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3,111,169

CONTINUOUS RETRIEVABLE TESTING APPARATUS

Filed June 19, 1959

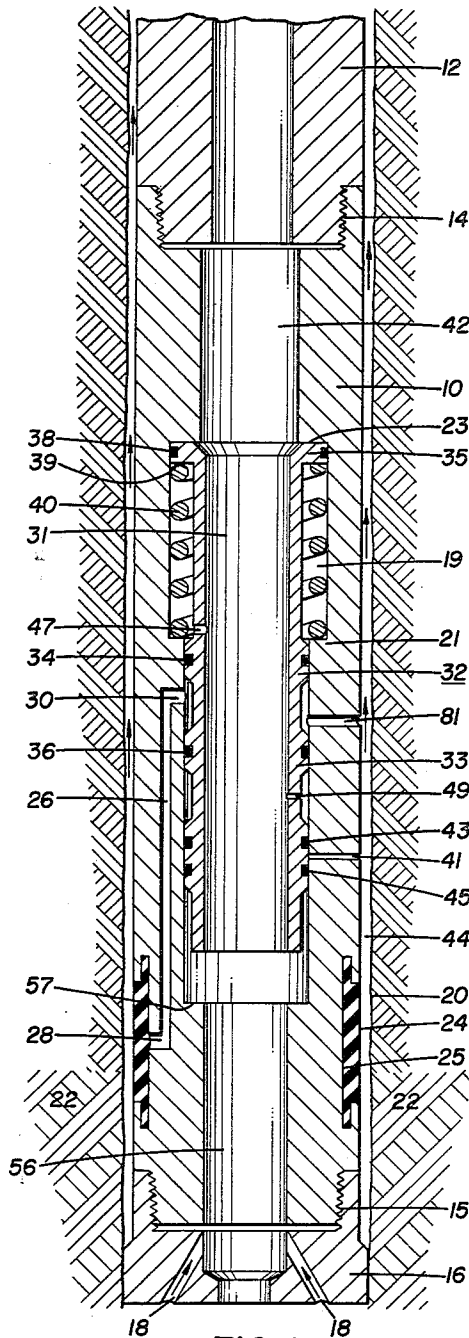


FIG. 1.

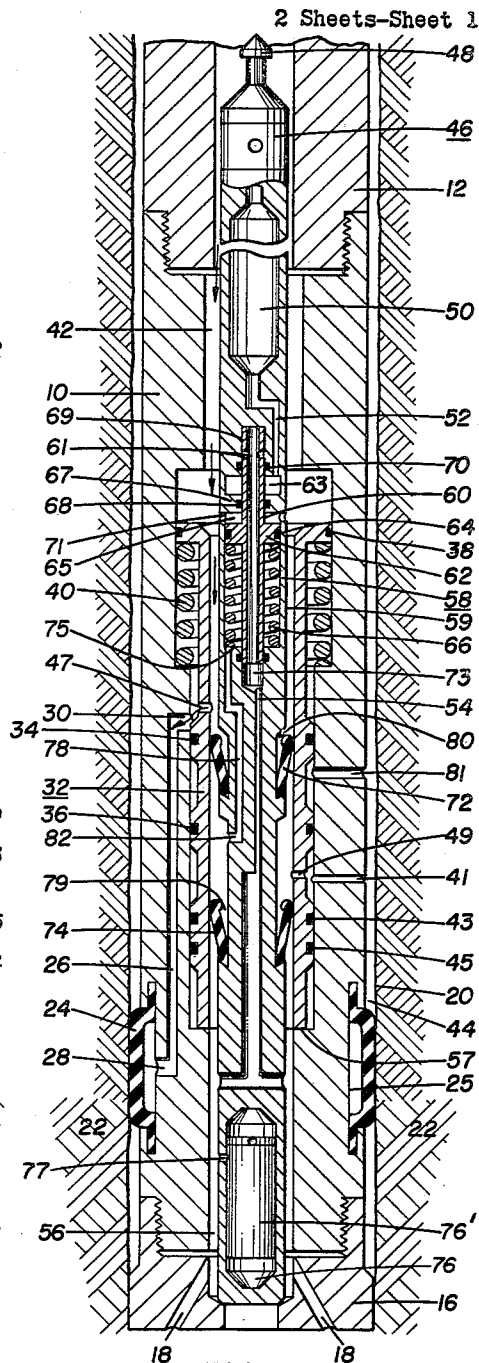


FIG. 2.

