Oct. 13, 1942. T. V. MOORE 2,298,834

MEANS FOR PRODUCING OIL WELLS

Filed May 24, 1940

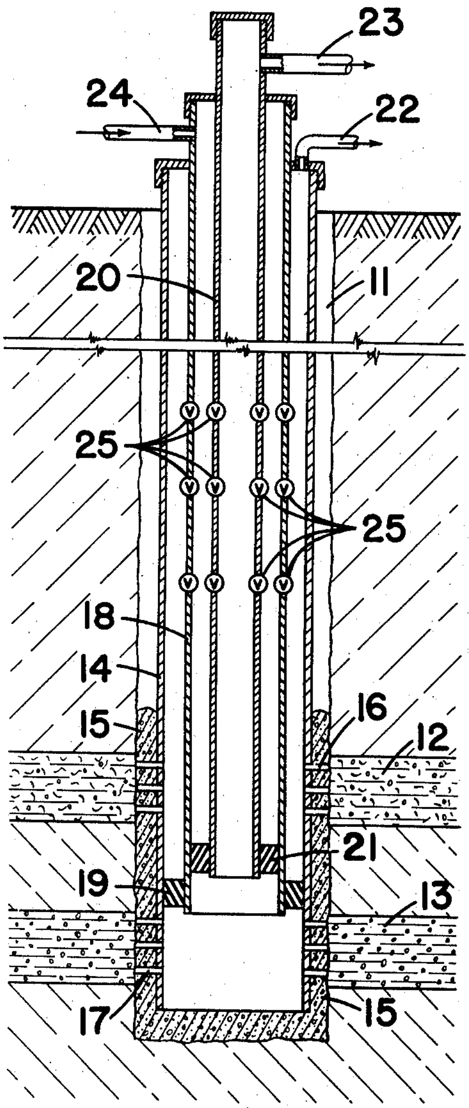

FIG. 1.

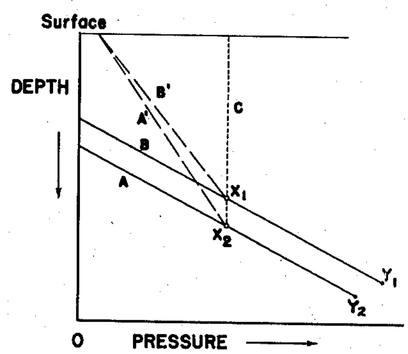

FIG. 2.

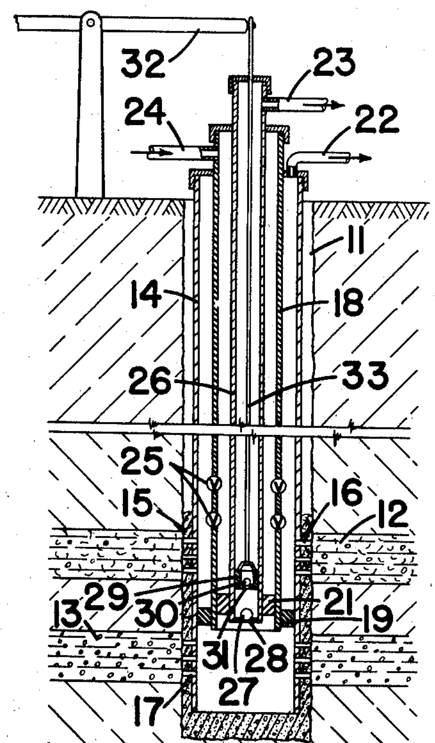

FIG. 3.

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Patented Oct. 13, 1942

2,298,834

UNITED STATES PATENT OFFICE

2,298,834

MEANS FOR PRODUCING OIL WELLS

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Application May 24, 1940, Serial No. 336,907

4 Claims. (Cl. 103—4)

The present invention is directed to means for producing oil from a plurality of zones through a single borehole.

It is an object of the present invention to produce fluid from a plurality of zones in a well and to control the rate of production from each zone individually.

It is a further object of the present invention to produce from a plurality of zones in a single well with the formation pressure of one or more of the zones such that artificial means must be resorted to in order to raise the fluid to the surface of the earth.

It is another object of the present invention to provide means efficiently utilizing available formation energy for carrying out production from a plurality of zones in a well.

Other objects and advantages may be seen from a reading of the following description taken in conjunction with the drawing in which

Fig. 1 is a cross sectional view of equipment placed in the borehole suitable for carrying out the present invention and

Fig. 2 is a curve to illustrate the manner in which the method may be carried out by the apparatus shown in Fig. 1.

Fig. 3 is a cross sectional view of another modification of means which may be used to carry out the invention.

In many oil fields, a number of producing zones are encountered. Because the nature of the separate zones is usually entirely different it has heretofore been regarded as inefficient practice to produce from two or more zones in the same well since by so doing it has been impossible to control the rate of production from each zone individually, and this often leads to waste of the reservoir energy of one zone and sometimes to drainage of the oil from the less exhausted sands of one zone into the more completely exhausted sands of another.

