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Dec. 8, 1942. T. B. FERGUSON 2,304,303

FLOW VALVE FOR WELLS

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Fig. 1.

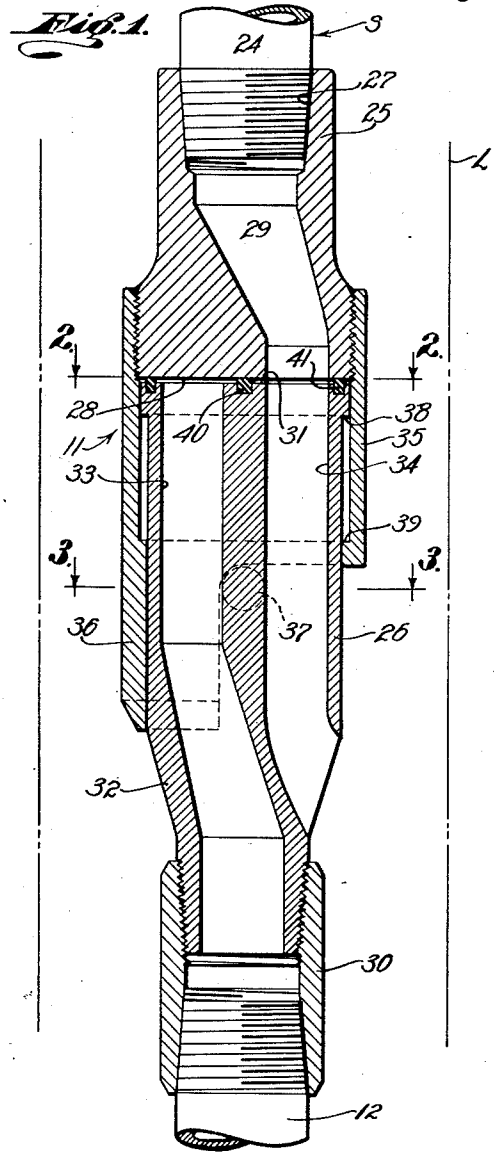


Fig. 4.

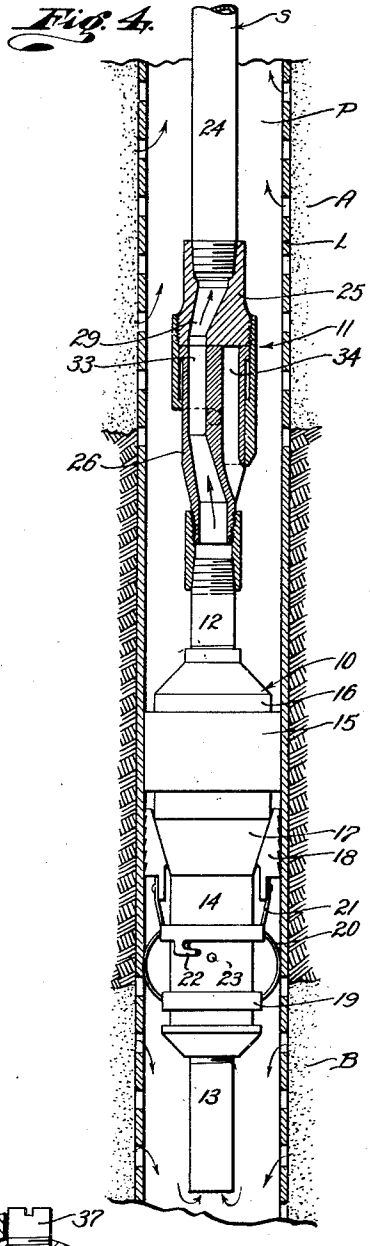


Fig. 2.

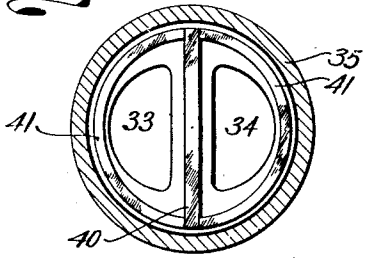
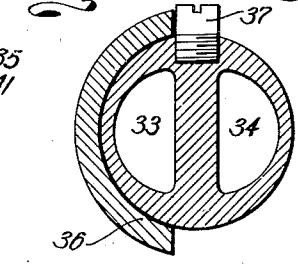


Fig. 3.



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FLOW VALVE FOR WELLS

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8 Claims. (Cl. 166—2)

This invention relates to well equipment and methods and relates more particularly to well production equipment and methods. A general object of this invention is to provide a method and apparatus for facilitating the production of fluid from a multiple zone well.

In oil wells and gas wells the well bores frequently penetrate two or more productive zones or strata. Under these conditions it is highly desirable to produce from the several zones in such a manner that the flow from the several zones may be independently handled and controlled. It is also important to keep the productive zones separate or independent when the flow is "swabbed in" or established.

