May 21, 1957 T. W. BELL ET AL 2,792,709

APPARATUS DETERMINING STATIC PRESSURES IN PUMPING WELLS

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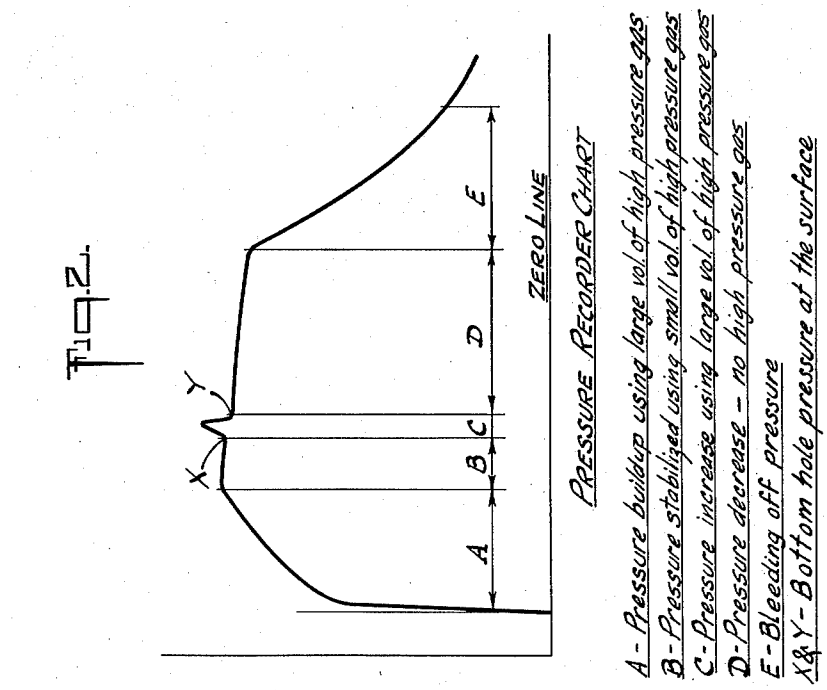


Fig. 2.

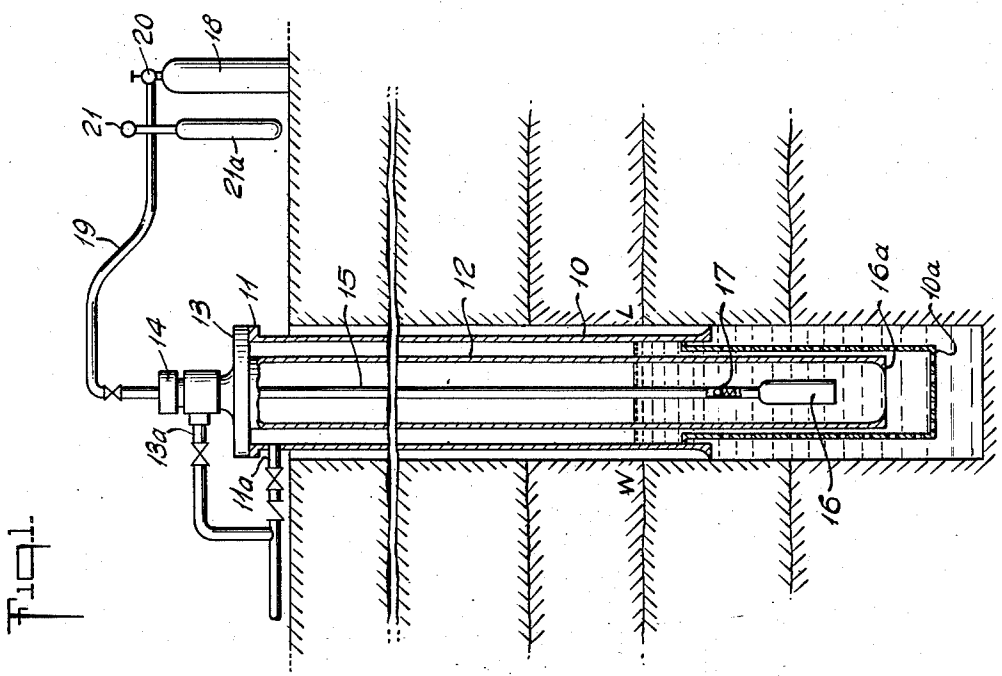


Fig. 1.

