Jan. 1, 1952 R. H. BLOOD 2,581,070

FORMATION TESTER

Filed Feb. 6, 1948 2 SHEETS—SHEET 1

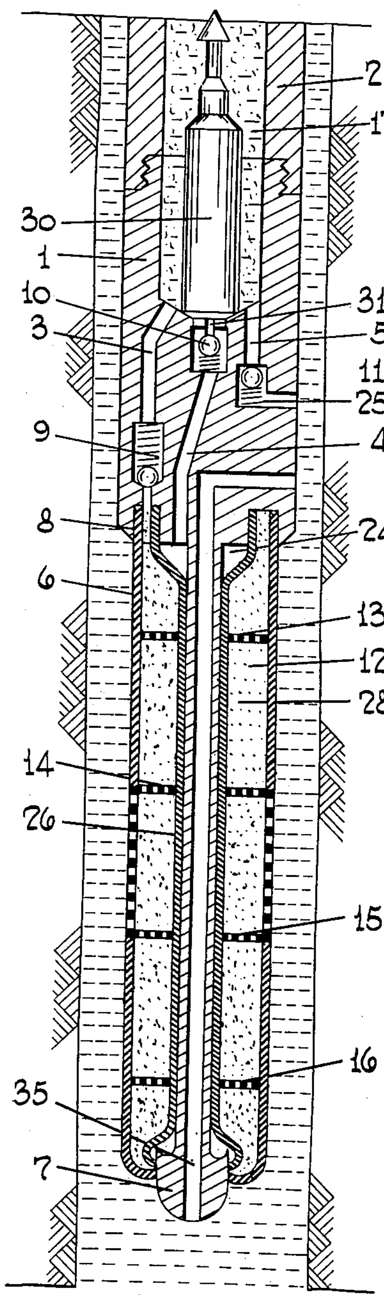

FIG.-1

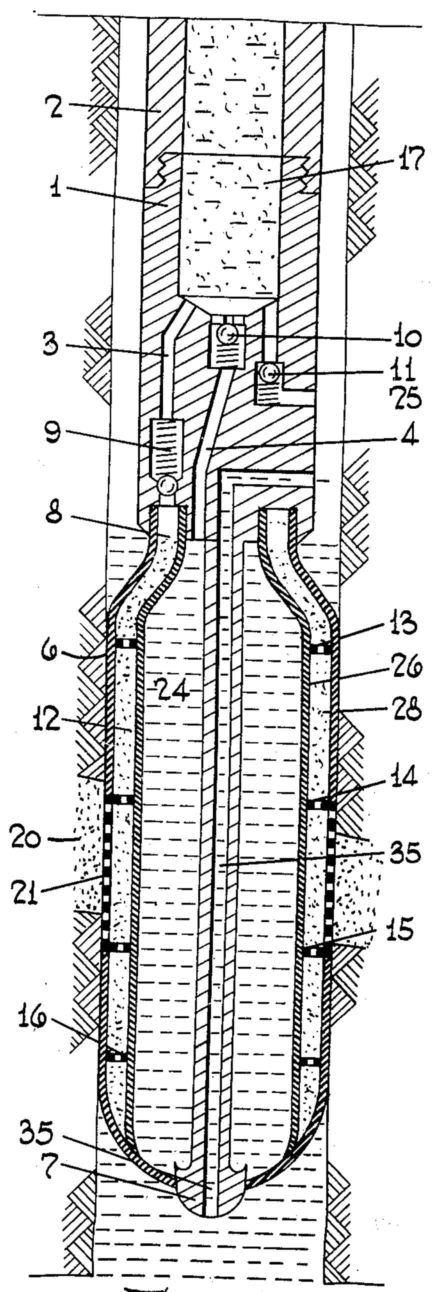

FIG.-2

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2 SHEETS—SHEET 2

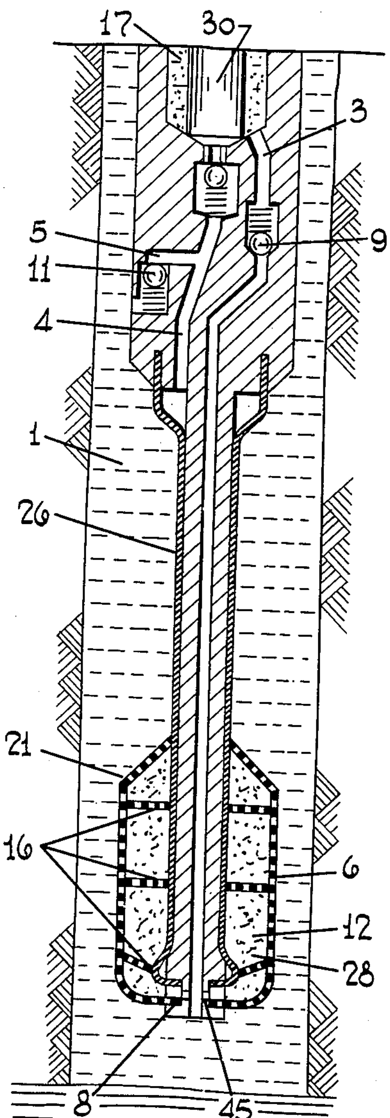

FIG.-3

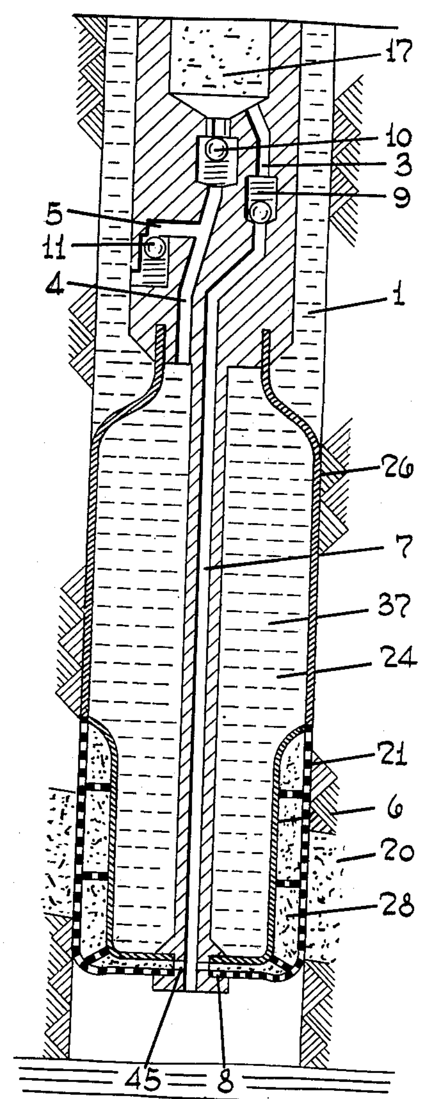

FIG.-4

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UNITED STATES PATENT OFFICE

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FORMATION TESTER

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6 Claims. (Cl. 166—10)

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This invention relates to improved apparatus for the testing of formations through which a hole is drilled to determine possible oil bearing strata. In particular the invention concerns a means which may be inflated to seal off a desired portion of a well and permeable means associated therewith through which fluid samples may be withdrawn from the desired portion of the well.

In conventional oil drilling operations, drilling devices are used to bore a hole in the earth. During drilling the hole is generally flooded with "drilling mud" which creates sufficient hydrostatic pressure to prevent the flow of any fluids from formations which are drilled. It is frequently desirable to periodically seal off the well and to reduce the hydrostatic pressure on the well sufficiently to enable samples of the fluids existing in the well to be brought to the surface. The present invention is concerned with an improved apparatus for sealing off the well and for withdrawing a portion of the fluid as desired. This operation is called "formation testing." Formation testing gives valuable information as to whether or not oil production may be expected from the formation tested. Information will be given relative to the possible productivity of the well, the pressure of the oil, and the ratio of gas to oil.