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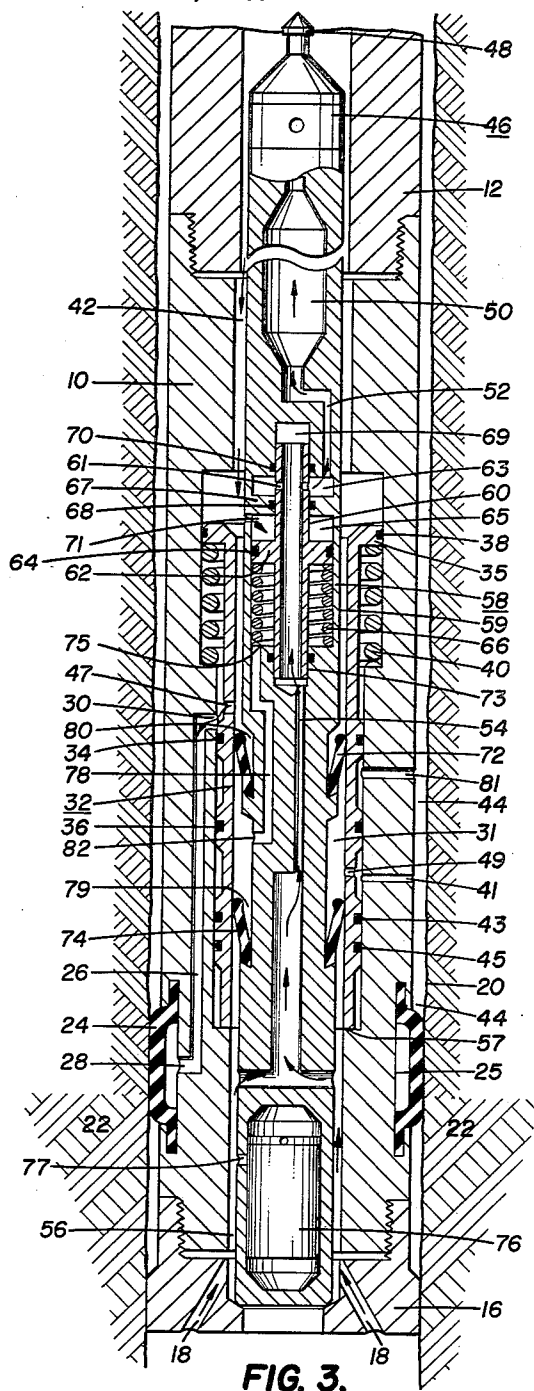


FIG. 3.

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3,111,169

## CONTINUOUS RETRIEVABLE TESTING APPARATUS

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8 Claims. (Cl. 166-145)

This invention relates generally to apparatus for obtaining samples of fluids produced by formations encountered during the drilling of oil or gas wells or the like. More specifically, it relates to a sample-taking apparatus adapted to obtain samples whenever they may be desired without removing the drilling string from the well.

During the drilling of an oil or gas well or the like, it is commonly desirable to obtain samples of the fluids produced by the various formations encountered as well as obtaining a record of the formation pressure. The usual procedure involves the use of equipment capable of obtaining the desired information installed as an integral part of the drilling string. This procedure is generally referred to as a drill stem test. With this arrangement of equipment, it is necessary to remove the drilling string from the well, insert the testing apparatus therein, run the drilling string and testing apparatus into the well and, after the sample is obtained and the pressure recorded, remove the drilling string and testing apparatus from the well to obtain the results of the test. Due to the necessity for making two round trips with the drilling string, this procedure is extremely time-consuming and expensive. This is particularly true where it is desired to test a plurality of zones or where the well is extremely deep.