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Fig. 3.

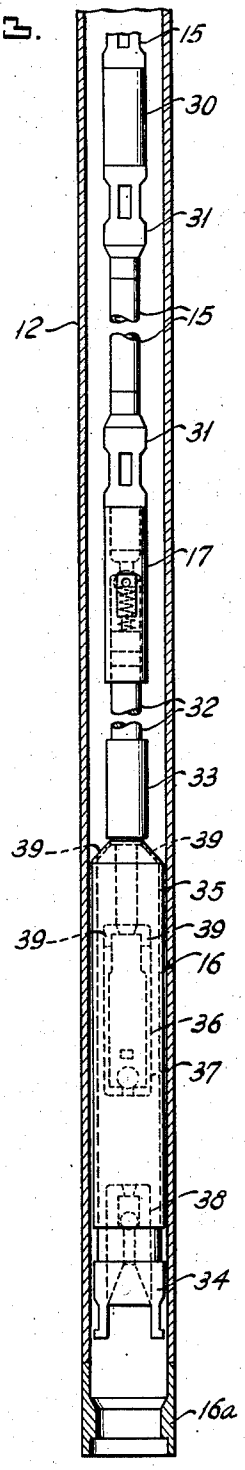
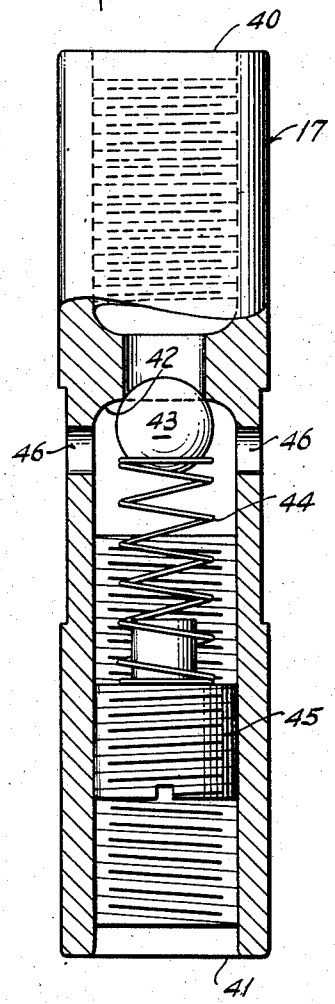


Fig. 4.



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APPARATUS DETERMINING STATIC PRESSURES IN PUMPING WELLS

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2 Claims. (Cl. 73—155)

This invention relates generally to pressure measurement in pumping wells and particularly to an apparatus for determining subsurface static pressures therein.

When low specific gravity, high viscosity crude oils are encountered in pumping wells, subsurface static pressures must be obtained usually by the use of pressure recording equipment. Due to solution gas contained in heavy crude oil, sonic fluid level tests give unreliable results.

The pressure recorder is generally run on the end of a string of solid sucker rods, a slow and costly operation, especially when the rods will not drop freely because of their own weight through the viscous crude oil.

Accordingly, it is an object of our invention to provide an improved apparatus for obtaining subsurface static pressures in pumping wells which is economical both in time and cost and yet precise.

It is another object of our invention to provide an improved apparatus for determining bottom hole static pressures where pumping of very viscous crude oil is encountered.

Still another object of invention is to provide an improved apparatus for determining bottom hole static pressures which is simple in structure and accurate in performance.

