March 23, 1937. J. E. GOSLINE 2,074,608

APPARATUS FOR PRODUCING WELLS

Filed March 16, 1936

FIG. 1.

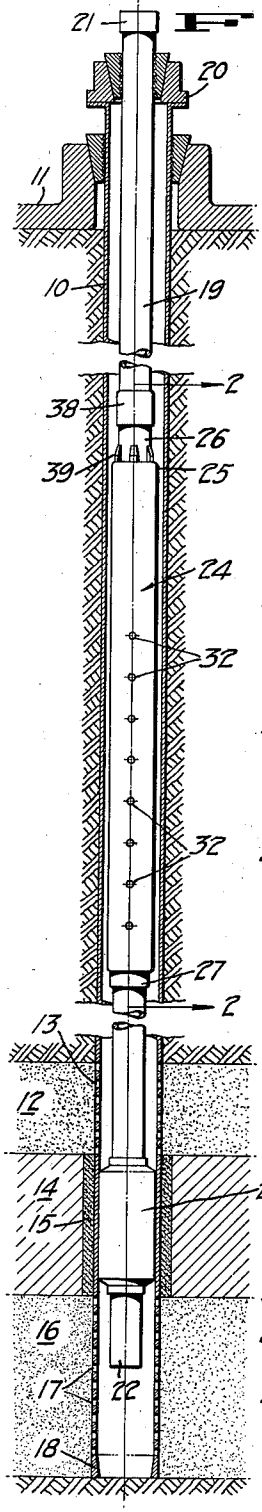
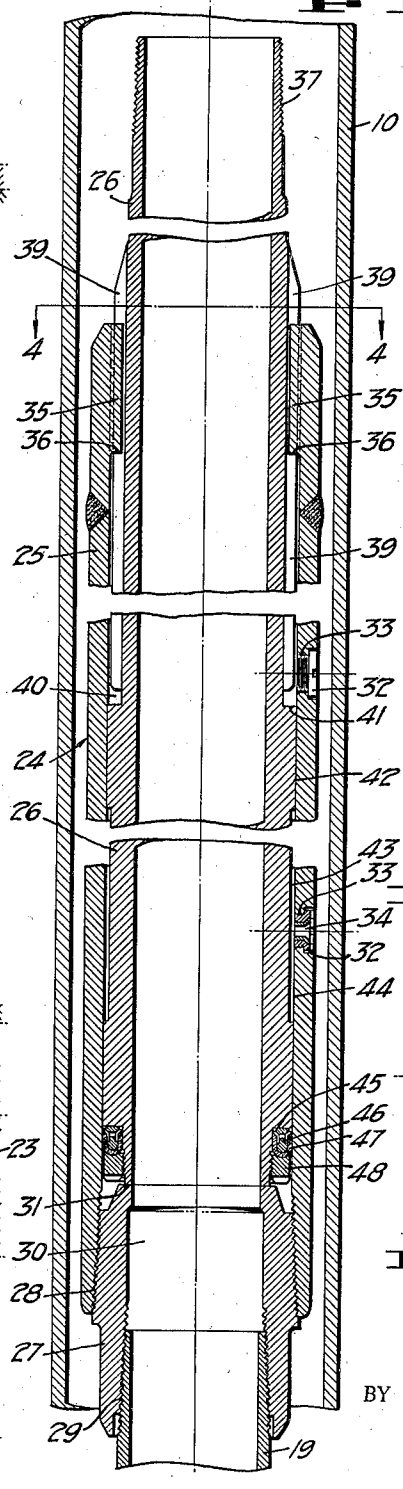


FIG. 2.



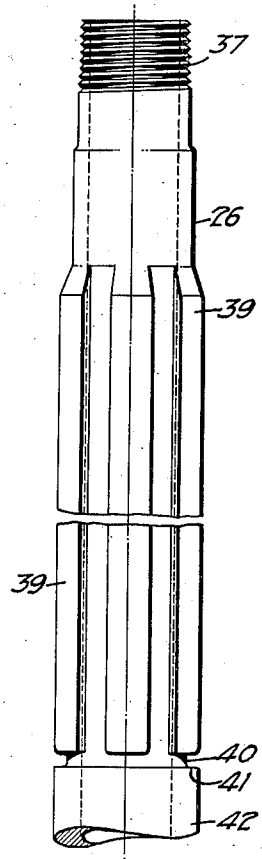


FIG. 3.

