Jan. 30, 1945. D. F. SAURENMAN 2,368,428

MULTIPLE ZONE PRODUCTION APPARATUS

Filed June 30, 1941 2 Sheets-Sheet 1

Fig. 1.

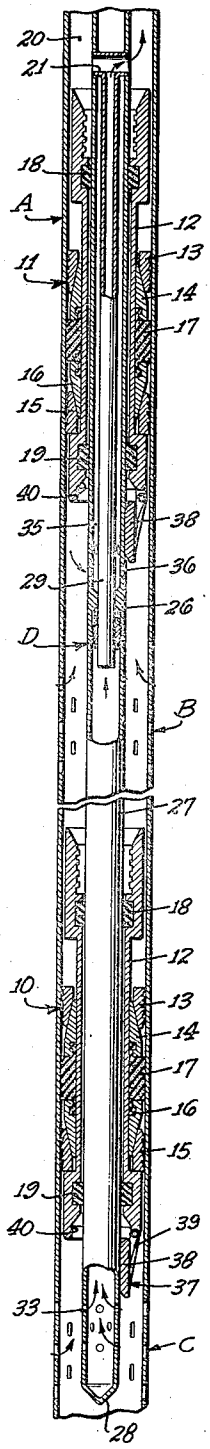

Fig. 2.

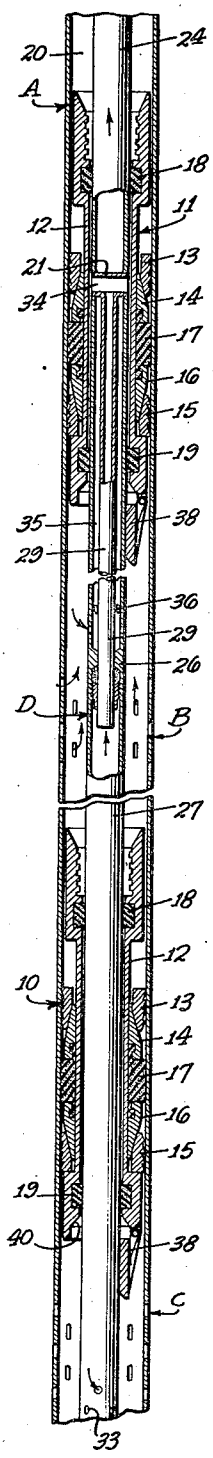

Fig. 3.

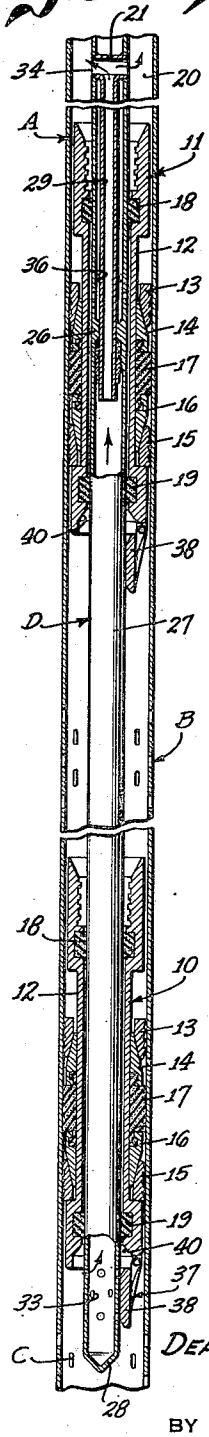

Fig. 4.