These and other objects and advantages of the present invention will be apparent from the following description of a preferred form of the invention and from the drawing in which:

Fig. 1 is a diagrammatic vertical sectional view of a well to which this invention has been applied;

Fig. 2 is a typical curve on a chart from a pressure recorder used in our apparatus for the determination of the bottom hole pressure;

Fig. 3 shows in detail the pumping structure end of the diagrammatic disclosure of Fig. 1; and

Fig. 4 is a partial sectional view of the crossover check valve.

In accordance with one aspect of the present invention, an apparatus for determining subsurface static pressure in pumping wells is disclosed which permits the measurement thereof by comparison of a balancing pressure of known value with the same.

The manner in which this is accomplished may be understood by referring to the drawings, which, in Fig. 1, discloses a well casing at **10**, with a casinghead therefor at **11** and suitable outlet at **11***a*. Production tubing **12** is located annularly within the casing **10**, with a tubing head at **13** and outlet therefor at **13***a*. The tubing head **13** supports a stuffing box at **14**, through which a series or string of hollow sucker rods **15**, joined together, extend, leakage therefrom being prevented by the use of a suitable packing material. These sucker rods actuate a lift pump shown diagrammatically at **16**, located at the bottom of the production tubing in the vicinity of perforated liner **10***a*. The pump is joined to the hollow sucker rods by a perforated coupling including some form of check valve device **17** to prevent flow of well fluid into the string of hollow sucker rods. Operation of the pump by

means of the sucker rod string is effected by conventional oil field methods, including the use of walking beams, etc., and since no invention is considered to be involved in this aspect of the combination, details thereof are not disclosed.

Referring specifically to Fig. 3, there is shown a series of hollow sucker rods **15** joined to each other by means of couplings, one of which is indicated at **30**, the sucker rods having end protectors shown in block form at **31**. The bottom sucker rod is joined to a cross-over check valve device **17** at one end thereof, with the other end of the check valve device being joined to a solid sucker rod indicated at **32**. The bottom end of this solid sucker rod **32** in turn is joined by a coupling **33** to a deep well lift pump **16**, which is adapted to be immersed in the well fluid to be pumped. This well pump is shown in conventionalized form and comprises the pump hold down structure at **34**, which is adapted to be placed in locking position with the lock down pump shoe shown at **16***a*. This pump comprises an outer shell or working barrel **35** and a plunger **36**, which contains the traveling valve structure at **37**. A standing valve structure at **38** is adjacent the bottom of the lift pump. Appropriate series of openings in the outer shell and plunger are disclosed at **39**.

The pumping operation may be described briefly as follows: the lift pump **16** is placed at a depth in the well at which the pump will stay covered by fluid during the pumping operation. The pumping cycle starts with an upward stroke of the sucker rods **15**, which pulls the plunger **36** up through the working barrel **35**. The traveling valve at **37** closes, the standing valve at **38** in the working barrel opens, and fluid enters the working barrel from the well. On a downward stroke of the plunger, the traveling valve opens, the standing valve closes, and fluid is forced from the working barrel through the plunger into the production tubing **12** through the openings **39**. Repeated strokes bring the well fluid to the surface through the outlet at **13***a*, Fig. 2.

Fig. 4 is an enlarged detail of the cross-over check valve device **17**. This comprises ends threaded to receive the bottom end of the series of hollow sucker rods at **40** and the top end of the solid sucker rod **32** at **41**. The axial bore of the valve device **17** has a valve seat at **42** for seating the valve ball **43**, which is held in closed or seated position by a bias spring **44**, which is adjusted by the spring follower **45**, inserted in the end **41** before the solid sucker rod **32** is attached thereto.

The valve device contains perforations which are equally spaced about the circumference, two of which are shown at **46**, passing through the wall of the valve device to establish communication with the internal axial bore.

The top of the string of hollow sucker rods is connected to a high pressure gas supply **18**, e. g. compressed nitrogen, by means of the line **19**, with a high pressure control valve at **20**. Manifolded to the gas supply line **19**, there is a pressure gage **21**, to indicate equilibrium conditions, and pressure recording means at **21***a*.

