

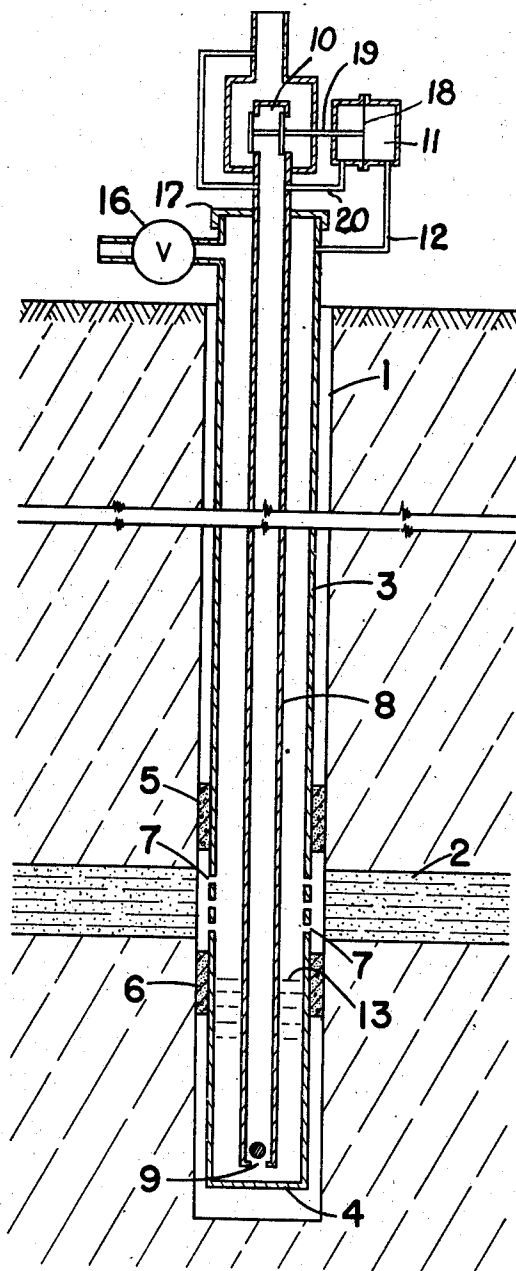
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METHOD AND APPARATUS FOR COMPLETING WELLS

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METHOD AND APPARATUS FOR COMPLETING WELLS

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5 Claims. (Cl. 166—2)

The present invention relates to an improved process and apparatus for completing oil wells.

An object of the present invention is to complete high gas-oil ratio oil wells so that oil containing a low gas ratio may be obtained from the well.

In accordance with my invention a mixture of gas and oil obtained from a producing formation penetrated by a borehole is separated within the borehole so that oil is obtained which has a low oil-gas ratio and in addition gas is obtained from the well. The gas may be obtained at a pressure substantially the same as that existing in the producing formation and may be returned to the producing zone by repressuring by the expenditure of very little additional energy. Other objects and advantages may be seen from the following description taken with the drawing in which the sole figure is a sectional view through a well producing oil and gas having applied thereto a modification of the present invention.

As shown by the figure, a borehole 1 penetrates a producing formation 2. This borehole is carried down a substantial distance below the producing formation 2 for reasons which will later be apparent. A casing 3 having its end closed by closure 4 is lowered into the borehole so that end 4 is at a substantial distance below producing formation 2. This casing is provided with a cement plug 5 above and cement plug 6 below producing formation 2, in order to prevent fluid leakage between the wall of the borehole and the casing as is well understood in the art.

Casing 3 is perforated with perforations 7 at a point opposite formation 2 so that fluid from the formation may enter directly into the casing. A tubing 8 provided with check valve 9 is placed within casing 3 so that its lower end reaches well below the producing formation 2. Cap 11 is secured to the top of casing 3 to close the annular space between the casing and the tubing. As shown by the drawing, the lower end of tubing 8 is preferably placed close to the lower end 4 of casing 3. Tubing 8 is provided with a valve 10 which is controlled by regulator 11.

Suitable means for controlling the action of valve 10 are well known to the art. A satisfactory regulator for use in practicing the present invention is described and illustrated on pages 43, 44 and Fig. 24 of the University of Oklahoma Bulletin Proceeding of the 1938 Southwestern Gas Measurement Short Course, New Series No. 748, and another is back pressure regulator #27 manufactured by the Mason-

Neilan Company. Regulators of this type have the valve mechanically connected to a diaphragm with each side of the diaphragm fluidly connected to a different source of pressure.

In the schematic drawing, regulator 11 is provided with diaphragm 18 connected to valve 10 by mechanical linkage 19. Pressure in casing 3 has access to one side of diaphragm 18 through line 12 and pressure in tubing 8 has access to the other side of the diaphragm through line 20. As thus arranged, regulator 11 will close valve 10 when pressure in the upper end of tubing 8 approaches the pressure in the upper end of the casing, so the difference in the two pressures is small. In a similar manner regulator 11 will open valve 10 when a substantial decrease in the pressure in the upper end of tubing 8 causes the difference in pressure between these two pipes to become relatively large.