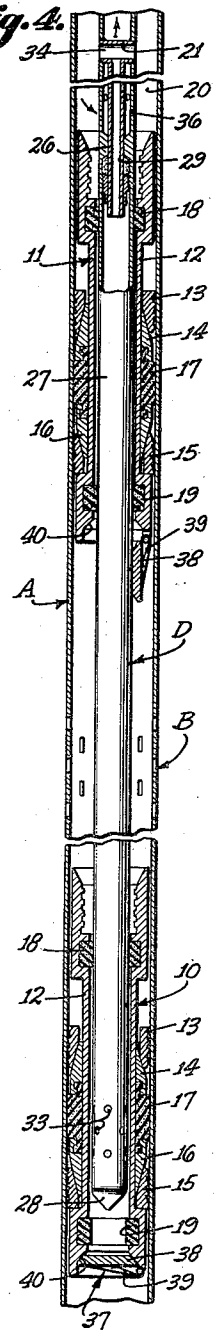

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Fig. 5.

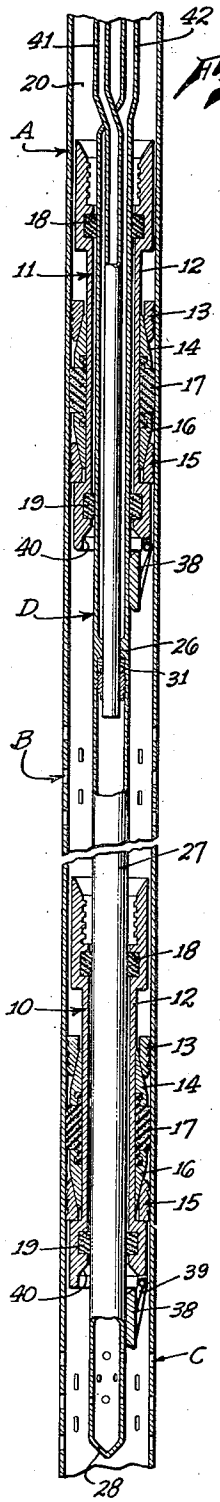


Fig. 6.

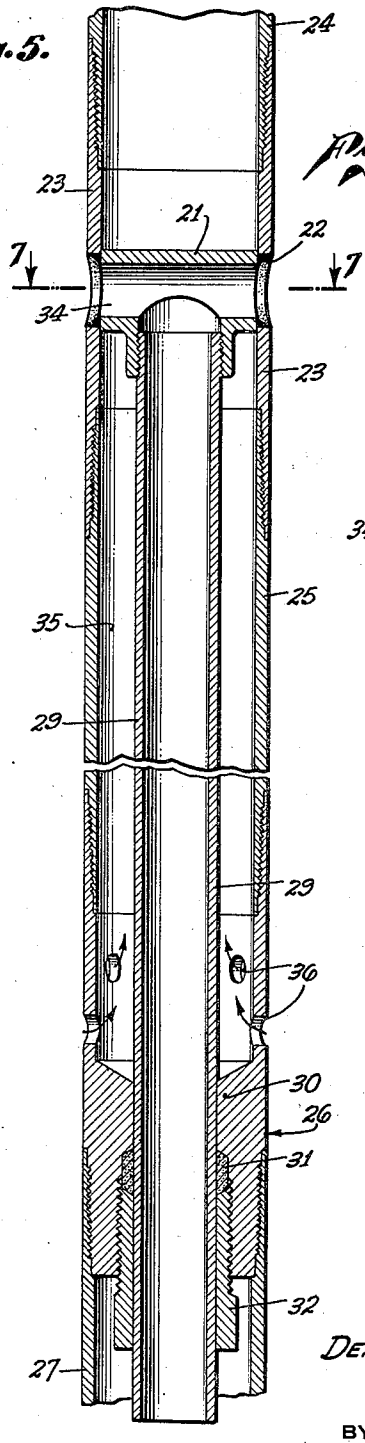
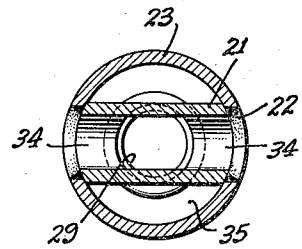


Fig. 7.



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MULTIPLE ZONE PRODUCTION APPARATUS

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Application June 30, 1941, Serial No. 400,404

6 Claims. (Cl. 166—1)

This invention relates to production control apparatus particularly useful in connection with the multiple zone production of oil and gas wells.

