a pass-through tube which can run the full length of the sampling device 7 passing through each of the chambers 12 without communicating with them so that the fluids can freely flow from the top to the bottom or from the bottom to the top of the sampling device as it is being raised or lowered in the well-bore respectively. This prevents a piston action and facilitates withdrawal and insertion of the sampling device. Electric or hydraulically operated valves may be included on either the sleeve 4 or the sampling device 7. Also, electric or hydraulic actuators may be used instead of wire lines to provide the necessary displacement of the sleeve and of the sampling container within the well-bore. For example, an inflatable packer may be incorporated at the bottom of the sleeve 4 so that the packer may be inflated to substitute for the no-go stop 3. As a further variation, an electric actuator attached to such a packer can be used to raise and lower the sleeve 4 while the packer remains in a fixed position in the well-bore, thus cutting off or permitting flow through the sleeve apertures 5 according to the position of the sleeve. Further, it is not necessary that either the sleeve or the sample container be deflected vertically to commence or discontinue flow through their respective apertures. Instead, other sealing means may be provided for controlling such flow without deflection of the unit itself, or the sleeve or sampling device may be rotated into or out of alignment with the apertures in the surrounding element. In the latter instance, suitable longitudinal seals can be provided to cut off flow when the apertures are not in alignment.

FIGURE 3 shows a second preferred embodiment of the devices of the invention which utilizes a dummy sampling device to plug the apertures 2 in the well casing when the sampling device 20 is not in the sampling position as it is shown in FIGURE 3. The sampling device 20 may be similar to the sampling device 7 shown in FIGURE 2 except that the sampling device in FIGURE 4 is of sufficiently large diameter as to be a tight fit in the well casing. O-rings 21 confined in retaining rings 22 and so positioned as to isolate apertures 24 which lead into the individual compartments 26 of the sampling container, and check valves 23 located in such said apertures are all provided as previously described under FIGURE 2. A dummy 27 provided with O-rings 29 and substantially the same spaced relationship as the O-rings on the sampling device 20 hangs below the sampling device by means of detachable hooking device 28. This hooking device may be electrically, mechanically, or hydraulically actuated in response to signals from the surface, or in response to the striking of an alignment pin which can be set into the well casing. A no-go stop 32 or its equivalent, is installed into the well casing in such position that when the dummy bottoms on no-go stop, the sample device is in position so that its apertures can withdraw samples from the well casing perforations 2. By-pass tubes 30 and 31 are provided in the sampling device and dummy, respectively in order to prevent a piston action as they move up and down the well-bore.

FIGURE 4 shows the dummy 27 in position for blocking flow from the well casing perforations 2.

In actual practice the dummy will first be placed in the position shown in FIGURE 4 and the well then pumped dry of fluids and the formation permitted to reach equilibrium. Then the sampling device 20 will be lowered down into the well-bore until it strikes the dummy 27 and deflects the dummy until it bottoms on the no-go stop 32 as shown in FIGURE 3. Sample will then be taken, either immediately or by the actuation of any electric valves or other aperture closing devices which may be additionally located on the apertures of the sample container 24 as described above under modifications which are possible with the embodiment of FIGURES 1 and 2. After the sampling chambers 26 have received the samples the sampling device 20 is raised until the detachable hook or other coupling 28 have pulled the dummy 27 into the position shown in FIGURE 4. The hook 28 is then detached and the sampling device 20 raised to the surface.

While the above described embodiments have been discussed as being used for the obtaining of samples which are then raised to the surface, it should be understood that the usual conventional techniques of telemetry, i.e. the remote measurement of rate of fluid flow, pressure, temperature, etc. may all be employed with the devices of the present invention without removal of the sampling device from the well-bore. The sampling chambers may readily be equipped with one or more pumps in order to permit them to be emptied after measurement of the desired physical properties and telemetering of the data to the surface. The sampling chambers may then be reused to once again sample fluids from the formation without bringing the sampling device to the surface.

A variety of other modifications and variations will be apparent to those skilled in the art upon a reading of the present specification and it is to be understood that the above embodiments are merely illustrative of the invention and that the claims appended hereto are to be taken as including all such apparent modifications and variations of the invention.