U.S. Patent No. 2,497,185, issued to C. E. Reistle, Jr., discloses a sampling apparatus. While samplers built in accordance with his disclosure have met with some degree of success, there are certain inherent features which allow contamination of the sample obtained. Also, upon the expansion of the packer, fluid confined in the annular space below the packer is compressed and tends to force the packer and drilling string up the hole possibly resulting in a faulty seat for the packer.

It is therefore a general object of this invention to provide improved apparatus for obtaining a sample of formation fluid without necessitating the removal of the drilling string from the well.

Another object of the invention is to provide improved sampling apparatus that is adapted to obtain a substantially uncontaminated sample of formation fluid.

A further object is to provide improved sampling apparatus that is adapted to permit pressure equalization above and below the packer.

An additional object of the invention is to provide improved sampling apparatus that is adapted to be run on a wire line and to allow samples of formation fluid to be taken without removing the drilling string from the well.

This invention provides apparatus for obtaining fluid samples and pressure recording of various formations during the drilling of an oil or gas well or the like. One portion of the apparatus, constructed in accordance with the invention, includes a tubular body, an expansible packer mounted on the tubular body, and a pressure-responsive sleeve valve member, movably mounted within the tubular body adapted to control the expansion of the packer. This portion of the apparatus is attached to and becomes an integral part of the drilling string. Another portion of the apparatus, also constructed in accordance with the invention, comprises a sample receiving assembly and is adapted to be run on a wire line within the drilling string and includes a pressure-recording device, a sample chamber, and a pressure-responsive valve member which is adapted to control the flow of fluid into the

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sample chamber. The two portions of the testing apparatus are arranged and constructed so that upon the seating of the sample receiving assembly within the tubular body, pressure may be applied within the drilling string to open the pressure-responsive sleeve valve member, expand the packer, and then, by applying additional pressure, to open the pressure-responsive valve member allowing formation fluid to enter the sample chamber.

The foregoing and additional objects and advantages of the invention will become apparent from the following description when read in conjunction with the accompanying drawing wherein similar parts are denoted by similar reference characters in all views and wherein:

FIGURE 1 is an elevation and cross-sectional view of the body of the tool attached to a string of drill pipe and showing a drilling bit attached to the bottom of the body.

FIGURE 2 is an elevation and cross-sectional view showing the fluid sample receiving assembly in the closed position installed in the tool body of FIGURE 1 with the various parts in position for expanding or setting the packer to isolate the zone from which it is desired to obtain a sample.

FIGURE 3 is an elevation and cross-sectional view showing the fluid sample receiving assembly installed in the tool body of FIGURE 1 with the various parts in position for obtaining a fluid sample.

Referring first to FIGURE 1 of the drawing, a tubular body 10 is shown attached to the bottom of a string of drill pipe 12 by a threaded joint 14. Attached to the bottom of the tubular body 10 by a threaded joint 15 is a bit 16, which may be either a conventional drilling bit or a coring bit. The bit 16 has passageways 18 extending therethrough. The entire assembly is shown in a bore hole 20 and penetrating a formation 22 which is to be tested.

The tubular body 10 has an axial passageway or bore 42 extending therethrough. The bore 42 includes a lower section 56 of reduced diameter providing a shoulder 57 therein and an enlarged section 19 which provides shoulders 21 and 23 therein.

A suitable formation packer 24, such as the inflation or expandable type, is positioned in an exterior recess 25 located in the tubular body 10.