Another object of this invention is to provide equipment for use in conjunction with a well production string that provides for the simultaneous production of fluid from spaced productive zones by employing the said string as a conductor for the fluid produced from one zone and by utilizing the well casing as the conductor for the fluid from the other zone.

Another and important object of this invention is to provide well equipment of the character mentioned that provides for the separate or independent establishment of flow from the upper and lower productive zones of a well. The equipment of the present invention is such that the upper and lower productive zones are kept out of communication and are successively and independently "swabbed in" or made to flow through the tubing or production string.

Another object of this invention is to provide equipment of the character mentioned embodying a novel valve connected in the production string and operable between positions where it allows for the successive and independent establishment of flow from the spaced productive zones of the well.

Another object of this invention is to provide equipment of the character mentioned in which the valve is easily controlled or operated by simple manipulation of the production string.

Another object of this invention is to provide well production equipment of the character mentioned that does not necessitate the cementing of the production string and, therefore, may be easily removed from the well.

Another object of this invention is to provide well production equipment of the character mentioned that assures a complete separation or isolation of the fluid produced from the upper and lower production zones.

A further object of this invention is to provide a novel, practical and effective method for operating or producing a multiple production-zone well.

The various objects and features of my invention will be fully understood from the following detailed description of a typical preferred manner of carrying out the method and a typical preferred form and application of the apparatus of my invention, throughout which description reference is made to the accompanying drawing, in which:

Fig. 1 is a central longitudinal detailed sectional view of the valve provided by the invention, set to provide for the establishment of flow from the upper zone through the production string. Figs. 2 and 3 are transverse detailed sectional views taken as indicated by lines 2—2 and 3—3, respectively, on Fig. 1, and Fig. 4 is a more or less diagrammatic view of the equipment in the operative position in a typical well illustrating the manner in which the fluid from the upper and lower zones is produced through the production string and the well casing and showing the valve in longitudinal section.

The apparatus of the present invention may be said to comprise, generally, a tubular production string S for conducting fluid from a well, a packer 10 connected in the string S operable to separate two productive zones A and B of the well, and a valve 11 connected in the string S above the packer 10 operable to put either the zone A or the zone B in communication with the production string S.

The production string S is adapted to be lowered into the well from the ground surface to assume a position where its lower end is in receiving relation to the lower production zone B. The well may be equipped with the conventional water string or casing (not shown) and a perforated liner L may be set in the lower productive portion of the well. The liner L is perforated at the production zones A and B to admit the fluid from these zones. The production string S is proportioned to extend through the casing (not shown) and the liner L with substantial clearance to leave an annular space or passage P of substantial fluid capacity. The string S may be made up of lengths of casing or tubing connected by couplings in the usual manner. The upper end of the string S may be supported by the usual head at the mouth of the well.

The packer 10 is operable to seal with the wall of the well or with the internal surface of the liner L at a point between the productive zones A and B to completely separate the portions of

the passage P communicating with the said zones. In accordance with the invention the packer 10 is connected in the lower portion of the string S and, as illustrated may be connected between two short sections 12 and 13 of the string. The section 13 may constitute the lowermost section of the string S and its lower end is open to receive the fluid from the production zone B as indicated by the arrows in Fig. 4. The packer 10 is preferably designed to engage in the liner L to support or to assist in supporting the string S.

In the form of the invention illustrated the packer 10 includes a mandrel 14 threadedly connected between the sections 12 and 13 of the string S. A body of packing 15 is provided on the mandrel 14 and has its upper end in engagement with a fixed collar 16 on the mandrel. A shiftable sleeve on cone 17 is provided on the mandrel 14 to cooperate with the lower end of the packing 15. Toothed slips 18 are engaged about the cone 17 and are operable to engage or grip the interior of the liner L. A tail piece or spring assembly controls the slips 18. This spring assembly may include spaced sleeves or rings 19 shiftable on the mandrel 14 and outwardly bowed springs 20 connected between the rings. The springs 20 frictionally engage the interior of the liner L to resist movement of the slips 18 in the liner. Reins 21 connect the slips 18 with the upper ring 19. A releasable latch 22 is provided on one of the rings 19 and cooperates with a pin 23 on the mandrel 14 to hold the slips 18 in their retracted positions.

With the equipment in the correct position in the well the mandrel 14 is turned to release the latch 22 from the pin 23 so that the cone 17 may actuate the slips 18 into active gripping cooperation with the liner L. When the slips 18 have been set, the weight, or a portion of the weight of the string S may be imposed on the packing 15 through the medium of the collar 16 to set or expand the packing so that it tightly seals with the liner L. As illustrated in Fig. 4 the packer 10 is arranged so that its packing 15 seals with the imperforate portion of the liner L located between the production zones A and B. The invention may utilize packers of different types and construction and is not to be construed as limited or restricted to the specific form of packer just described.

