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DRILL STEM TESTING METHODS

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Fig 1A

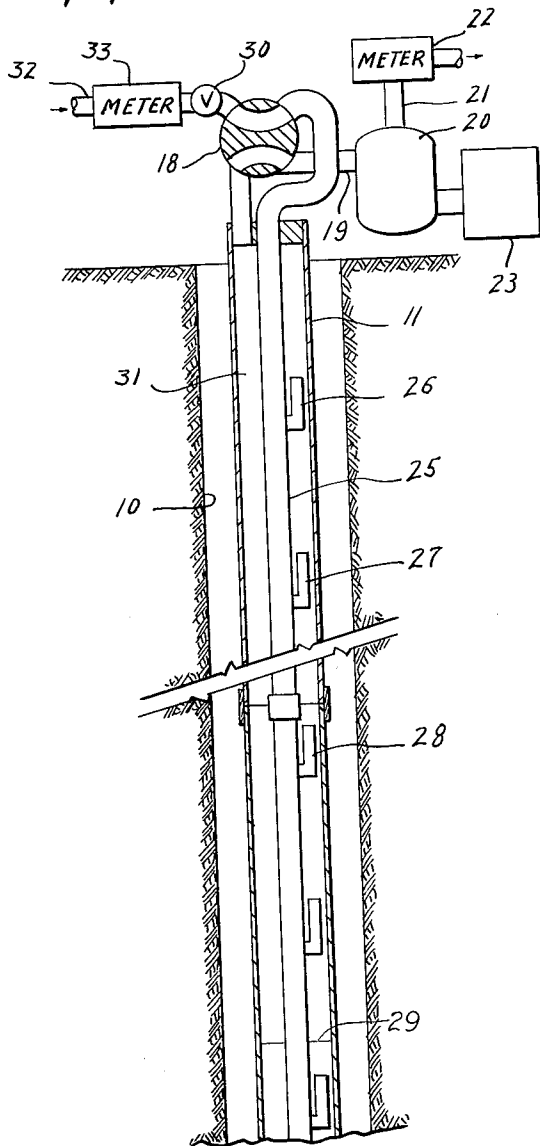
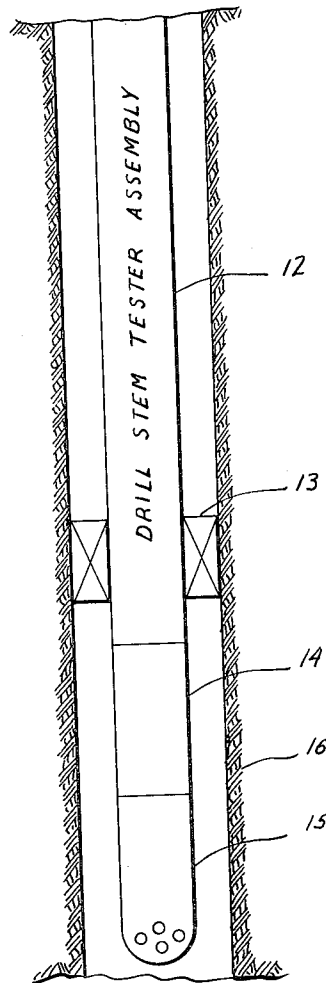


Fig. 1B



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DRILL STEM TESTING METHODS

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This invention relates to drill stem testing of earth formations traversed by a well bore. More particularly, this invention relates to methods for testing earth formations and obtaining production information at the time of drill stem testing where fluid pressures are insufficient to provide a surface flow.

The purpose of a drill stem test is to allow the formation or potential pay zone in a well bore to produce fluid prior to final completion of the well so that the owner of the well can decide if he desires to risk the cost of completion. This drill stem test is typically accomplished by a testing tool assembly coupled to a drill pipe. A packer on the testing tool assembly bridges or packs off the well bore above the potential earth formation pay zone to isolate the selected earth formations from the pressure of the mud and then the tool is opened to allow the zone to produce formation fluid into the empty or near empty drill pipe or tubing. In many wells tested, the pressures are sufficient to provide a fluid flow to the surface which after a period of time stabilizes to a "steady state flow." This "steady state flow" is essentially a production of the zone on a minor scale and from this production and the data obtained in the drill stem test, the productivity of the well, the nature of the fluids in the formations and the extent of the reservoir can be estimated with some degree of accuracy.