A passageway 26 enters the recess 25 at an opening 28 and extends upwardly within the side wall of the tubular body 10 entering the bore 42 at an opening 30 just below the shoulder 21 permitting fluid communication from the bore 42 to the interior of the packer 24. A port 41 extends through the sidewall of the tubular body 10 slightly above the packer 24 permitting fluid communication between the bore 42 and the annulus 44. A port 81 extends through the sidewall of the tubular body 10 slightly below the opening 30 permitting fluid communication between the bore 42 and the annulus 44.

A pressure-responsive sleeve valve member 32 is slidably located within the bore 42 of the tubular body 10. The sleeve valve 32 includes a hollow body 33, which is provided with a flange 35 located on the upper end thereof, and a valve spring 40.

The flange 35 extends into the enlarged section 19 of the bore 42 and carries in its outer periphery a suitable O-type seal 38. The O-type seal 38 provides a wiping action between the flange 35 and the interior wall of the enlarged section 19 assuring the freedom of movement of the sleeve valve 32 within the tubular body 10. The hollow body 33 is also provided with ports 47 and 49 which, when the sleeve valve 32 is in the lower or open position, as shown in FIGURE 3, allows fluid to enter the passageway 26 and the port 41 respectively from the interior 31 of the sleeve valve 32.

Sealing rings 34, 36, 43 and 45 are suitably arranged on the hollow body 33 so that, when the sleeve valve

32 is in an upper or closed position, as shown in FIGURE 1, fluid-tight seals are effected which prevent fluid from entering the opening 26 and the port 41 from the interior 31 of the sleeve valve 32, but permit fluid from the annulus 44 to flow to the interior of the packer 24 through the port 81, opening 30, passageway 26, and the opening 28.

The valve spring 40 encircles the hollow body 33 and is retained thereon between a lower surface 39 of the flange 35 and the shoulder 21 in the bore 42. The valve spring 40 is of the compression type and, in its normal position, holds the sleeve valve 32 in an upper or closed position as shown in FIGURE 1.

Referring to FIGURES 2 and 3 of the drawing, a sample receiving assembly 46 is shown disposed inside the tubular body 10. The sample receiving assembly 46 is adapted at 48 for lowering and retrieving by a conventional wire line (not shown).

The sample receiving assembly 46 includes a sample chamber 50 located within the upper portion thereof, a pressure-responsive valve assembly 58 located below the sample chamber 50 and interconnected therewith by a passageway 52, and a chamber 76 located in the lower portion of the sample receiving assembly 46. The sample receiving assembly 46 is also provided with sealing members 72 and 74 which are illustrated in FIGURES 2 and 3 as being upwardly facing cup-type packers. The sealing members 72 and 74 are positioned in recesses 79 and 80 located in the exterior of the sample receiving assembly 46.

The pressure-responsive valve assembly 58 includes a valve housing 59 formed within the sample receiving assembly 46, a hollow chamber closing valve member 60 slidably mounted within the valve housing 59, and a spring 66, also mounted within the valve housing 59, which tends to hold the hollow chamber closing valve member 60 in its upward or closed position as shown in FIGURE 2.

The hollow chamber closing valve member 60, as illustrated, is a tubular member provided with an exterior flange 62 near the longitudinal center thereof and provided with ports 61 extending through the side wall of its upper end portion. The exterior flange 62 carries an O-type seal 64 which is adapted to form a slidable yet fluid-tight seal with the interior of the valve housing 59.

The valve housing 59 is divided into an upper valve chamber 63 and a lower valve chamber 65 by an inwardly projecting flange 67. An O-type seal 68 is located in a recess in the inner periphery of the flange 67.

The hollow chamber closing valve member 60 is positioned in the valve housing 59 in such a manner that the exterior flange 62 is located in the lower valve chamber 65. When so positioned, the upper end portion thereof extends into a section 69 of the upper valve chamber 63 that is of a reduced diameter. The section 69 of reduced diameter is provided with an O-type seal 70 which forms a slidable seal with the hollow chamber closing valve member 60.