During normal pumping operation, the pump is locked on the pump shoe indicated at **16***a*. For subsurface pressure determinations, the pumping is suspended and the pump is raised off the pump shoe, as indicated in Fig. 1, to allow the fluid level, shown at W—L in the well casing **10** and production tubing **12**, to equalize in accordance with the subsurface formation pressure. The well is allowed to stand idle so long as considered necessary for the static formation pressure to reach equilibrium conditions before determination of the subsurface static pressure is started.

Then high pressure gas from the supply **18** is injected periodically into the string of hollow sucker rods **15**, until the pressure as indicated by the pressure gage **21**, manifolded to the supply line **19**, reaches equilibrium.

This operation unseats the valve ball **43** and displaces any fluid which may have passed into the hollow sucker rods and is depicted in the chart shown in Fig. 2, where that portion of the curve over area "A" indicates the initial build-up of the bottom hole pressure, and the portion "B," under the curve, indicates the pressure stabilized at the surface with a small volume of gas flowing down the sucker rods.

High pressure gas is injected momentarily several times into the hollow sucker rods and the pressure allowed to reach equilibrium, in order to assure that well fluid, which may have accumulated in the string of hollow sucker rods, is expelled. This action is indicated at portion "C," under the curve, which covers the fast build-up of pressure by increasing the volume of flowing gas from supply **18** and a relatively fast decline to the stabilized pressure; while portion "D," under the curve, indicates the gradual decline of the pressure due to leaks in the equipment, and the portion "E," under the curve, indicates the bleeding-off pressure decline. The points indicated at X and Y are the pressures used in the calculation of the bottom hole pressures.

The subsurface pressure at a desired level as obtained by the described procedure, will be equal to the equilibrium pressure indicated by the pressure gage at **21**, Fig. 1, plus the computed pressure head exerted by the gas column contained within the hollow sucker rods at that level. Data for such a computation are available from the density of the gas used, the known depth of the spring loaded check valve, **17**, below the surface at the desired level, and the pressure recorded by the gage at **21**, Fig. 1.

The pressure measured at the surface by gage **21** can be corrected to the pressure at the bottom of the gas column by using Dice's formula, expressed as:

P (at check valve **17**) $=P$ (at surface, gage **21**) e^x where e equals 2.718

and

$$x=\frac{Gh}{53.3(t+460)}$$

where G is the density of the pressurized gas;
h is the depth of check valve **17** below the surface, and
t is the average of the temperatures at the surface and at the depth of the check valve. The constant "53.3" is the same for all gases.

Experiments have shown that the pressure values obtained by the use of hollow sucker rods and corrected by this formula are as accurate as those obtained by running a pressure recorder on solid sucker rods into the well.

Since certain changes may be made in the above described method and apparatus without departing from the scope of the invention herein involved, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not limitative.

We claim:

1. An apparatus for determining bottom hole static pressure in a pumping well containing low specific gravity, high viscosity well fluid comprising, in combination, means for leading off said well fluid extending down into said well, pumping means for lifting said well fluid through said first mentioned means, a plurality of hollow rods connected to each other within said first mentioned means and joined to said pumping means for actuating the same, means for providing high pressure fluid connected to said plurality of hollow rods, and means coupled into said rods adjacent said pumping means for controlling the flow of said high pressure fluid and said well fluid from said plurality of hollow rods and for preventing reverse flow of well fluid thereinto.

2. In an apparatus for measuring the bottom hole static pressure of a pumping well containing very viscous fluid, the combination comprising production tubing, means for lifting well fluid located within said tubing, means for actuating said first mentioned means connected thereto and including a hollow sucker rod and a perforated coupling, and means providing pressurized gas to said hollow sucker rod, said last mentioned means including means for indicating pressures exerted in said hollow sucker rod, said perforated coupling being located adjacent said first mentioned means and including flow check means permitting an outflow of said pressurized gas and well fluid from said hollow sucker rod and preventing inflow of well fluid.

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