The formation pressure in producing formation 2 causes a mixture of oil and gas to flow through the perforations 7 and into casing 3. When this mixture enters the space within casing 3 the reduction in pressure and change in direction of the fluid allows the oil to separate from the gas. The oil is heavier so it drops down and rests upon the bottom 4 of the casing while the gas fills the upper portion of casing 3. After a certain period of time the system will come to equilibrium with the level of the oil within casing 3 being at point 13. It is evident that if after the system reaches this condition the valve 10 is opened the position of liquid level 13 will drop the gas pressure in the casing forcing the oil up through tubing 8 and out of the well at the surface of the earth. If this valve 10 is allowed to remain open, eventually all of the oil from casing 3 will be produced and a mixture of gas and oil as it comes from the formation 2 will then flow through tubing 8.

In accordance with my preferred method of carrying out the invention the regulator 11 is set to close valve 10 as soon as the oil level 13 drops to such a low point that it no longer forms a liquid seal and allows a mixture of oil and gas to be produced from the well. Valve 10 is provided with a small by-pass 14 which allows gas to be produced from the tubing at a slow rate. After valve 10 has closed the by-pass 14 allows the gas with which tubing 8 has become filled to be slowly released so that as the oil is produced from formation 2 and fills the lower end of casing 3 the oil level in tubing 8 is allowed to slowly rise. After the oil level in tubing 8 rises to such a height that the

pressure difference between the oil in tubing 8 and that in the upper end of casing 3 reaches a predetermined amount the regulator 11 opens valve 10 and allows oil to be once again produced through tubing 8 until the oil level 13 drops so that there is no longer a liquid seal and the pressure in tubing 8 and that in casing 3 are partially equalized, when the valve 10 is again closed and the cycle is repeated.

As a modification of the present invention the regulator may be set so that the oil level 13 is always above the lower end of tubing 8 and forms a liquid seal. When this modification of the invention is desired, the regulator 11 opens valve 10 and allows oil to be produced, the liquid level 13 dropping. As the liquid level 13 drops the pressure in the top of tubing 8 gradually decreases because there is not so much oil in casing 3 to balance the liquid in tubing 8. When the liquid level 13 is near the bottom of tubing 8 the pressure becomes so low that the regulator closes valve 10 and allows oil from formation 2 to flow into the casing and partially balance the liquid in tubing 8. When the height of liquid 13 has risen to a certain distance the pressure in tubing 8 will be increased, regulator 11 will open valve 10, and the cycle will be repeated.

It is evident that if production of fluid through tubing 8 does not produce sufficient drop in the formation pressure gas may be withdrawn from the upper part of casing 3 by means of connection 15 provided with valve 16. The gas removed through valve 16 is at a very high pressure and is particularly suitable for repressuring.

While I have disclosed several specific modifications of carrying out my invention, it is evident that other procedures may be used for carrying out the broad features of the present invention and I do not intend to be bound by the specific examples but wish to claim my invention as broadly as the prior art permits.

I claim:

1. Apparatus for producing fluid from a high gas-oil ratio oil well having its borehole penetrating a substantial distance below a producing formation comprising, in combination, a casing arranged within said borehole with its lower end a substantial distance below said producing formation, perforations in said casing opposite said producing formation, a string of tubing arranged in said casing with its lower end adjacent the lower end of said borehole, a closure for the upper end of said casing, a valve arranged in the upper end of said string of tubing, a relatively small by-pass around said valve and a pressure regulator arranged to open said valve when the

pressure in the upper end of the tubing becomes less than that in the upper end of the casing by a predetermined amount, and to close the valve when the pressure difference between these two points becomes less than a predetermined value.

2. Apparatus in accordance with claim 1 in which a conduit controlled by a valve is attached to the upper end of said casing in fluid communication with the interior thereof.

3. In a high gas-oil ratio oil well having a borehole penetrating a substantial distance below a producing formation with a casing arranged therein, means for fluid communication between said producing formation and the interior of said casing, a string of tubing within said casing with its lower end adjacent the lower end of said borehole, and a closure for the upper end of said casing, means for controlling the flow of fluid through said tubing comprising in combination a valve arranged in the upper end of said string of tubing, a small by-pass around said valve, a pressure regulator in fluid communication with the upper portion of said casing arranged to open said valve when the pressure in the upper end of the tubing becomes less than that in the upper end of the casing by a predetermined amount, and to close the valve when the pressure difference between these two points becomes less than a predetermined value.

4. A process for producing fluid from a high gas-oil ratio oil well in which the bore hole penetrates a substantial distance below a producing formation and is provided with a casing perforated at the producing formation and with a string of tubing having its induction end a substantial distance below the producing formation comprising the steps of allowing liquid to accumulate in the bottom of the borehole until its upper surface is substantially above the induction end of said tubing, producing liquid through said tubing until said liquid surface drops below the induction end of the tubing and gas fills the tubing, bleeding gas from the upper end of said tubing at a rate slower than the rate of liquid accumulation in said borehole whereby liquid accumulates in the bottom of the well and rises within said tubing and again allowing liquid to be produced through said tubing.

5. A process in accordance with claim 4 in which high pressure gas is withdrawn at the surface of the earth from the space between the tubing and casing in order to allow liquid to accumulate in the bottom of the borehole at the desired rate.

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