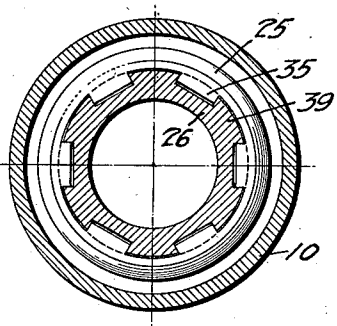


FIG. 4.

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Patented Mar. 23, 1937 2,074,608

UNITED STATES PATENT OFFICE

2,074,608

APPARATUS FOR PRODUCING WELLS

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Application March 16, 1936, Serial No. 69,024

10 Claims. (Cl. 166—2)

This invention relates to an apparatus for producing an oil and gas well from a number of formations or zones differing in fluid content and pressure, and particularly refers to means for controlling the flow from the various formations to compensate for the formation pressure changes encountered during the life of the well.

In certain locations, oil and gas productive formations are encountered in a series of layers at different depths below the surface of the earth, these layers being separated by dense and impervious non-productive formations. Certain of these productive formations may have entirely different fluid or gas and oil contents as well as varying pressure characteristics from those formations above or below them. For example, an upper formation or productive zone may be of such character that the release of a large quantity of gas at high pressure is required to produce a relatively small quantity of oil, so the zone is said to have a high gas oil ratio. Below this zone, and separated from it by one or more impervious and non-productive formations, may be a zone in which the gas pressure is low, but the type or condition of the oil is such that a relatively small quantity of gas will lift to the surface a relatively large quantity of oil, so that the zone may be said to have a low gas oil ratio.

An unfortunate characteristic of a condition as just outlined is the low gas pressure of the lower zone, which reduces its initial natural flow of oil, and, due to the inevitable decrease in formation pressure, soon requires mechanical pumping. In certain fields, due to the depth of these formations, such pumping is very costly, if not impossible, and a great quantity of valuable oil is thus not obtainable after the gas pressure of the lower zones has decreased to a certain value.

This invention contemplates an apparatus for producing an oil and gas well under the conditions outlined, and provides means for controllably utilizing the gas and oil from an upper formation to assist the production from a lower formation. This controlling function also permits certain adjustments during the normal life of the well that will give the operator opportunity to utilize the varying gas and oil pressures to best advantage, thereby prolonging the useful life of the well, and recovering a greater quantity of oil therefrom.

It is an object of this invention to provide an apparatus for producing oil and gas wells that will permit a simultaneous controlled production from a plurality of productive zones of different characteristics of pressure and flow, with a minimum of equipment in the well, and a maximum degree of flexibility in choice of operating conditions.

Another object is to provide an apparatus that may be readily installed and removed from a well, and which may be handled by a single string of tubing without resort to auxiliary lines or tools or other hazardous equipment that may become lost in the well and require an expensive fishing program.

Another object is to provide an apparatus that utilizes standard and readily available equipment to the greatest degree.

Another object is to provide an improved tubing valve, that will permit controlled communication between the inside and outside of a string of well tubing, and that will also permit apparatus auxiliary to the tubing to be operated without the use of special tools or equipment.

These and other objects and advantages will be more fully apparent from the following description and from the accompanying drawing, which forms a part of this specification and illustrates a preferred embodiment of this invention.

In the drawing, Figure 1 is a vertical sectional view of a well, showing a string of tubing in place therein with a lateral valve and packer in position to practice this invention.

Figure 2 is a vertical sectional view of the tubing valve that comprises an element of this invention, taken on line 2—2 of Figure 1, and to an enlarged scale.

Figure 3 is a vertical elevational view of the upper or inner portion of a part of the tubing valve illustrated by Figure 2.

Figure 4 is a horizontal sectional view taken on line 4—4 of Figure 2 and illustrates one form of splines or torques transmitting means between the two parts of the tubing valve.

Referring to the drawing, and particularly to Figure 1, the reference numeral 10 denotes a well casing, supported at the surface of the earth by a casing landing head generally designated 11. While only one string of casing is here illustrated, it is understood that a plurality of concentric strings of varying length may be installed and suitably supported and sealed in accordance with conventional and well known practice. Under such circumstances, the casing 10 is the innermost or deepest, that extends into and in some cases through the productive formations.