The lower valve chamber 65 also has a section 73 of reduced diameter forming a shoulder 75 therein. The lower end portion of the hollow chamber closing valve member 60 extends into the section 73. The lower valve chamber 65 also has ports 71 which extend through the side wall thereof, allowing fluid from the bore 42 to enter the lower valve chamber 65 above the exterior flange 62 of the hollow chamber closing valve member 60, but below the inwardly projecting flange 67.

The spring 66 encircles the hollow chamber closing valve member 60 in the lower valve chamber 65 and is retained in this position by the lower surface of the exterior flange 62 and the shoulder 75. The lower valve chamber 65 is connected to a passageway 54 which extends downwardly through the sample receiving assembly 46 and has its lower end open to the section 56 of

the bore 42 below the cup-type packer 74, but above the chamber 76.

A passageway 78 extends downwardly from the shoulder 75 opening at 82 into the interior 31 of the hollow body 33. The passageway 78 permits fluid communication between the lower valve chamber 65 and the interior 31 of the sleeve valve 32.

The chamber 76 has a port 77 extending through the sidewall thereof allowing fluid from the bore 42 to enter therein. The chamber 76 is adapted to receive a conventional pressure recording device 76'.

An illustration of the operation and coaction of the elements of the invention is as follows:

During drilling operations, the tool 10 is connected to the lowest section of the drill pipe 12 and a bit 16 is attached at the bottom. The pressure-responsive sleeve valve 32 is in the closed position, as shown in FIGURE 1 of the drawing. Drilling fluid is circulated in the conventional manner down through the bore 42, out through the passageway 18 in the bit 16, and back to the surface through the annulus 44. Since the opening 30 is isolated by the sealing rings 34 and 36 on the sleeve valve 32, no drilling fluid can reach the interior of the packer 24 from the bore 42. To prevent the unintentional expansion of the packer 24, the port 81 is located so that fluid from the annulus 44 may communicate with the interior of the packer 24 through the opening 30, the passageway 26, and the opening 28. Thus hydrostatic pressure, due to the height of the column of drilling fluid, is exerted both on the interior and exterior of the packer 24.

When it is desired to obtain a sample of the fluid contents of a formation 22, the sample-receiving assembly 46 is either pumped down or lowered on a wire line and seated in the bit 16, as shown in FIGURES 2 and 3 of the drawing. The spring 66 maintains the valve 58 in the closed position as shown in FIGURE 2 and is of such strength that it will hold the valve 58 closed until a pressure in excess of that required to inflate the packer 24 is applied.

With the sample receiving assembly 46 seated in the bit 16, pump pressure at the surface is applied to the drilling fluid in the drill pipe 12. The drilling fluid is restrained from downward passage around the sample receiving assembly 46 by the lips of the upward facing cup packer 72. The pressure on the fluid surrounding the sample receiving assembly 46 is transmitted to the sleeve valve 32. When sufficient pressure is applied to overcome the resistance of the spring 40 and the upward force on the sleeve valve 32 due to hydrostatic pressure of the well fluids, the sleeve valve 32 moves downwardly until the sealing ring 34 moves below the opening 30 placing the ports 30 and 47 in fluid communication and sealing the port 81 between the seals 34 and 36. Consequently, the drilling fluid is forced through the port 47 and the opening 30 into the passageway 26 and into the packer 24 through the opening 28. Sufficient drilling fluid is pumped to inflate the packer 24, so that it firmly engages the wall of the bore hole 20 forming a fluidtight seal therewith. As the packer 24 inflates, a volume reduction takes place beneath it with a resulting pressure build-up on the trapped drilling fluid. The pressure build-up forces the trapped drilling fluid through the passages 18 of the bit 16, into the section 56 of the bore 42 around the sample receiving assembly 46, past the lip of the packer 74 and out into the annulus 44 by means of the ports 49 and 41, which have been aligned by the movement of the sleeve valve 32, so that fluid may communicate through them. Thus, the pressure below and above the packer 24 will be equalized.