In oil and gas wells having a plurality of producing zones, it is desirable to maintain the production from each zone separate. In some instances, the various zones may be flowed individually to the surface of the well bore, but if the formation pressure of an upper zone is too low, it is essential that its production be pumped through a tubular string to the surface of the well.

It is an object of the present invention to provide a multiple zone production apparatus in which an upper producing zone can be pumped through production tubing, while production from a lower zone follows a separate path to the well surface.

Still another object of the invention is to provide an improved apparatus capable of selectively flowing or pumping fluids from separated zones in a well bore having a plurality of producing strata. In this connection, a plurality of zones can be produced separately or simultaneously, as desired.

A further object of the invention is to provide an apparatus in which an upper or lower producing zone may be produced separately or simultaneously through a single tubular string.

In situations wherein an upper zone is being pumped through production tubing, while production from the lower zone flows to the surface of the well bore through the annular space between the tubing and casing, depletion of the formation pressure in the lower zone will prevent its continued flowing, leaving a substantial head of oil in the aforementioned annular space. It is a further object of the present invention to provide an apparatus which will not only allow an upper producing zone to be pumped through tubing and a lower producing zone to flow independently of the upper production to the surface of the bore, but which can also effect the pumping of the fluid from the annular space between the tubing and casing whenever desired.

Yet another object of the invention is to provide an apparatus in which the production from spaced zones in a well bore can be pumped simultaneously through separate channels to the surface of the well bore.

This invention has other objects that will become apparent from a consideration of the embodiments shown in the drawings accompanying and forming part of the present specification. These forms will now be described in detail to illustrate the general principles of the invention, but it is to be understood that such detailed description is not to be taken in a limited sense, since the scope of the invention is best defined by the claims appended hereto.

Referring to the drawings:

Figures 1, 2, 3 and 4 are longitudinal sections through a multiple zone well bore illustrating the production apparatus of the present invention in different positions of operation;

Figure 5 is a longitudinal section through a well bore showing a modified form of apparatus;

Figure 6 is a longitudinal section on an enlarged scale of part of the flow apparatus disclosed in Figures 1 to 4, inclusive; and

Figure 7 is a cross-section taken along the line 7—7 in Figure 6.

As disclosed in the drawings, a casing or liner string A is run in the well bore with an upper set of perforations B positioned opposite an upper producing zone, and a lower set of perforations C positioned opposite a lower producing zone. A lower production packer 10 is anchored in packed-off condition in the casing between the upper and lower casing perforations to isolate the production from the two zones. Similarly, an upper production packer 11 is anchored in the casing in packed-off condition above the upper perforations.

The production packers 10, 11 may be of any suitable type. Those illustrated are specifically described in United States Patent No. 2,189,703, being designed for anchoring in the casing against movement in both longitudinal directions. Each of these packers consists of a generally tubular body 12 carrying a set of upper slips 13, which are cooperable with an upper expander cone 14 mounted on the body to secure the latter against movement in an upward direction with respect to the casing A. A lower set of slips 15 is also provided for cooperation with a lower expander cone 16 mounted on the body to secure the latter against movement in the casing in a downward direction. A packing sleeve 17 between the two expander cones effects an annular seal between the body 12 and casing A, for the purpose of preventing passage of fluids therebetween.

Each packer is designed to permit movement of production tubing D through its body 12 without leakage between the exterior of the tubing and the body. To this end, upper and lower packing seals 18, 19 are secured in the body for slidable engagement with the production tubing

to prevent passage of fluid between the tubing and body member.

Further details of the production packers 10, 11 are unnecessary for an understanding of the present invention, and may be found in the patent above referred to.