In order to overcome the difficulty of producing from more than one zone in the same well it is customary in some areas to drill twin wells, one well into each producing zone, in order to permit the production of each zone separately. This involves the drilling of an additional well with all of its attendant expenses.

It has also been the practice in some areas to cement a string of casing through both zones, perforate the casing into each zone and set a string of tubing with a packer between the two zones. Under such an arrangement, the lower zone is allowed to produce through the tubing, and the upper zone to produce through the annular space between the tubing and the casing. This method is satisfactory if the conditions in both zones are such that they will produce their oil by natural flow. With this arrangement, however, it is impossible to produce the oil from the upper zone by artificial lifting means. In almost all instances the formation pressure in a new field is such that it will cause the oil to flow from the formation by natural means, but as the field is produced the formation pressure drops so that artificial means must be resorted to in order to raise the oil to the surface of the earth. When the pressure in the upper formation in the above mentioned arrangement reaches the point that artificial lifting means must be resorted to, this arrangement becomes inoperable because there is no way of artificially lifting the oil from the upper zone.

The present invention is directed to an improved means for completing wells in a multiple number of zones which enables the production of oil from one or more zones by gas lift and thus permits the separate production from each zone beyond the period of its flowing life.

Referring now to the drawing and first to Fig. 1, a borehole **11** is shown penetrating the separate producing formations **12** and **13**. The casing **14** is cemented into the borehole by means of cement plug **15**. This step is conventional to the art and is carried out in the usual manner, care being taken, however, that the annular space between the wall of the hole and the casing between producing formations **12** and **13** is made fluid-tight to prevent any leakage from one of the formations to the other. At a point opposite producing formation **12** the casing and the cement plug is perforated by perforations **16** produced in the usual manner to allow fluid communication between the formation **12** and the interior of casing **14**. In like manner, perforations **17** are produced through the casing and the cement plug opposite producing formation **13** in order to allow fluid communication between this formation and the interior of casing **14**.

A string of large tubing **18** provided with a packer **19** at its lower end is then run into the well and the packer is set between the tubing and the casing at a point intermediate the two producing zones. This packer prevents the oil from one zone flowing into the other. Inside string of tubing **18** a smaller string of tubing **20** provided with a packer **21** is arranged. Packer **21** is set to provide a fluid-tight seal between the two strings of tubing. A flow line **22** is provided at the surface from casing **14** which may lead, for example, to conventional gas-oil separators and then to storage tanks which are not shown in the drawing. In like manner, tubing **20** is provided at the surface with a flow line **23** which also may lead to the conventional gas-oil separators and then to storage. A gas input line **24** leads into the string of casing **18** so that it will flow in the annular space between tubing **18** and tubing **20.**

At suitable intervals, tubing **18** and **20** are provided with flow valves **25**, which allow gas from the annular space between tubings **18** and **20** to flow into tubing **20** and into the annular space between tubing **18** and casing **14**, when the pressure differential between the input gas and the fluid on the other side of the gas input valves is maintained within small definite limits.

The use of gas input valves for gas lifting is conventional to the art. Any suitable gas lifting valves may be used in the present invention, for example, those shown in U. S. Patent No. 2,148,592, or U. S. Patent No. 2,216,967.

The action of gas inlet valve in a gas lift system is well known to the art. Generally speaking, at the point where the pressure of the gas in one conduit is equal to the pressure of the fluid on the other side of the wall of the conduit the gas inlet valve opens, allowing gas to flow through the valve into the fluid on the other side of the wall of the conduit, causing the density of this fluid to become less and allowing it to flow to the surface. As the column of fluid becomes lighter due to the injection of the gas therein, its pressure becomes less and allows a second gas inlet valve located deeper in the well to open because the pressure of the fluid at this point becomes equal to the gas pressure, and causes the valve which first opened to close because the pressure in the fluid at this point has become less than that of the gas.

According to the present invention, gas from the annular space between tubing **18** and tubing **20** flows both in the interior of tubing **20** and into the annular space between casing **14** and tubing **18**. A representation of the pressure conditions which would prevail in the system during the flow is illustrated in Fig. 2 of the drawing. The point Y_1 indicates the pressure and depth conditions at the upper producing stratum **12**, while Y_2 indicates the pressure and depth conditions at the lower producing stratum **13**. Line A shows the variation of pressure with depth in the inside string of tubing, which is in communication with lower zone **13**, when no artificial lifting means are employed. The line B shows the same relation in the annular space which is in communication with upper zone **12**. It is observed that each line intersects the depth axis at a point below the surface, indicating that each producing zone does not have sufficient pressure to bring about natural flow. In order to produce from either zone it is necessary to lower the pressure gradient prevailing in the flow strings. This may be done by injecting gas. Line C represents the nearly constant gas pressure which is maintained in the anular space between the outer string of tubing and the inner string of tubing.