Oil bearing formations generally occur in permeable zones positioned below an impermeable zone in the earth. It is generally desired therefore to seal off the well immediately below the impermeable zone in such a manner that the hydrostatic pressure of the drilling mud maintained in the well may be decreased sufficiently to permit withdrawing a sample of the fluid existing below the impermeable layer and so that the sample of fluid may be brought to the surface. In accordance with the present invention a balloon type packer, which may be inflated, is suspended in the well at the point it is desired to test the formation. On suitably inflating this packer the well may be completely sealed off at the desired point so that the hydrostatic head above the seal may be reduced. A permeable membrane associated with the inflated packer permits withdrawal of fluids from the formation. The reduction of the hydrostatic head above the inflated packer permits the fluid flowing through the membrane to flow upwardly through the drilling string to the surface of the earth.

My invention will be more fully understood from the following detailed description in con-

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nection with the accompanying drawings in which:

Figure I represents an embodiment of my invention in the deflated position adapted for sampling a formation which is not at the bottom of the hole being drilled;

Figure II represents the same apparatus in the inflated position suitable for withdrawing the desired sample;

Figure III represents an embodiment of my invention in the deflated position which is adapted for sampling a formation at the bottom of a drilled hole and;

Figure IV represents the embodiment of Figure III in the inflated position adapted for withdrawing the desired sample.

