

**United States Patent** [19]**Rhoades**[11] **3,712,129**[45] **Jan. 23, 1973****[54] SIMPLIFIED WELLBORE PRESSURE TESTING APPARATUS****[75] Inventor:** Vaughan W. Rhoades, Tulsa, Okla.**[73] Assignee:** Cities Service Oil Company, Tulsa, Okla.**[22] Filed:** June 2, 1970**[21] Appl. No.:** 42,832**[52] U.S. Cl. ....**73/151, 73/388 R**[51] Int. Cl. ....**E21b 47/06**[58] Field of Search ....**73/155, 438, 439, 299, 388 R,  
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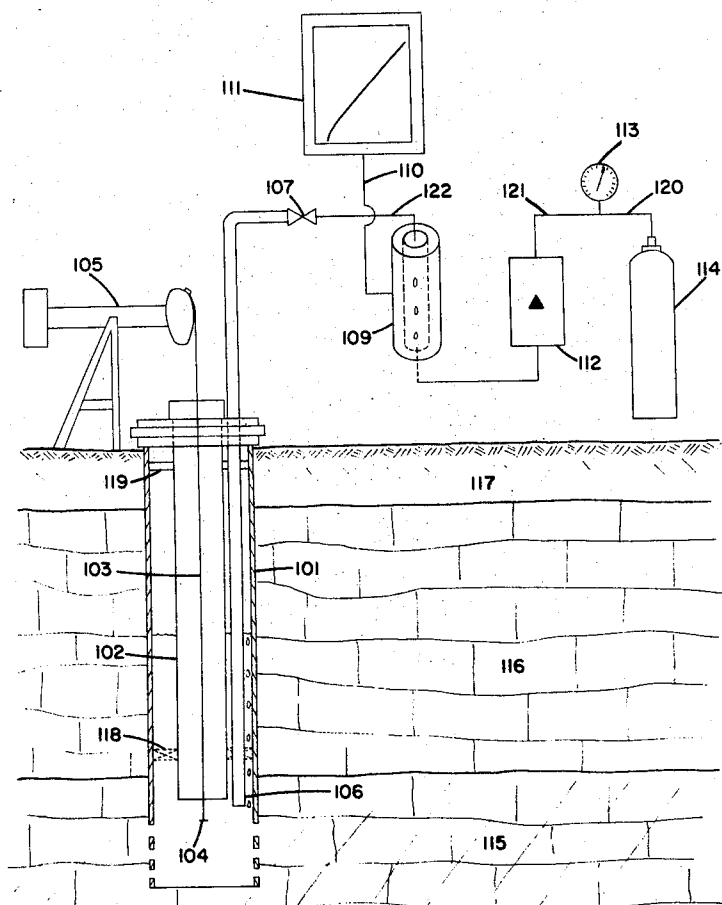
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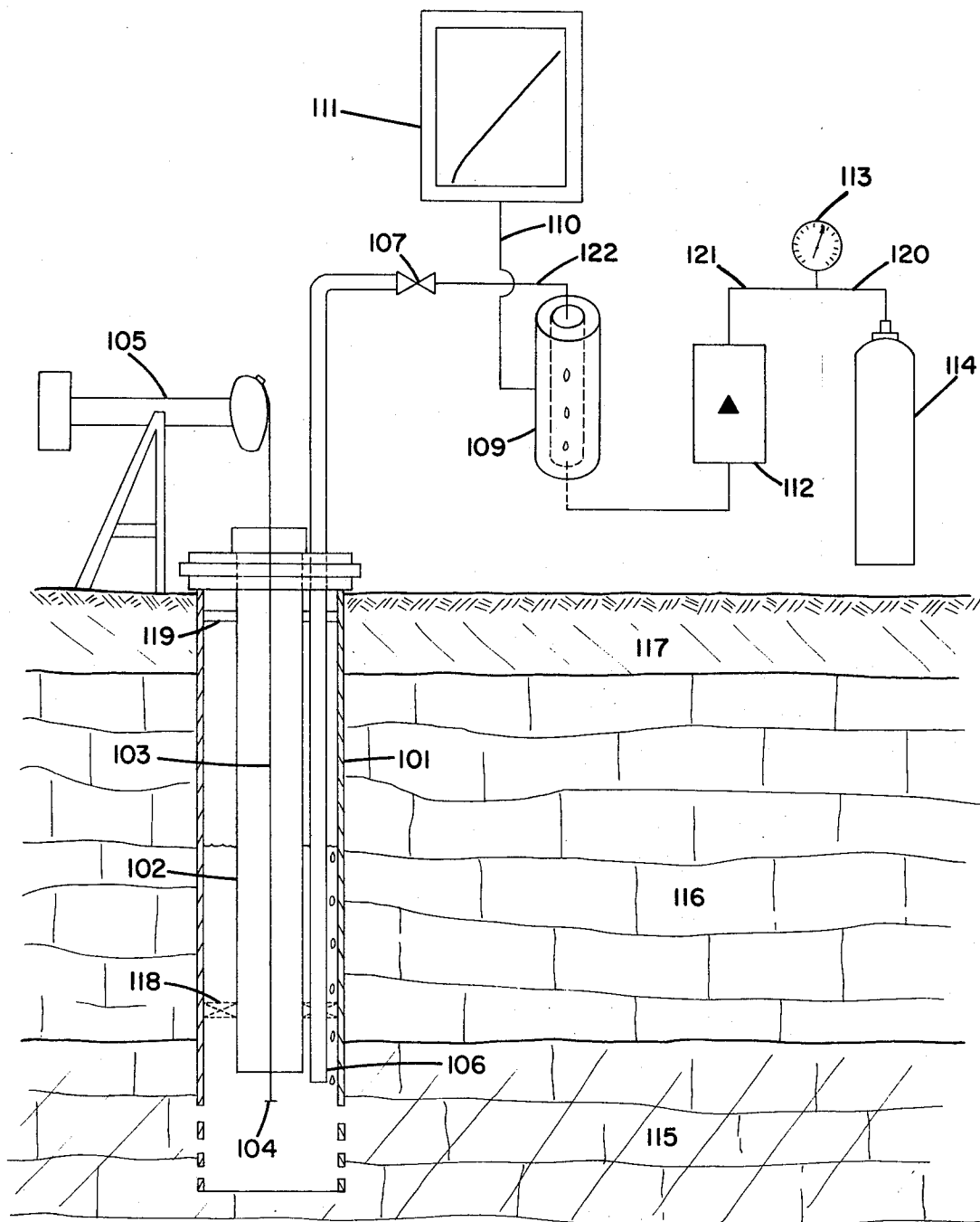
*Primary Examiner*—Jerry W. Myracle*Attorney*—J. Richard Geaman**[57] ABSTRACT**