What is claimed is:

1. A fluid sampling device for simultaneously sampling fluids from a plurality of levels within a well-bore having a perforated well casing which preventing substantial mix-

ing of fluids from different elevations in the well-bore and additionally preventing such mixing within the sample device, said device comprising in combination: a sampling device having a plurality of fluid-tight compartments for retaining fluid samples, each said compartment having at least one closeable aperture, said apertures being so positioned as to correspond with perforations in the well casing and being fitted with sealing means for sealing said apertures in communication with the perforations in the well casing; means for sealing the perforations in the well casing to prevent substantial flow through said perforations into said well-bore at times when said sampling device is not positioned for sampling said fluids; means for displacing said perforation sealing means at times when said sampling device is positioned for sampling.

2. The device of claim 1 wherein the apertures and said sealing means are positioned by lowering them until they contact a no-go stopping means.

3. The device of claim 1 wherein the perforation sealing means comprises an outer sleeve having perforations coinciding with the elevations of said casing perforations through which fluid is to be sampled, said apertures having sealing means external to said sleeve, said sealing means being designed for sealing said perforations in communication with said apertures, said outer sleeve being displaceable so that said perforations can be sealed by displacing said sleeve so that said perforations are not in communication with said apertures in said sleeve, means for displacing said sleeve so that said apertures alternately communicate with said perforations and do not communicate with said perforations.

4. The device of claim 3 wherein the displacement of said sleeve is accomplished by raising or lowering said sleeve by means of a wire line controlled from the surface.

5. The device of claim 1 wherein the perforation sealing means comprises a substantially cylindrical dummy sampling device which seals said perforations but does not communicate with said perforations, said dummy sampling device being capable of vertical displacement so as to unseal said perforations when the sampling device of claim 1 is positioned for sampling.

6. The device of claim 5 wherein the displacement of said sleeve is accomplished by raising or lowering said sleeve by means of a wire line controlled from the surface.

7. A fluid sampling device for simultaneously sampling fluids from a plurality of levels within well-hole while preventing substantial mixing of fluids from different elevations in the borehole and additionally preventing such mixing within the sampling device, said device comprising in combination: an outer sleeve having apertures coinciding with the elevations from which fluid is to be sampled, said apertures having sealing devices external to said sleeve, said sealing devices being designed for contacting perforations in the outer walls of said well-bore; a substantially cylindrical sampling device having a plurality of fluid-tight compartments for retaining fluid samples, each said compartment having at least one closeable aperture, said apertures being so positioned as to correspond with the apertures in said sleeve and being fitted with sealing means for sealing said apertures in communication with the apertures in said sleeve, said sample container being sufficiently small in diameter as to permit its insertion within said sleeve; means for raising and lowering said sleeve and said sample container into and out of a well-bore; means for cutting off communication between said apertures in said sleeve and said apertures in said sample chamber, whereby when said sleeve is positioned within said well-bore so that the apertures in said sleeve coincide with the apertures in said well-bore, said sample container may be inserted within said sleeve and positioned so that the apertures of said sample container communicate through the apertures of said sleeve with the apertures of said well-bore and so that each of said apertures is circumferentially sealed to prevent cross flow and mixing of fluids from different elevations within the well-bore.

8. A process for simultaneously sampling fluids from a plurality of levels within a well-bore while preventing substantial mixing of fluids from different elevations in said well-bore and additionally permitting such mixing within the sampling device, said process comprising, in combination, the steps of perforating said well-bore casing at a plurality of elevations, sealing said perforations with perforation sealing means, allowing sufficient time to elapse to permit the fluids within said formation to come to substantial equilibrium, positioning said sampling device for said sampling of said fluids, after or immediately before said positioning of said sampling device, deflecting said perforation sealing means so as to unseal said perforations, thereafter withdrawing samples through said perforations into said sampling device while preventing mixing of said samples within the bore-hole and within the sampling device.

9. The process of claim 8 wherein the sealing and unsealing of said perforations is accomplished by raising and lowering a wire line controlled at the surface.

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