The upper productive formation 12, in this example, may be a zone of high gas oil ratio production or may contain only gas, and casing 10 is suitably perforated as at 13 to permit fluid

to flow from the formation into the casing. Below formation 12 is a layer of impervious and barren formation 14, and, in accordance with the usual practice, casing 10 is cemented therein as at 15, this serving to keep fluid from the upper zone 12 from mingling with fluid from lower zone 16 around casing 10. Casing 10 is also perforated at 17 to permit entrance of oil and gas from the lower productive zone 16. The lower end of casing 10 is customarily fitted with a shoe 18 and is illustrated as being set at the bottom of formation 16.

A production string of tubing 19 is suspended in casing 10 and is partially supported therein by the tubing landing head generally designated 20, as will be explained more fully below. Oil and gas from the well are conducted from the top of tubing 19 by suitable connections to fitting 21, which may also serve as a means for attaching the tubing hoisting equipment provided at such wells.

The lower end 22 of tubing 19 is shown as being open and in communication with the lower perforated section 17 of casing 10. A wall type packer 23, of any conventional construction, is used on tubing 19 to provide a seal between the tubing 19 and casing 10 in that portion of casing 10 which lies between the upper and lower perforations 13 and 17, respectively. Thus fluid from the two productive formations 12 and 16 cannot pass between perforations 13 and 17 inside casing 10, for a purpose which will be explained below.

At a suitable distance above packer 23, generally not less than about one-fifth the distance to the surface, is a tubing valve generally designated 24, which is shown in detailed longitudinal section in Figure 2. This valve, in the embodiment shown, is adapted to provide controlled communication between the outside and the inside of tubing 19 at a point above packer 23, and, ordinarily, must also be capable of transmitting torque as well as up and down longitudinal force to set and release the packer 23.

Referring to Figure 2, tubing valve 24 comprises two mutually telescoping cylindrical members, namely, an outer shell 25 and an inner shell 26. Outer shell 25 is threaded onto a bushing 27 as at 28, and bushing 27 is, in turn, threadedly connected as at 29 to the lower section of tubing 19. Bushing 27 is provided with a bore 30 of substantially the inside diameter of tubing 19, and has a face or shoulder 31 on which the lower end of inner shell 26 is adapted to seat when a downward force is to be transmitted through tubing valve 24.

Intermediate the ends of outer shell 25 are a plurality of longitudinally spaced bushings 32, which may be threaded through the wall of shell 25 as at 33, and each of which are provided with a port or opening 34, preferably lined with a hard metal to prevent enlargement due to fluid flow and abrasion. The upper end of outer shell 25 is provided with a plurality of inwardly extending splines 35, the lower ends or faces 36 of which are preferably hardened for a purpose to be explained below.

The inner shell 26 of tubing valve 24 is secured to tubing 19 as by threaded connection 37 and collar 38. Splines 39 (Figure 3) on the outer surface of shell 26 are adapted to mesh with the corresponding splines 35 on the inner surface of outer shell 25, and thus are adapted to permit relative longitudinal motion and to prevent relative rotation between the two parts or elements of tubing valve 24. Consequently, valve 24 is adapted to transmit torque in any position in which it may be adjusted. Groove 40, at the lower end of splines 39, forms a shoulder 41, preferably hardened, which is adapted to seat against the lower ends or faces 36 of the splines 35 in the outer shell 25, when the valve is in its fully opened or extended position, as for example, when it is being lowered into casing 10 or is being lifted to raise the lower section of tubing 19 and packer 23 out of the well.

The outer face 42 of inner shell 26, below splines 35, is preferably relieved as at 43 to reduce friction and possible binding, the remainder of the shell 26 slidably fitting the bore 44 of outer shell 25. The lower end of inner shell 26 is provided with a shoulder 45, on which is mounted an annular seal ring 46 and a packing member 47, both the latter being held in place by a threaded nut 48.

Thus there is provided a slidable piston type tubing valve, sealed against leakage, and with its two main members 25 and 26 adapted to be selectively positioned to uncover the desired number of ports or openings 34. Splines 35 and 39 prevent relative rotation in all positions of members 25 and 26. Downward force can be transmitted through the valve 24 by the contact of face 31 with the lower end of shell 26. Upward force can be transmitted through valve 24 by the lower ends 36 of splines 35 seating on shoulder 41 of groove 40.

A preferred method of utilizing the combination of elements just described, in the production of a well from more than one zone as outlined in the first part of this specification, will now be described.