After the packer 24 has been inflated, and will accept no additional fluid, continued pumping of drilling fluid forces a portion of the fluid from the bore 42 through the port 71 into the lower valve chamber 65 above the exterior flange 62. When sufficient pressure has built

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up to overcome the force exerted by the spring 66, the hollow chamber closing valve member 60 is moved downwardly from a closed position, as illustrated in FIGURE 2, to an open position, as illustrated in FIGURE 3. In this position the ports 61 in the hollow chamber closing valve member 60 are open to the upper valve chamber 63. Fluid from the formation 22, which may have already filled the passageways 18 and 54, can pass through the valve assembly 58 into the passageways 52 and thence into the sample chamber 50 which is at atmospheric pressure.

Although the fluid, which is initially in the bore 42 and the passageways 18 and 54, is a mixture of the various fluids produced with those used in drilling operations, further contamination of the fluid produced from the formation 22 during the test is prevented by the packer 24 and the cup-type packers 72 and 74.

After the sample chamber 50 has filled with fluid, the pressure being exerted by the pumps at the surface is released. When the pressure on the exterior flange 62 has decreased sufficiently, the hollow chamber closing valve member 60 will be moved upwardly by the spring 66. It will be noted that the sleeve valve 32 is still in the open position and fluid in the annulus 44, which is at hydrostatic pressure, may pass through the ports 41 and 49 entering the lower valve chamber 65 through the passageway 78 and exerting hydrostatic pressure on the lower side of the exterior flange 62 assisting the spring 66 to move the hollow chamber closing valve member 60 rapidly into the closed position. This is very important in that it decreases the possibility of contamination occurring. The port 61 in the upper end portion of the hollow chamber closing valve member 60 moves past and is sealed by the O-type seal 70. The O-type seal 68 provides a fluid-tight seal with the hollow chamber closing valve member 60 thereby preventing fluid flow from the upper valve chamber 63 to the lower valve chamber 65. The valve assembly 58 is then in the closed position, as shown in FIGURE 2, and the formation fluid is trapped in the sample chamber 50, the passageway 52, and the upper valve chamber 63.

Further decreases in pressure permits the sleeve valve 32 to return to its closed position due to the force exerted by the spring 40. As a practical matter, both the sleeve valve 32 and the valve assembly 58 close almost instantaneously when the pressure is released. It should be noted however, that the valve assembly 58 closes before the sleeve valve 32 thereby eliminating the possibility of contaminated fluids entering the sample chamber 50. If the sleeve valve 32 closed first allowing the packer 24 to collapse, fluid in the annulus 44 above the packer 24 would flow downwardly into the portion of the bore hole 20 therebelow and possibly enter the sample chamber 50 contaminating the fluid sample therein.

After the sample has been obtained, the sample receiving assembly 46 may be retrieved by conventional means, such as a wire line, and drilling operations continue until it is desired to take another test.

While only one embodiment of the invention has been shown and described herein, it will be understood that various changes may be made without departing from the spirit of the invention or the scope of the annexed claims.

I claim:

1. Apparatus for obtaining fluid samples from a formation penetrated during the drilling of an oil or gas well or the like without removing the drilling string therefrom comprising a tubular body adapted to be connected in said drilling string near the lower end thereof, an expandable packing member encircling a portion of said tubular body, said packing member being deformable to form a fluid tight seal with the wall of said well, said tubular body having a passageway extending from the interior thereof in communication with the interior of said packing member, a sleeve valve member movably mounted in said tubular body for controlling flow through