The producing string D is adapted to extend through both production packers, and is so designed, for one position of operation, as to allow production from the upper producing zone to be either flowed or pumped through the tubing D, while production from the lower producing zone is directed in a separate path through both packers 10, 11 for passage through the annulus 20 between the tubing D and casing A above the upper packer 11. To permit this mode of operation to occur, a portion of the production tubing has a by-pass including a T 21 secured therein in any suitable manner, as by fillets 22 of welding material integrating the outer ends of the T to the walls of an upper sub 23 threaded on an upper joint on tubing 24 (see Figures 6 and 7).

An outer tube 25 depends from the upper sub 23, having a lower sub 26 screwed on its bottom terminus, from which extends a lower production string 27 terminating in a bull nose 28 for guiding the tubing into the packers. An inner by-pass tube 29 is disposed within the outer tube 25, with its upper end screwed into the by-pass T 21, isolation of fluid within the by-pass 21, 29 from that around the by-pass and within the outer tube 25 being effected by extending the by-pass tube 29 through an inwardly extending section 30 of the lower sub 26 and providing a packing seal 31 between this section and tube 29. The seal 31 is compressed by a packing nut 32 threaded into the sub 26 to prevent passage of fluids between the outer tube 25 and the inner tube 29.

Due to the by-pass arrangement disclosed, fluid can flow through the inlet ports 33 at the lower end of the lower production tubing 27 for upward passage through this tubing and into the fluid inlet at the bottom end of the by-pass inner tube 29, continuing through this inner tube for exhaustion through the fluid outlets 34 in the by-pass T 21 connection and upper sub 23. Fluid may also enter the annular space 35 between the outer tube 25 and the exterior of the inner tube 29 through the fluid inlet ports 36 in the lower sub 26 for upward passage around the by-pass T 21 into the upper production tubing 24, from where it can flow or be pumped to the surface of the well bore.

It is to be noted that the lower tubing 27, upper tubing 24, intermediate outer tube 25, and connecting subs 23, 26 are all externally flush to allow a slidable sealing movement of the tubing string D through the packing seals 18, 19 fixed at the upper and lower ends of the production packers 10, 11. It is only essential for the tubing to be externally flush along the length movable through these packers. Any other suitable type of tubing or tubing connections may be employed above this particular section.

Many production control positions are possible with the production tubing and production packer arrangement disclosed in the drawings. The different positions may be selected merely by elevating or lowering the tubing within the casing, the slidable seals 18, 19 functioning to prevent passage of fluids along the exterior of the tubing through the production packers 10, 11.

As disclosed in Figure 1, the outlets 34 of the by-pass T 21 are positioned above the upper production packer 11, the fluid inlets 36 formed through the lower sub 26 are positioned between the production packers, and the inlet openings 33 in the lower tubing are positioned below the lower production packer 10. With the parts located in this manner, fluid from the lower zone can flow through the lower tubing 27, inner by-pass tube 29, T connection 21, into the annulus 20 between upper production tubing 24 and casing A, while production from the upper zone can flow through the inlet ports 36 in the sub 26 and through the annulus 35 around the inner tube 29 and around the T 21 into the upper production tubing 24, through which it can either flow or be pumped to the surface of the well bore, independently of the production from the lower zone.

As illustrated in Figure 2, the producing string has been lowered so as to position the by-pass T 21 between the upper and lower seals 18, 19 in the upper production packer 11. When in this position, production from the lower zone is shut in or stopped, since the upper and lower seals prevent flow around the tubing string 24 or 25 through the packer body 12; but the upper zone can either flow or be pumped through the tubing in the same manner as described in connection with the Figure 1 position, in view of the location of the inlets 36 between the packers 10, 11.

If the tubing string is elevated so that the fluid inlets 36 in the lower sub 26 are positioned between the upper and lower seals 18, 19 of the upper production packer 11, the upper zone is shut in and production can be obtained only from the lower zone, flowing through the lower tubing 27 and by-pass 29, 21 into the annular space 20 between the production tubing and casing above the upper packer 11 (see Figure 3).