At point X_1 the pressure between the outer string of tubing and the casing equals the pressure between the two strings of tubing as indicated by the intersection of lines B and C. This equalization of pressure will cause a flow valve positioned at a corresponding depth in the well to open, admitting gas into the casing and thereby permitting flow. The pressure relation above this point after the injection of the gas is shown by the line B'. It will be observed that line B' intersects the depth axis at a point above the surface indicating that at the surface a pressure is maintained sufficient to bring about flow to the surface equipment and into the tank battery.

Point X_2 denotes similarly the position at which a flow valve in the wall of the inner string of tubing will be open to admit gas into the inside string of tubing and permit the gas lift to operate and flow oil from the lower zone. The line A indicates the pressure gradient in this inner string of tubing before gas is injected and the line A' shows the pressure gradient after the injection of gas.

During the production of the well the pressure relationships in the oil producing zones will vary. This would serve to change the relative position of lines A, A', B, and B'. However, such pressure changes will simply cause one open flow valve to close while another one in a different position of the well will automatically open and thus continue the operation of the gas lift.

Another means for carrying out the present invention is shown in Fig. 3 in which like parts are given the same designation as those in Fig. 1. In this modification, the borehole penetrating two producing formations has arranged therein a casing **14** secured to the bore hole by cement, with perforations therethrough penetrating both the casing and cement at points adjacent the two producing formations. Inside of the casing is arranged a large tubing **18** provided with a packer **19** between the tubing and casing and arranged inside of the tubing **18** is another tubing **26** which is provided in its lower end with a packing **21** between this string of tubing and string of tubing **18**. At the lower end of tubing **26** is arranged a valve **27** on valve seat **28**. A plunger **29** is provided with a valve **30** on which rests the valve seat **31**, and connecting the plunger **29** to a suitable reciprocating means, such as the end of a walking beam **32** arranged at the surface of the earth is a conventional string of sucker rods **33**.

It will be seen that in the modification shown in Fig. 3 the lifting of the oil from the lowermost formation is done mechanically by means of the pump arranged within tubing **26**, while the lifting of the fluid from the upper formation is carried out by means of a gas lift with gas under pressure from inlet line **24** passing down in annular space between tubings **18** and **20** and then upwardly in the annular space between tubing **18** and casing **14** by means of gas outlet valves **25**.

Various modifications of the present invention may be used. For example, it may be possible to produce from the lower zone by natural flow under which circumstances no lifting equipment would be required for producing from the inner tubing. On the other hand, it may be possible to eliminate the flow valves from the system and inject gas directly into the produced fluid without controlling it by means of flow valves. As another modification more than one producing zone may be fluidly connected to a single conduit with this plurality of zones being allowed to produce either through the inner string of tubing or through the annular space between the casing and the outer string of tubing. It is therefore not my intention to be limited to the modifications disclosed, but to claim the invention as broadly as the prior art permits.

I claim:

1. Means for producing fluid from a plurality of formations in a borehole comprising a casing arranged within said borehole provided with

means for communication between each of said producing formations and the interior of the casing, a string of tubing arranged inside of the casing, a packer on said string of tubing between two producing formations arranged for sealing the annular space between said casing and said tubing, a second string of tubing arranged inside of said first string of tubing, a second packer arranged adjacent the lower end of said second string of tubing to seal the annular space between said first and second strings of tubing, means for injecting high pressure gas in the annular space between said first and second strings of tubing, gas inlet valves arranged on said first string of tubing to allow gas to flow from the annular space between said two strings of tubing into the annular space between said casing and said outer string of tubing.

2. Apparatus in accordance with the preceding claim in which the inner string of tubing is provided with gas inlet valves to allow gas to flow from the annular space between said strings of tubing into the smaller string of tubing.

3. An apparatus in accordance with claim 1 in which the inner string of tubing is provided with mechanical means for raising fluid through the inner string of the tubing.

4. Means for producing fluid from a plurality of formations in a bore hole comprising a casing arranged within said bore hole provided with means of communication between each of said producing formations and the interior of the casing, a string of tubing arranged inside of the casing, packing means arranged for sealing the annular space between said casing and said tubing at a point between two producing formations, a second string of tubing arranged inside of said first string of tubing to extend a substantial distance into said bore hole, a second packing means arranged at a substantial depth in the bore hole to seal the annular space between said first and second strings of tubing, passages spaced along the axis of the bore hole arranged in said first string of tubing to allow gas to flow from the annular space between said two strings of tubing into the annular space between said casing and said outer string of tubing and passages spaced along the axis of the borehole arranged in said second string of tubing to allow gas to flow from the annular space between said strings of tubing into the smaller string of tubing.

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