A length of microtubing is strung from the surface to the bottom of a well string during well completion and sealed at the surface by a valve. Pressure is recorded as desired by regulation of a pressurized gas, metered by a microflow mechanism, into the microtubing so that a predetermined flow of gas is continuously bubbled from the exit of the microtubing at the bottom of the well. A pressure gauge may be attached to the microtubing at the surface so as to measure the shut-in or flowing pressure of the well. The injected gas is of a known density so that a correction for the flowing head can be made to accurately determine the bottomhole pressure.

**6 Claims, 1 Drawing Figure**

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## SIMPLIFIED WELLBORE PRESSURE TESTING APPARATUS

### BACKGROUND OF THE INVENTION

This invention relates to the monitoring of static and flowing wellbore pressures in subterranean reservoirs. More particularly, the invention relates to the use of a simplified permanent installation for the recording of pressures and pressure transients in pumping and flowing oil wells.

In order to pressure test a pumping well with conventional pressure testing apparatus, it is generally necessary to pull the rods and pump and the tubing string from the wellbore in order to place the pressure apparatus therein. After the tubing string has been removed from the well, a pressure bomb is attached to the bottom of the pump or the bottom of the tubing string, whichever the circumstances dictated, and the tubing string or the tubing string and the pump are then returned to their respective positions in the well. In the use of a pump, subsequent to the tubing string being placed in the well, the rods are returned into the well before the flowing pressure test may be begun. The reverse procedure is necessitated to reacquire the pressure bomb after the pressure test is completed. The procedure is both tedious and expensive as there is lost production and labor incurred. Therefore, with conventional pressure testing techniques, it is necessary to manipulate the well completion equipment before the pressure test may be begun and in the case of an unsuccessful pressure test, the bomb must be removed from the well and replaced therein, resulting in an additional loss of production time and expenditure of labor.

Although surface transient measurement has been attempted in the past, it is normally unsuccessful since there is generally a considerable head of liquid in the multiphase flowing wells, with an undeterminable amount of gas present in the well which makes it nearly impossible to determine bottomhole pressure transient behavior from surface pressure measurements. Although, in the macro sense, bottomhole pressure transient behavior may be measured at the surface, it is highly unsuccessful in most cases and especially poor when there are high gas throughputs within the wellbore with various multiphase conditions occurring simultaneously throughout the tubing string. A further difficulty in the measuring of pressure transients from surface conditions is the fact that most pressure transients involve a small change in pressure as compared with the total pressure drop over the wellbore from surface to bottomhole, which may be several hundred or more pounds per square inch. Therefore, a slight error in the measurement of the pressure at the surface may make the transient pressure behavior at the bottom of the well unpredictable or uncertain.

What is required is a method of measuring bottomhole pressure transient behavior and bottom hole stagnant pressure behavior by means of a permanent surface installation whereby field personnel may continuously monitor a flowing or pumping well without the necessity of lost production time and high labor expenditure.

It is an object of the present invention to provide an apparatus for the continuous monitoring of bottomhole pressures in oil wells.

It is a further object of the present invention to provide for a permanent installation by which bottomhole pressures in both free-flowing and pumping wells may be measured.

It is still a further object of the present invention to provide apparatus which may be utilized as a permanent installation for the measurement of bottomhole pressures in static, pumping and flowing wells.

With these and other objects in mind the present invention is hereinafter set forth with particular reference to the accompanying drawing and description.

### SUMMARY OF THE INVENTION

The objects of the present invention are achieved by use of apparatus for the measurement of bottomhole pressures in free-flowing, pumping and static fluid wells. The apparatus comprises a well having a bottomhole pressure greater than the normal hydrostatic pressure and a length of microtubing fastened to a tubing string including a packer extending from the surface of the earth to the depth in the well below the packer and at which the pressure is to be measured. A microflow valve is connected to the microtubing at the surface. Also provided are means, connected to the microflow valve, for supplying and regulating a fluid and detachable means, connected to the microtubing at the surface, for measuring the pressure in the microtubing. In general, the means for supplying and regulating fluid may comprise a pressurized gas cylinder in conjunction with a pressure regulator having the high pressure side of the regulator connected to the pressurized gas cylinder and the low pressure side connected to the microflow valve.

The apparatus provides a permanent pressure measurement installation within the well. By use of microtubing, the pressure at the surface is essentially that of bottomhole neglecting the slight head of fluid in the microtubing and wall frictional losses. Injected fluid rate is extremely small so that the frictional drop is truly negligible. The density of the injected fluid is known and the bottomhole pressure can be corrected in accordance with this valve is extreme precision is required. Pressure gauges of extreme precision may be attached to microtubing as they are not exposed to the wellbore elements as in the use of conventional bottomhole pressure measurement bombs. Continuous monitoring of the bottomhole pressure may be afforded by pressure recording means which are detachable so that more than one well may be monitored with the same recording instruments. The invention allows simplified measurement of pumping or flowing wells without the necessity of interrupted production or well workovers, thereby providing an economical method for pressure testing oil wells.

### BRIEF DESCRIPTION OF THE DRAWING

The present invention is hereinafter described in further detail, with particular reference to the accompanying drawing in which:

FIG. 1 depicts the wellbore with the apparatus for pressure recording as described in the present invention contained therein.