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said passageway, a sample receiving assembly having a sample receiving chamber therein and a passageway extending generally downwardly from said chamber, said downwardly extending passageway having its lower end in communication with the well below said packing member, said sample receiving assembly being removably inserted in said tubular body and sleeve valve member and having seal means cooperable with said sleeve valve member to permit pressure to be built up in the drilling string thereabove, a chamber closing valve member movably mounted in said downwardly extending passageway for controlling fluid flow therethrough, said chamber closing valve member having a portion thereof exposed to the pressure of fluid in the drilling string, said sleeve valve member and chamber closing valve member being movable to permit flow of pressure liquid from the interior of said drilling string into said packing member and subsequently to permit fluid flow of formation fluid into said sample chamber upon the application of predetermined pressures in said drilling string, and means, including a port in said sleeve valve member and a port extending through the wall of said tubular body above said packing member, to permit equalization of pressure in the well above and below said packing member during the expansion thereof.

2. Apparatus for obtaining fluid samples from a formation penetrated during the drilling of an oil or gas well or the like without removing the drilling string therefrom comprising a tubular body adapted to be connected in said drilling string near the lower end thereof, an expandable packing member encircling a portion of said tubular body, said packing member being deformable to form a fluid tight seal with the wall of said well, said tubular body having a passageway extending from the interior thereof in communication with the interior of said packing member and an upper port extending through the wall thereof above the packing member in communication with said well, a sleeve valve member mounted in said tubular body for controlling flow through said passageway and upper port, said sleeve valve member being mounted for movement from a first position in which said port and passageway are in communication with each other to equalize pressure inside and outside said packing member, to a second position in which said port is closed and said passageway is in communication with the interior of the drilling string thereby permitting hydraulic expansion of said packing member by fluid in the drilling string, said tubular body also having a lower port extending through the wall thereof above said packing member and in communication with said well, means on said sleeve valve member preventing flow through said lower port when the sleeve valve member is in said first position and permitting flow therethrough when the sleeve valve member is in its second position thereby equalizing the pressure of fluid in the well above and below said packing member during the expansion thereof, said sleeve valve member being movable from the first to the second position upon the application of a predetermined pressure to the fluid in the drilling string, a sample receiving assembly removably inserted in said tubular body and sleeve valve member, sealing members encircling said assembly engageable with said sleeve valve member to permit pressure to be built up in the drilling string thereabove, said assembly having a sample chamber therein and a passageway extending downwardly from said chamber therein, said downwardly extending passageway having its lower end in communication with the well below said packing member, a chamber closing valve member movably mounted in said downwardly extending passageway for controlling flow therethrough, said chamber closing valve member having a portion thereof exposed to the fluid in the drilling string, and said chamber closing valve member being movable upon the application of a predetermined pressure to said fluid in excess of that required to move said sleeve valve member.

3. The invention of claim 2 including means forming

a second chamber in said assembly, a port extending through the wall of said assembly permitting fluid communication between said second chamber and the well below said packing member, and a pressure recording device mounted in said second chamber for recording the pressure of fluid in the well below said packing member.

4. Apparatus for obtaining fluid samples from a formation penetrated during the drilling of a well without removing the drilling string from the well, comprising in combination: a tubular body adapted for connection to the drilling string near the lower end thereof, a sample receiving assembly insertable into said tubular body through said drilling string, a deformable packer encircling a portion of said tubular body and expandable into contact with the wall of the well, hydraulic means including a passageway in said tubular body for conveying liquid under pressure from the interior of said tubular body to expand said packer, said tubular body having lateral port means extending through the wall thereof, and valve means on the tubular body movable between a first position connecting said passageway to said port means for equalizing the pressure inside and outside said packer and a second position connecting said passageway to the interior of the drilling string, said valve means in said second position also acting to connect the interior of said tubular body below said packer to said port means in order to equalize pressure above and below said packer during expansion thereof.