Tubing string 19, with packer 23 in its retracted position, and valve 24 in its predetermined location, is lowered into the well casing 10, which has previously been perforated at 13 and 17 and cemented at 15 according to conventional practice. When the tubing string 19 has reached the predetermined position shown, packer 23 is set by whatever method is applicable, usually involving a lifting and rotation of the tubing 19, followed by a lowering of the latter, to cause the packer to expand and seal the space between tubing 19 and casing 10. Sufficient weight consistent with good practice is then left on the packer 23 to hold it in expanded position in casing 10. This is accomplished by supporting the length of tubing 19 between the packer 23 and valve 24 on the packer, the length being ordinarily not less than about one-fifth of the total tubing string. Thus, the lower portion of the tubing 19 up to and including the outer shell 25 of the valve 24 is supported upon the packer 23.

As has already been mentioned, it may be desired to supplement the lifting effect of the gas from formation 16 with the gas or gas and oil from the upper formation 12, to increase the production of the well and get increased production or an overall gas oil ratio that is more favorable than the gas oil ratio of either formation. The gas or gas and oil from the upper formation, being confined in the upper part of casing 10 by packer 23 and casing landing head 11 may be controllably admitted into the rising stream of gas and oil inside tubing string 19, by raising or lowering the upper portion of tubing 19, together with the inner shell 26 of valve 24, thus selectively uncovering the desired number of bushing ports 34. Thereafter, as formation pressures, flow rates and the like may change

during the life of the well, the rate of admission of fluid from the upper formation 12 may be varied at will by the same procedure, without removing the tubing string or without introducing anything such as tools, chokes, perforators or the like into the tubing or the casing.

If it is desired to remove the tubing string 19 from casing 10, this may be done by suitable manipulation of the packer 23, as valve 24 will transmit any force, rotational or otherwise, that could be transmitted through a string of tubing alone. Furthermore, there is nothing cemented, or otherwise permanently secured in the casing that would be difficult or expensive to remove, in case the well were to be altered as by being drilled deeper, or cleaned out, or further perforation made in casing 10, to permit production from other formations.

Although a specific construction involving this invention has been described and illustrated in the foregoing specification, it is to be understood that the invention is not limited to that specific device, and all such modifications and changes as come within the scope of the appended claims are embraced thereby.

I claim:

1. In an oil well including a casing and spaced perforation zones in said casing adapted to admit fluid from a plurality of spaced productive formations, the combination of a tubing string extending from the top of said casing to a point adjacent one of said perforation zones, a packer carried by said tubing for sealing said casing above said last named perforation zone to separate fluid therein from that entering said casing above said zone, and valve means in said tubing string above said packer adapted to be controlled from the top of said tubing for admitting fluid from an upper perforated zone into said tubing string.

2. A combination according to claim 1 in which said valve means is adapted to be operated by a movement of said tubing.

3. A combination according to claim 1, in which that portion of said tubing below the valve means is supported in said casing by said packer, and the valve means is operable by a movement of that portion of the tubing above said valve.

4. A combination according to claim 1, in which said valve means is adapted to be operated by a vertical movement of the tubing above said valve means, the remainder of said tubing below said valve means, together with said packer, remaining stationary in said casing.

5. A combination according to claim 1, in which said valve means comprises mutually telescoping members, a plurality of longitudinally spaced ports in one of said members, one of said members being supported in said casing by the lower part of said tubing and said packer, and the other of said members operable to selectively uncover said ports by a vertical movement of said last named member by the tubing extending from said valve to the top of said casing.

6. A tubing valve, comprising a splined outer shell, a splined inner shell adapted for longitudinal motion in said outer shell, and a plurality of longitudinally spaced ports in said outer shell, said ports being adapted to be progressively uncovered by the relative position of said shells, said splines being effective to prevent respective rotation of said shells in any longitudinal position thereof.

7. A tubing valve according to claim 6 with the addition of cooperating upper and lower shoulders in said shells, to limit the respective longitudinal motion thereof.

8. A tubing valve according to claim 6 with the addition of packing means carried by one of said shells, to prevent fluid leakage therebetween.

9. A tubing valve according to claim 6, in which said ports comprise hard faced bushings.

10. In a well including a casing and spaced perforation zones in said casing adapted to admit fluid from a plurality of spaced productive formations, the combination of a tubing string extending from the top of said casing to a point adjacent one of said perforation zones, means for sealing the space between said tubing and said casing above said last named perforation zone to separate fluid therein from that entering said casing above said zone, and means in said tubing string above said sealing means and adapted to be controlled from the top of said tubing for admitting fluid from an upper perforated zone into said tubing string.

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