The quantitative data from a drill stem test typically includes pressure build-up data such as initial hydrostatic mud pressure (tester closed, packer unset), initial flow pressure (tester open, packer set), initial shut-in build-up pressure (tester open, packer set, shut-in tool closed), final flow pressure (tester open, packer set, shut-in tool open), final shut-in buildup pressure (tester open, packer set, shut-in tool closed), and final hydrostatic mud pressure (tester closed and by-passed, packer unset). The quantitative data from a drill stem test also includes a sample of the type and amount of fluid produced by the reservoir during the time the test tool was open and the reservoir temperature. At the earth's surface, the recovered fluids can be metered and measured. From the data obtained an oil-reservoir performance study can be made.

From the foregoing, it will be readily appreciated that if the drill stem testing apparatus is open in the well bore and the formation fluids are at insufficient pressure to flow to the surface of the well, it is not possible to provide a full reservoir evaluation of the well from the drill stem test.

Accordingly, it is an object of the present invention to provide a new and improved method of testing non-flowing well bores.

A further object of the present invention is to provide a new and improved method of obtaining testing data from non-flowing well bores.

In the present invention, in a non-flowing well bore, a formation is isolated with a packing element attached to a first tubing string which extends between the earth's surface and the isolated formation. A second tubular string is introduced into the first tubing string to extend below the fluid level in the first tubing string. An input gas is provided to drive the fluid in a well bore to the earth's surface. At the earth's surface, the recovered fluid is separated into its gas and liquid constituents. The amount of input gas is measured when it is injected in

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the well, the total amount of gas produced with the liquid is measured as it is produced, and the difference between these two volumes is the net amount of gas produced with the liquid from the reservoir. Liquid recovery at the earth's surface is also measured. Pressure and temperature of the fluid in the well bore are measured. This data is highly useful in determining the productivity of the well, the nature of the fluids in the formation and the extent of the reservoir.

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

FIGS. 1A and 1B are views in cross section of a well bore and apparatus for performing the method of the present invention.

Referring now to FIGS. 1A and 1B, this apparatus shown includes a drill pipe 11 adapted to be lowered into a well bore 10 traversing earth formations where formation 16 is selected for a test. Coupled to the lower end of the drill pipe 11 is a conventional drill stem tester assembly 12. The drill stem tester 12 has a packer 13 thereon for packing off the well bore. Coupled to the drill stem tester 12 below the packer are a conventional pressure measuring and recording device 14 and a conventional temperature measuring and recording device 15.

In testing, the drill pipe 11, drill stem tester 12, packer 13 and pressure recording and measuring and recording device 15 are lowered into the well bore until the packer is just above the formation of interest. Tester 12 is normally closed so that the interior of the drill pipe 11 is empty of fluids. Before the packer 13 is set, the pressure device records the mud pressures. After the packer 13 is set, the pressure device records the initial shut-in pressure. Next, the drill stem tester is opened and if fluid flows to the surface of the earth through the drill pipe 11, a drill stem test is performed. This is accomplished at the casing head by connecting the upper end of the drill pipe 11 through a casing head connection to switching valve 18 which, in the position shown, connects the drill pipe 11 to a conventional separator 20 by a conduit 19.

However, if no fluid flows, it is difficult to obtain any reliable production data from the drill stem test. To obtain such information from a non-flowing well, there is provided a tubing assembly 25 having spaced conventional gas lift valves 26, 27, 28 along its length which assembly 25 is sized to be insertable in the drill pipe 11. Tubing 25 is connected to switching valve 18 so that a 90° rotation of the valve connects the tubing 25 to the separator 20 via conduit 19. In the rotated position of valve 18, the drill pipe 11 is connected to a normally closed valve 30. Valve 30, when opened permits a gas input through the drill pipe 11 to drive fluid 29 in the drill pipe 11 through tubing 25 to the separator. While the foregoing described system is preferred, it should be appreciated that tubing 25 can be connected to the separator 20 while the annulus 31 between the tubing 25 and drill string 11 is connected to the valve 30.