Whenever the head of fluid in the annulus 20 between the production tubing D and casing A above the upper packer 11 is greater than the formation pressure in the lower zone, the latter zone will cease to flow. Should this condition obtain, the elevation of the producing string to the position illustrated in Figure 4 enables this annulus to be relieved of its fluid head. This is accomplished by locating the lower tubing inlet openings 33 between the upper and lower seals 18, 19 in the lower packer 10 and the fluid inlet ports 36 normally employed for the upper producing zone above the upper packer 11. To prevent production from flowing into the lower tubing 27 when in this position, a back-pressure valve 37 in the form of a flapper 38 closed by a spring 39 is pivotally mounted at the bottom end of the lower packer 10, automatically engaging its cooperable valve seat 40 in the bottom of the packer. Moreover, production from the upper zone is also arrested, due to the sealing action of the seals 18, 19 of the upper packer against the external surface of the tubing D, and the location of the inlet ports 36 above the upper packer 11. The annulus 20 between the producing tubing D and casing A, however, is now in communication with the interior of the production tubing string D through these inlet ports 36, which enables the fluid in this annulus 20 to be unloaded or pumped through the production tubing whenever necessary.

Should it be desirable to shut in the upper zone and pump the lower zone through the tubing, the tubing string D is lowered until the fluid inlet ports 36 in the sub 26 are positioned below the lower seal 19 in the lower packer 10, the fluid outlets 34 of the by-pass T preferably

being placed between the upper and lower seals 18, 19 of this packer 10. When situated in this manner, production from the lower zone flows into the tubing string D through the fluid inlet ports 36 and may flow or be pumped from this point through the tubing to the surface of the well bore.

If the upper and lower packers 10, 11 are spaced apart sufficiently, it might be possible to produce both zones simultaneously through the tubing by lowering the tubing D until both the by-pass T 21 and the lower sub ports 36 are positioned between the packers 10, 11. The production from the upper zone then flows into the tubing through the fluid inlet ports 36 as before, and in addition, production from the lower zone flows through the lower tubing 27 and inner by-pass tube 29 for exit through the by-pass T 21 into the annular space between the packers, joining the production from the upper zone for passage through the inlet ports 36 into the production tubing and to the well surface.

Various other operating conditions can be had by suitable maniplation of the tubing D with respect to the packers 10, 11, so as to obtain simultaneous or separate flowing of the production from each zone either through the tubing or through the annular space 20 between the tubing and casing. The apparatus may also be used to repressure one zone from the other by proper positioning of the tubing with respect to the packers.

A modified form of apparatus is illustrated in Figure 5. Instead of a single length of tubing 24, two separate sets 41, 42 extend from the flush joint tubing apparatus upwardly to the surface of the well bore. One string of tubing 42 is connected to the outer tube 25, while the inner by-pass tube 29 is connected to the other string of tubing 41. With this particular device, it is possible to flow or pump the upper and lower zones separately through individual tubing strings. For example, production from the lower zone can pass into the lower tubing 27 and through the inner by-pass tube 29 into one of the tubing strings 41. On the other hand, production from the upper zone passes through the fluid inlets 36 in the lower sub 26 into the annulus 35 between the inner and outer tubes for upward flowing or pumping through the other string of tubing 42. By use of this device, each zone may either be flowed or pumped, avoiding the necessity for shifting the tubing in the casnig in the event that the formation pressure of the lower zone drops sufficiently so as to be unable to overcome the hydrostatic head of fluid thereabove, as described in connection with the Figure 4 position.

It is apparent that a novel multiple zone production apparatus has been provided which is capable of allowing the upper zone to be pumped through a tubular string, while obtaining separate flow from a lower producing zone. Merely through the expedient of raising or lowering the production string, it is possible to produce selectively from either or both zones in various ways.

I claim:

1. Well production apparatus, including a packer for separating the production from upper and lower zones in a well bore, a second packer above said upper zone, and a production string adapted to extend through both of said packers in leak-proof relation with respect thereto, said production string having by-pass means provided with an inlet and outlet adapted to be positioned below said lower packer and above said upper packer, respectively, for by-passing fluid from said lower zone through said upper zone to a point above said upper packer, said production string also having an inlet adapted to be positioned between said packers for delivering fluid from said upper zone into the production string and for conducting it through said string to the surface of the well bore independently of the production flowing through said by-pass means, said production string being movable as a unit to shift the positions of said inlets and outlet with respect to said packers.