## DETAILED DESCRIPTION OF THE INVENTION

The present invention provides an apparatus for the measurement of static fluid, transient buildup and drawdown pressure tests in oil wells. The apparatus consists of a length of microtubing extending from the surface to the depth at which the pressure is to be measured. The microtubing is attached at the surface to a microflow valve. This valve may be utilized to provide an incremental flow of fluid through the microtubing. Attached to the microflow valve is means for supplying and regulating a fluid. Also incorporated in the surface apparatus is detachable means for measuring the pressure. In the application of the present invention a supply of gas is allowed to flow through the microtubing as controlled by the microflow valve. Flow is adjusted by a microflow valve so that a slow incremental flow or bubble type flow is allowed to exit from the microtubing at the depth at which the pressure is to be measured. The pressure gauge or other pressure sensing device attached to the microtubing is utilized in such a manner that the pressure at the bottomhole or at the end of the microtubing is essentially the same as the pressure measured at the surface. Therefore, continuous monitoring of the pressure at the bottomhole during drawdown, buildup or other pressure testing periods of the production history of the well is afforded.

In general, the microtubing utilized in the present apparatus will have an inside diameter of about 1/16 to about 1/4 inch. This diameter allows a small amount of gas be introduced into the bottom of the well so as not to interrupt production in the well, but allows a sufficient amount of flow within the tubing such that it may be regulated at the surface. Typical materials of construction for the microtubing would be nylon and stainless steel tubing or any tubing which is both corrosion resistant to the elements of the wellbore and has the necessary strength to withstand the pressure exerted upon it. In a pumping well the tubing will be run along the outside of the tubing string within the wellbore. Since the tubing string in a pumping well is attached to the bottomhole by a tubing anchor, the microtubing may be conveniently slipped through the tubing anchor and thereby attached to the bottom of the tubing string adjacent to or above the depth of the bottomhole pump. When the apparatus is utilized in a flowing well, the microtubing may be run down the exterior of the tubing string and through a production packer or anchor and attach at the bottomhole to the end of the tubing string so as not to require penetration of the production tubing.

In general, the fluid which is used to flow through the microtubing to analyze the pressure transient behavior at the bottom of the hole would be a gas. The use of a gas or similar low density material must be used in lieu of a dense fluid to assure that the head of injected material exerts less pressure at the microtubing outlet than does the head of wellbore fluid at that point. Gases utilized in the present invention should not be extremely compressible and should exhibit small head pressure with depth such as air, natural gas, nitrogen and other light gases which may be commonly purchased and provided on the pressure measurement site. The source of these gases would generally be a pressurized cylinder

bottle attached to the microtubing by a regulator so that the pressure on the microtubing may be set so as to overcome the bottomhole pressure of the well. For example, in the use of a nitrogen gas source, a pressurized nitrogen gas cylinder having an average cylinder pressure of 2,000 pounds could be used for wells in conjunction with microtubing, whereas, in some cases a small pressure pump might be used to introduce atmospheric air into the microtubing.

A microflow meter may be used in conjunction with the microflow valve such as a microflow valve hooked to a rotometer so that a minimal amount of fluid flow through the tubing may be maintained to yield a slow bubbling effect at the bottom of the well. In accordance with the invention, the means for recording the pressure in the microtubing may be supplied by any pressure measuring device. Such devices would include a Bourdon tube gauge, manometer, quartz tube pressure measuring device, or the microtubing pressure may be monitored by an electric pressure transducer. Any sensitive pressure measuring device may be utilized in the present apparatus as long as sufficient control on the pressure measurement may be maintained. It is desirable that the pressure device be portable and easily connected to the microtubing such that the pressure measuring device may be transferred from one well site to another.