Valve 30 is connected to an input pipe coupling 32 which is provided with a flow meter 33. To obtain a fluid flow, an inlet gas input (not shown), such as a nitrogen source, is supplied to the input pipe coupling 32 with the switching valve 18 connected to the drill pipe annulus 31 while the valve 30 is open. The gas will drive fluids 29 in the drill stem 11 up the tubing 25 and via the switching valve 18 to the separator 20. Gas lift valves 26-28 may be set at different pressures to as-

sist the lifting of the fluid to the surface in a well-known manner. It is, however, not necessary to use gas lift valves since the size of tubing 25 may permit use of orifices to control the gas lifting operation. In the separator 20, the liquids and gases are separated. The separator 20 performs its usual function of separating the gas in solution from the liquid, the separated gas rising in the separator 20 and exiting via a pipe coupling 21 to a flow meter 22 which obtains a quantitative measurement of the gas in the fluids. The liquids from the separator 20 are drained into a calibrated reservoir tank 23 which measures the quantity of fluid recovered. Hence, water-oil ratios are readily determined from the recovered liquid in the reservoir tank 23 and gas-oil ratios are readily determined from the ratio of gas and oil recovered.

The metered gas output will be a combination of the gas from the well plus the gas drive applied to the input. Hence, subtraction of the input flow from the output flow will yield the net gas in the fluid.

It will be appreciated from the foregoing description that data can be obtained from a non-flowing well to calculate the conditions of the well and the reservoir. It will also be appreciated that the foregoing described apparatus is illustrative only of typical apparatus to perform the method.

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

What is claimed is:

1. A method of testing earth formations traversed by a well bore wherein formation fluids are inadequate to provide a surface flow, comprising the steps of: isolating a formation with a packing element attached to a first tubing string which extends between the earth's surface and the isolated formation; introducing a second tubing string into the first tubing string to extend below any fluid level in the first tubing string; providing metered input gas under sufficient pressure to one of said tubing strings to displace a fluid recovery comprised of the input gas and formation fluids through the other tubing string; maintaining the fluid recovery in a closed system to prevent the escape of any constituents from the fluid recovery; taking the fluid recovery from the closed system at the earth's surface and separating the gas and liquid constituents from the fluid recovery; and measuring the separated gas at the earth's surface whereby the difference between the separated gas and the input gas

is determinative of net formation gas in the fluid recovery.

2. A method of testing earth formations traversed by a well bore wherein formation fluids are inadequate to provide a surface flow, comprising the steps of: isolating a formation with a packing element attached to a first tubing string which extends between the earth's surface and the isolated formation, said first tubing string being normally closed until the formation is isolated; introducing a second tubing string into the first tubing string to extend below any fluid level in the first tubing string; providing input gas under sufficient pressure to one of said tubing strings to displace fluid through the other tubing string; maintaining the input gas and displaced fluid in a closed system; separating the gas and liquid constituents from the displaced fluid at the earth's surface; measuring the input gas and separated gas at the earth's surface to determine the net gas in the fluid; continuously obtaining and recording temperature and pressure data of the isolated formation; and opening the first tubing string to the isolated formation before providing gas under pressure.

3. A method of testing earth formations traversed by a well bore wherein formation fluids are inadequate to provide a surface flow, comprising the steps of: isolating a formation with a packing element attached to a first tubing string which extends between the earth's surface and the isolated formation, said first tubing string being normally closed until the formation is isolated; introducing a second tubing string into the first tubing string to extend below any fluid level in the first tubing string; providing input gas under sufficient pressure to one of said tubing strings to displace fluid through the other tubing string; maintaining the input gas and displaced fluid in a closed system; separating the gas and liquid constituents from the displaced fluid at the earth's surface; measuring the input gas and separated gas at the earth's surface to determine the net gas in the fluid; continuously obtaining and recording temperature and pressure data of the isolated formation; opening the first tubing string to the isolated formation before providing gas under pressure; and measuring the liquid recovery at the earth's surface.

References Cited by the Examiner

UNITED STATES PATENTS

2,229,884	1/1941	Chalkley	166—3X
2,663,545	12/1953	Grable	166—3
2,745,282	5/1956	Rochon	73—19

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