The valve 11 is an important feature of the invention. The valve 11 is operable to provide for the successive independent initiation or establishment of flow from the zones A and B through the string S and is operable to provide for the continued flow of fluid from the zone B through the string S while diverting or requiring the fluid from the zone A to flow through the passage P of the liner L and the well casing. The valve 11 is preferably connected in the string S above the packer 10 and, as illustrated, may be connected between the string section 12 and the next higher string section 24. In accordance with the invention the valve 11 includes two relatively movable body members or valve members 25 and 26. The member 25 is connected with the string section 24 while the member 26 is connected with the section 12. In the construction illustrated the valve member 25 has a socket 27 in its upper end receiving the threaded lower portion of the section 24. The member 25 is provided with a flat horizontal lower end or face 28. A port or passage 29 extends downwardly through the member 25 from the socket 27 to the lower face 28. The passage 29 is curved or formed to have its lower end offset from the central longitudinal axis of the member 25. It is preferred to make the passage 29 of substantial fluid capacity, for example, of substantially the same capacity as the string section 24.

The lower member 26 of the valve 11 may have its lower end connected with the string section 12 by a suitable threaded coupling 30. The upper major portion of the member 26 is generally cylindrical and is provided with a flat, horizontal upper face 31. A tapered portion 32 is provided on the member 26 adjacent its lower end. A port or passage 33 extends longitudinally through the member 26 from its upper face 31 to its lower end. The lower end of the passage 33 is in direct communication with the string section 12. The upper end of the passage 33 occurring at the face 31 is offset from the central longitudinal axis of the member 26. The passage 33 or at least the upper end of the passage 33 is preferably of the same size and shape as the lower end of the passage 29 and the passage 33 is of substantially the same fluid capacity as the string section 24.

The invention provides a second port or passage 34 in the valve member 26. The passage 34 extends longitudinally through the section 26 from its upper face 31 to its tapered portion 32 where it is open to communicate with the well or the interior of the liner L. The upper end of the second passage 34 is preferably of the same size and shape as the lower end of the passage 29 and the passage 34 is of substantially the same fluid capacity as the string section 24. The passage 34 has its upper end offset from the central longitudinal axis of the member 26. The two valve members 25 and 26 are co-axial and the upper ends of the passages 33 and 34 are offset from the central longitudinal axis of the assembly the same distance as the lower end of the passage 29. As will be subsequently described, the valve members 25 and 26 are connected for relative turning so that the lower end of the passage 29 may be brought into communication with the upper end of the passage 33 or with the upper end of the passage 34.

The valve members 25 and 26 are connected for relative turning and for relative longitudinal movement. A tubular apron or extension 35 is connected with the member 25 and extends downwardly around the upper part of the member 26. The extension 35 may be threaded on the lower portion of the member 25. A lug 36 of substantially 180° circumferential extent projects from the lower end of the extension 35. A stop pin 37 projects from the member 26 and is cooperable with the vertical ends of the lug 36 to limit relative turning of the members 25 and 26. The stop parts are related so that the cooperation of the pin 37 and the lug 36 serves to locate the member 25 in one position where its passage 29 is in communication with the passage 33 and serves to locate the member 25 in a second position where its passage 29 communicates with the upper end of the passage 34. These two positions of the member 25 are illustrated in Figs. 1 and 4, respectively. An annular downwardly facing external shoulder 38 is provided on the member 26 and opposes an upwardly facing internal shoulder 39 on the extension 35. The shoulders 38 and 39 are engageable to limit relative longitudinal movement between the members 25 and 26 and to prevent disconnection of the members. The shoulders 38 and 39 are spaced a substantial distance apart when the valve

members 25 and 26 are in their normal positions. This relationship of the shoulders 38 and 39 provides for a substantial vertical movement of the member 25 relative to the member 26.

Packing means is provided for sealing between the valve members 25 and 26 and for preventing the passage or leakage of fluid from between the upper ends of the passages 33 and 34. A strip or band 40 of packing is seated in a transverse or diametric groove in the upper end of the member 26. As illustrated in Fig. 2 of the drawing the packing band 40 passes between the upper ends of the passages 33 and 34 to form a barrier or partition between the passages. Substantially semi-circular packing elements 41 are set in an annular groove in the upper end of the member 26 and have their ends in engagement with the packing band 40. The packing elements 41 are in surrounding relation to the upper ends of the passages 33 and 34. The packing band 40 and the packing elements 41 project from the upper face 31 of the member 26 to seal with the lower face 28 of the member 25. When the weight, or a portion of the weight of the string S is imposed on the valve 11 the face 28 tightly bears against the packing band 40 and the elements 41 so that an effective seal is provided between the opposing faces of the members 25 and 26. It will be observed that the packing means just described assures the complete separation of the passages 33 and 34 when the valve member 25 is in either of its positions.