To illustrate the apparatus of the present invention, referral to FIG. 1 is suggested. In FIG. 1 the wellbore pressure may be monitored by the pressure testing apparatus as described herein. A well 101 is completed from the surface 117 through overburden 116 and into the hydrocarbon bearing formation 115. A tubing string 102 is hung by hanger 119 from the earth's surface 117 into the formation 115. The tubing string is anchored by tubing anchor 118 to a point slightly above the formation producing zone. A pump jack 105 is connected by sucker rod 103 to wellbore pump 104 positioned opposite the formation 115. The apparatus of the present invention consists of microtubing 106 hung from earth's surface 117 in the formation 115 and attached to the exterior portion of the tubing string 102. Microtubing is placed so that the bottom of the tubing extends within the formation 115 to a predetermined depth at which pressure measurement is desired. At the surface, the microtubing 106 is connected to a connector valve 107 from which a quick release mechanism is provided so that the length of surface microtubing 122 and the recording equipment may be transported from well site to well site. The recording equipment consists of a pressurized fluid cylinder 114 with high pressure tubing 120 connected from the cylinder 114 to a pressure regulator 113. From the pressure regulator 113, connector microtubing 121 extends to a microflow meter and valve 112 which is used to regulate the fluid flow through the surface microtubing 122, connector valve 107 and microtubing 106. Also in line is a pressure sensor 109 which may consist of a pressure transducer electrically connected by line 110 to an electronic recorder 111.

In the operation of the apparatus of the present invention the gas is allowed to flow from gas cylinder 114 through pressure regulator 113 into microflow meter and valve 112, wherein the flow in the microtubing 106 is set so that periodic bubbles will be produced from

the microtubing 106 at the bottomhole. When this minimal flow is established, the pressure measured at the bottom of the microtubing 106 is essentially that measured by the pressure transducer 109 and is recorded on electronic recorder 111 excluding the head of injected fluid in the microtubing. Therefore, one may continuously monitor the transient pressure behavior at the bottom of the well without requiring introduction of a bomb or pressure sensing device into the wellbore. It may be necessary to correct the measured pressure in very deep wells for the head of fluid in the microtubing. The frictional wall forces and head of fluid are generally insignificant. Also, the microtubing at these depths or greater depths must be of sufficient structural strength to withstand the high pressures experienced within the microtubing. It is therefore a necessary criteria of the present invention that various tubing materials be used for various well depths to be pressure measured. Generally, the apparatus as described herein will function in any well at any depth with the only constraint being the necessary correction for pressure differences measured between the bottom of the well and at the surface.

It can be seen by use of the present invention that the pressure transient buildup or drawdown in an oil well can be continuously monitored by a simply constructed apparatus. The means for recording pressure are detachable and may be utilized for monitoring the transient pressure behavior of an entire oil field. Therefore, one can disconnect the means for recording the pressure from the connector valve and transfer it to another wellhead site. The only remaining pressure measuring equipment in the wellbore being the microtubing extending to the formation of interest and a connector valve at the surface. The extreme advantages gained over conventional pressure bombs are apparent by use of the simplified apparatus as presented.

While the invention has been described above with respect to certain embodiments thereof, it will be understood by those skilled in the art that various changes

and modifications may be made without departing from the spirit and scope of the invention as set forth herein.

Therefore, I claim:

1. Apparatus for the measurement of bottomhole pressure in free flowing, pumping and static fluid wells which comprises:

- a. a well having a bottomhole pressure greater than the normal hydrostatic pressure of said well;
- b. a tubing string extending from the surface to a depth within said well;
- c. a packer connected to said tubing string;
- d. a length of microtubing fastened to said tubing string and extending from the surface to a depth below said packer;
- e. means for supplying and regulating a fluid under pressure to said micro-tubing;
- f. means for recording the bottomhole pressure in said micro-tubing.

2. The apparatus of claim 6 in which the means for supplying and regulating a fluid comprises:

- a. a pressurized gas cylinder; and
- b. a pressure regulator having the high pressure side of the regulator connected to the pressurized gas cylinder and the low pressure side connected to the microflow valve.

3. The apparatus of claim 2 in which the means for recording the pressure in the microtubing is a pressure gauge.

4. The apparatus of claim 2 in which the means for recording the pressure in the microtubing is an electronic pressure transducer.

5. The apparatus of claim 1 in which said quick release means comprises a quick release connector valve attached to the means for supplying and regulating a fluid and means for recording the pressure are connected.

6. The apparatus of claim 1 further comprising a quick release connector valve attached to said microtubing at the surface to which the microflow valve, means for supply and regulating a fluid and means for recording the pressure are connected.

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