5. In a device for use with a drilling string in a well, the sub-combination of a tubular body adapted for connection to the drilling string near the lower end thereof, a deformable packer encircling a portion of said tubular body and expandable into contact with the wall of the well, hydraulic means including a passageway in said tubular body for conveying liquid under pressure from the interior of said tubular body to expand said packer, said tubular body having lateral port means extending through the wall thereof, and a valve on the tubular body movable between a first position connecting said passageway to said port means for equalizing the pressure inside and outside said packer and a second position connecting said passageway to the interior of the drilling string, said valve in said second position also acting to connect the interior of said tubular body below said packer to said port means in order to equalize pressure above and below said packer during expansion thereof.

6. Apparatus for obtaining fluid samples from a formation penetrated during the drilling of a well without removing the drilling string from the well, comprising in combination: a tubular body adapted for connection to the drilling string near the lower end thereof, a deformable packer encircling a portion of said tubular body and expandable into contact with the wall of the well, hydraulic means including a passageway in said tubular body for conveying liquid under pressure from the interior of said tubular body to expand said packer, said tubular body having lateral port means extending through the wall thereof, a sleeve valve on the tubular body movable longitudinally between a first position connecting said passageway to said port means for equalizing the pressure inside and outside said packer and a second position connecting said passageway to the interior of the drilling string, said sleeve valve in said second position also acting to connect the interior of said tubular body below said packer to said port means in order to equalize pressure above and below said packer during expansion thereof, a sample receiving assembly longitudinally insertable into said tubular body and sleeve valve through the drilling string, and seal means acting to prevent leakage between said sleeve valve and

said sample receiving assembly, and means on the sleeve valve responsive to liquid pressure in said drilling string for moving the sleeve valve from first to second position.

7. Apparatus for obtaining fluid samples from a formation penetrated during the drilling of a well without removing the drilling string from the well, comprising in combination: a tubular body adapted for connection to the drilling string near the lower end thereof, a deformable packer encircling a portion of said tubular body and expandable into contact with the wall of the well, hydraulic means including a passage in said tubular body for conveying liquid under pressure from the interior of said tubular body to expand said packer, a sleeve valve on the tubular body movable longitudinally to connect said passageway to the interior of the drilling string, means on the sleeve valve responsive to liquid pressure in said drilling string for moving the sleeve valve from first to second position, a sample receiving assembly longitudinally insertable into said tubular body and sleeve valve through the drilling string, and seal means acting to prevent leakage between said sleeve valve and said sample receiving assembly, the sample receiving assembly having a member provided with a passage in communication with the well below the packer to receive a sample of well fluid, valve means on said assembly controlling flow through the latter said passage, and means on said assembly for operating said valve means.

8. Apparatus for obtaining fluid samples from a formation penetrated during the drilling of an oil or gas well or the like without removing the drilling string therefrom comprising a tubular body adapted to be connected in said drilling string near the lower end thereof, an expandable packing member encircling a portion of said tubular body, said packing member being deformable to form a fluid tight seal with the wall of said well, hydraulic means including a passage in said tubular body for conveying liquid under pressure from the interior of said tubular body to expand said packing member, said hydraulic means including a sleeve valve member movably mounted in the interior of said tubular body for controlling flow of liquid through said passage, said sleeve valve member and said tubular body having means including ports providing a by-pass passageway circumventing said packing member for equalizing the pressure above and below said packing member during expansion thereof, said sleeve valve member having pressure responsive means movable upon the application of a first predetermined pressure to the liquid in said drilling string and tubular body to enable said liquid to be conveyed to said packing member, a sample receiving assembly removably inserted in said tubular body and sleeve valve member and having means cooperable with said sleeve valve member to close the bore thereof to permit pressure to be built up to said first predetermined pressure in the drilling string thereabove, said assembly having a sample receiving chamber therein and a passageway therein extending generally downwardly from said chamber, said assembly also having a chamber closing valve member movably mounted in said downwardly extending passageway for controlling flow there-through, said chamber closing valve member having a portion thereof exposed to the liquid in said drilling string and being movable to open position upon the application of a predetermined pressure to said liquid in excess of that required to move said sleeve valve member.

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