Referring now to Figure I, the numeral 1 designates a metallic structure which is suitably connected to the drilling pipe or string 2. The drilling string is generally connected in 30 foot sections and extends upwardly to the surface of the earth. The structure 1 is partially drilled out at its upper end to provide a cavity 17 having the same diameter as the hole in the drill pipe 2. Connecting to this cavity in the structure 1, are three passages 3, 4, and 5. The function of these passages will be hereinafter described. Connected to the lower portion of the structure 1 are a pair of concentrically positioned elastic bags 6 and 26 defining between them an annular chamber 28. These bags are suitably sealed at the lower end to a rod 7, attached to or integral with the structure 1, and extending downwardly through the elastic bag 26. The elastic bags are conveniently composed of rubber, although it is to be understood other materials may be used such as impermeable cloth or fabric. The bags are so attached to the structure 1 that they are separated by permeable plug 8 at the juncture with structure 1. This plug may consist of permeable rubber or may be metallic in nature. Provision of this permeable plug permits a flow of fluid from inside chamber 28, through the permeable plug 8, into the passageway 3, which is controlled by check valve 9. This valve is so connected as to permit a flow of fluid upwardly from the bag but so as to prevent the flow of fluid downwardly from the drill string into the bag. This valve will be designated as the production valve. The passageway 4 extending from the cavity of the structure 1, downwardly to chamber 24 within elastic bag 26, is controlled by a similar check valve 10. This valve is adapted to permit the flow of fluid from the cavity 17 to chamber 24 in the elastic bag while preventing the flow of fluid in the reverse direction. This valve may be called the inflation valve. The passageway 5 connects the cavity 17 to the external portion of the well around the structure 1. A check valve 11 controls the flow of fluid through this passageway so as to permit flow from the cavity 17 to the well.

Contained within the annular chamber 28 formed by the elastic bags 6 and 26, are a multitude of pellets 12. These may consist of glass beads, metal balls, or equivalent packing. The pellets 12 are maintained throughout the chamber by means of separating partitions 13, 14, 15, and 16. These partitions consist of permeable membranes such as permeable rubber, adapted to prevent the passage of the packing material 12, from one compartment to another while permitting the flow of fluid through the different compartments. Circumferentially extending around the wall of the bag 6, approximately midway between the top and the bottom of the bag, is a permeable membrane 21. This membrane may consist of permeable rubber, for example, or if desired may consist of a fine mesh metallic screen. This section of the bag is an integral part of the wall of bag 6. It will be noted that a comparatively small circumference of the bag is provided with the permeable material 21.

In operating the embodiment shown in Figure I, after a suitable hole has been drilled, the device shown is lowered into the well attached to the bottom of a drill string. The device is lowered to the point at which it is desired to test for possible oil production, which may have been determined by well-logging or equivalent procedures carried out during the drilling procedure. In Figure I it is assumed that a possible production zone, permeable stratum 20, exists adjacent to the permeable membrane 21 of the bag. The bag 26 is then inflated to the position shown in Figure II by pumping drilling mud or other fluid through the drill string, through the cavity 17 of the structure 1, and through the passageway 4 into chamber 24 of the flexible bag. During this operation, valve 9 prevents flow of the mud into annular chamber 28 and valve 11 is likewise closed. This is effective in causing the bag to inflate as in Figure 2, completely sealing the hole along the expanded circumference of the bag. When the pressure of the drilling mud pumped within the bag reaches a predetermined level, determined by the toughness of the bag, further expansion is limited by the opening of the by-pass valve 11, which serves to by-pass the flow of drilling mud into the external portion of the well. This may be accomplished by suitably adjusting the force of the spring 25 in the valve 11, so that the drilling mud will be by-passed when the bag has been inflated to a desired pressure. When mud has been pumped into the drilling stem sufficiently long so that the bag will have been completely inflated and some by-passing of the mud will have occurred, pumping may be discontinued causing the valves 10 and 11 to close, completely sealing the drilling mud in the expanded bag. Thereafter, pressure may be relieved from the fluid contained in the drilling string so that the hydrostatic head in the drilling stem is lower than the pressure existing in the formation 20 to be tested. Suitable decrease in the hydrostatic pressure existing in the drilling string may be achieved simply by discontinuing the pumping of fluid through the string and by applying a pump to withdraw fluid from the drilling string. When this has been achieved, fluids from the production zone 20 will permeate the membrane 21, flowing within the annular chamber 28. The pressure differential will cause the fluid to flow upwardly through the annular chamber and through the production valve 9, into the cavity of the structure 1, and upward through the drilling string. By this means a sample of the fluid existing in the zone 20, may be withdrawn and passed to the surface of the earth. It will be noted that the packing material 12 is effective during this portion of the operation to prevent the sealing of the annular chamber between the bags by virtue of the pressure of the drilling mud within the bag 26. After a suitable sample has been withdrawn from the formation to be tested, the bag may be deflated by dropping a suitable tripping device into the drill string. As illustrated in Figure I, the tripping device 30 may consist of a cylindrical metallic object having an extending lug 31 at its lowermost end. This lug is adapted to press against the valve 10 so as to permit flow of fluid through the passageway 4 upwardly into the drilling stem. Suitable corrugations along the contact surface of the tripping device 30 may be employed to permit the flow of fluid between the tripping device and the structure 1. By this means the valve 10 is opened permitting the flow of drilling mud from the inside of the bag 26, causing deflation of the bag. The entire device may then be withdrawn from the well and drilling operations may be resumed. It is to be noted that in the embodiment shown in Figures I and II the formation to be tested is not at the bottom of the well. Consequently on sealing off the upper part of the well a considerable pressure differential could develop above and below the sealing bag. This could be caused for example by the loss of drilling mud below the tester into an adjacent formation. A conduit 35 is provided through the rod 7 providing a passageway to permit equalization of this pressure.