2. Well production apparatus, including a packer for separating the production from upper and lower zones in a well bore, a second packer above said upper zone, and a production string having externally flush joint tubing adapted to extend through both of said packers in leak-proof relation with respect thereto, said flush joint tubing having by-pass means provided with an inlet and outlet adapted to be positioned below said lower packer and above said upper packer, respectively, for by-passing fluid from said lower zone through said upper zone to a point above said upper packer, said flush joint tubing also having an inlet adapted to be positioned between said packers for delivering fluid from said upper zone into the production string and for conducting it through said string to the surface of the well bore independently of the production flowing through said by-pass means, said production string being movable as a unit to shift the positions of said inlets and outlet with respect to said packers.

3. Well production apparatus, including a packer for separating the production from upper and lower zones in a well bore, a second packer above said upper zone, a production string adapted to extend through both of said packers, sealing means between said production string and packers to prevent leakage therebetween, said production string having by-pass means provided with an inlet and an outlet adapted to be positioned below said lower packer and above said upper packer, respectively, for by-passing fluid from said lower zone through said upper zone to a point above said upper packer, said production string also having an inlet adapted to be positioned between said packers for delivering fluid from said upper zone into the production string and for conducting it through said string to the surface of the well bore independently of the production flowing through said by-pass means, said production string being movable longitudinally as a unit to shift the positions of said inlets and outlet with respect to said packers.

4. Well production apparatus, including a packer for separating the production from upper and lower zones in a well bore, a second packer above said upper zone, and a production string adapted to extend through both of said packers in leak-proof relation with respect thereto, said production string having by-pass means provided with an inlet and outlet adapted to be positioned below said lower packer and above said upper packer, respectively, for by-passing fluid from said lower zone through said upper zone to a point above said upper packer where said fluid will pass outwardly of the production string for upward flow therearound to the surface of the well bore, said production string also having an inlet adapted to be positioned between said packers for delivering fluid from said upper zone into the production string and for conducting it through said string to the surface of the well bore independ-

ently of the production flowing through said by-pass means and around said production string, said production string being movable as a unit to shift the positions of said inlets and said outlet with respect to said packers.

5. Well production apparatus, including a packer for separating the production from upper and lower zones in a well bore, a second packer above said upper zone, and a production string adapted to extend through both of said packers in leak-proof relation with respect thereto, said production string having by-pass means provided with an inlet and outlet adapted to be positioned below said lower packer and above said upper packer, respectively, for by-passing fluid from said lower zone through said upper zone to a point above said upper packer where said fluid will pass outwardly of the production string for upward flow therearound to the surface of the well bore, said production string also having an inlet adapted to be positioned between said packers for delivering fluid from said upper zone into the production string and for conducting it through said string around said by-pass means to the surface of the well bore independently of the production flowing through said by-pass means, said production string being movable as a unit to shift the positions of said inlets and outlet with respect to said packers.

6. Well production apparatus, including a packer for separating the production from upper and lower zones in a well bore, a second packer above said upper zone, a first production string adapted to extend through both of said packers in leak-proof relation with respect thereto, said first production string having by-pass means provided with an inlet and outlet adapted to be positioned below said lower packer and above said upper packer, respectively, for by-passing fluid from said lower zone through said upper zone to a point above said upper packer, a second production string connected to said outlet for conducting fluid from said by-pass to the surface of the well bore, said first production string also having an inlet adapted to be positioned between said packers for delivering fluid from said upper zone into said first production string and for conducting it through said first production string to the surface of the well bore independently of the production flowing through said second production string, said production strings being movable as a unit to shift the positions of said inlets and outlet with respect to said packers.

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