A further embodiment of my invention is illustrated in Figures III and IV. The embodiment illustrated is particularly adapted for the testing of a formation located at the bottom of a drilled hole. In Figures III and IV, parts similar to those of Figures I and II are identified by similar numerals. The apparatus illustrated may be fully understood by reference to the foregoing description of the apparatus shown in Figures I and II. It will be noted that in order to test a formation at the bottom of the hole, the permeable portion 21 of bag 6 is positioned at the bottom of the bag rather than midway up the bag. Consequently, it is not necessary that the outer bag 6 extend over the entire length of bag 26, it only being necessary that the lower portion of the packer have an annular chamber 28. When the bag has been inflated, according to the procedure described, and when the hydrostatic pressure in the drilling string has been suitably decreased, fluid samples flowing from the formation 20 will enter the annular chamber 28 through the porous membrane 21. The fluid may then flow through the permeable plug 8, which in this embodiment is a circular ring, and may then enter the passageway 37 through the connecting passageway 45, and thence to the surface through valve 9, chamber 3 and the drill string. Since the formation tester in this case is positioned at the bottom of the drill hole, it is not necessary to provide means for equalizing the pressure above and below the elastic packer. Consequently, it is not necessary to have the equivalent of passage 35 in Figure I, in the embodiment of Figures III and IV.

As described my invention comprises a packer consisting of a pair of concentrically positioned elastic bags, adapted to be lowered into a drill hole. A portion of the wall of the outer elastic bag consists of a porous membrane permitting a flow of fluid through the membrane to the annular chamber defined by the two bags. The bags are suitably attached to a supporting member, and a permeable plug is positioned in the termination of the annular chamber so that the fluid may flow through this permeable plug into chambers provided to conduct the fluid into the drilling string and to the surface of the earth. While my invention has been described in connection with drill pipe, it is to be understood that it may readily be adapted to wire-line devices as well. It is apparent many other modifications of the apparatus described may be made. The appended claims are, therefore, to be given a broad interpretation commensurate to the contribution to the prior art.

Having now described my invention, I claim:

1. Apparatus for use in testing a borehole to determine the presence of possible oil bearing formations which comprises supporting means adapted to be connected to a drill string, a pair of concentrically disposed elastic bags fixed to said supporting means and defining between them an annular chamber, pelleted packing material maintained within said annular chamber, a permeable membrane comprising a portion of the wall of the outer of said pair of elastic bags, a conduit connecting the interior of the drill string with the interior of the inner of said pair of elastic bags, said conduit having a valve permitting the flow of fluid from the interior of the drill string to the interior of said inner elastic bag and preventing fluid flow in the opposite direction, and a conduit connecting the interior of the drill string with said annular chamber, said last named conduit having a valve permitting flow of fluid from said annular chamber to the interior of the drill string and preventing fluid flow in the opposite direction.

2. The apparatus defined by claim 1 including a conduit connecting the interior of the drill string with the exterior thereof through a valve permitting flow of fluid outwardly into the borehole from the interior of the drill string when a predetermined fluid pressure is attained within the drill string.

3. Apparatus according to claim 1 including a plurality of permeable separating partitions disposed within said annular chamber and defining separate compartments for said packing material.

4. The apparatus defined by claim 1 in which the said permeable membrane is positioned approximately midway between the top and the bottom of the outer elastic bag.

5. The apparatus defined by claim 1 in which the said permeable membrane is positioned substantially at the bottom of the outer elastic bag.

6. The apparatus defined by claim 1 in which the elastic bags are constructed of rubber.

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