In the use of the equipment described above and in carrying out the method of the invention the string S provided with the packer 10 and the valve 11 is lowered into the well. The well may have been previously prepared for production from the zones A and B. The string is lowered to locate the packer 10 in the blank or imperforate portion of the liner L between the production zones A and B. When the string S is lowered through the well it may be preferred to set the valve 11 in the position where the port 33 communicates with the port 29 to allow for the free downward movement of the packer 10 through the well. When the string S has been lowered to its final position it is turned slightly to release the latch 22 from the pin 23 and is moved downwardly to actuate the slips 18. The engagement of the lug 36 with the stop pin 37 may transmit the turning movement from the string S to the section 12 and the packer 10 to effect the release of the latch 22 from the pin 23. Following the actuation of the slips 18 and the setting of the packing 15 the string S may be raised to free the face 28 from the packing band 40 and the packing elements 41, and the string is then turned to bring the member 25 to the position where its passage 29 communicates with the passage 34. The string S is then allowed to settle to bring the face 28 into contact with the packing band 40 and the sealing elements 41. With the parts in the position just described the productive zone A is in communication with the string S and the productive zone B is completely cut off from the string S and from the portion of the well above the packer 10. The flow of fluid from the productive zone A may be initiated or established through the string S by swabbing in or by any other action. It is to be particularly noted that this establishment of production from the zone A through the string S may be accomplished without disturbing the productive zone B in any manner.

When the upper productive zone A has been cleaned through the flow action and the swabbing-in action and the flow from this zone has been fully established, the string S may be raised to release the face 28 from the packing band 40 and the packing elements 41 and then turned to bring the passage 29 into communication with the passage 33. The string S is then allowed to settle to re-engage the face 28 with the packing band 40 and the elements 41. This operation cuts off the flow of fluid from the zone A to the string S and places the zone B in communication with the string S. The flow of fluid from the upper production zone A is diverted from the string S into the annular passage P and the fluid from the zone A flows upwardly through the liner L and the well casing to the well head where it may be controlled and conducted away as found practical.

With the passage 29 in communication with the passage 33, as illustrated in Fig. 4 of the drawing, the flow of fluid from the lower productive zone B may be established through the string S by a swabbing-in operation. As indicated by the arrows in Fig. 4 the fluid from the zone B is free to enter the lower end of the string section 13 and pass upwardly through the passage 33 and the passage 29 and the remainder of the string S. The fluid from the zone B is conducted to the ground surface by the string S and is controlled at the surface by the conventional Christmas tree arrangement. It is to be observed that the fluid from the zone A is completely isolated from the fluid produced from the zone B and that the passage P and the string S constitute fluid conductors of ample capacity for handling the two fluid flows. If at any time it becomes necessary or desirable to remove the string S and the other equipment from the well the string may be raised to release the slips 18 and may be freely withdrawn from the well to recover the packer 10, the valve 11 and the entire string S.

After a period of operation or production it may be desirable or necessary to renew the flow from the upper zone A. This may be easily accomplished by raising the string S to separate the faces 28 and 31. The face 28 may be moved a substantial distance from the face 31 to provide free communication between the passages 33 and 34. The string S may be closed off at its upper end to divert the fluid flow from the zone B to the passage 34 and the annular well space or passage P. The fluid from the zone B flowing upwardly through the passage P has an inductive action similar to a gas lift action and induces the flow of fluid from the zone A into the passage P. When the flow or production from the upper zone A has been been re-established the string S may be lowered and brought to the position where the passage 29 is in communication with the passage 33 and the zones A and B may produce separately through the passage P and the string S respectively as above described.

Having described only a typical, preferred form of apparatus and manner of carrying out the method of my invention, I do not wish to be limited or restricted to the specific details herein set forth, but wish to reserve to myself any variations or modifications that may appear to those skilled in the art or fall within the scope of the following claims:

Having described by invention, I claim:

1. Apparatus for use in a well having two vertically spaced productive zones comprising a tubular production string adapted to be installed in

the well, a packer on the string operable to seal off the well between said zones, and a valve connected in the string above the packer operable to successively independently establish production from said zones through the string, said valves comprising two relatively turnable and relatively vertically movable members connected with adjacent opposing sections of the string, one member having a passage communicating with its respective section, the other member having a port open to the well above said packer and a passage communicating with its respective section of said string, the members being relatively turnable between a position where the passage of the first named member communicates with the port of the second named member to initiate production from the upper zone through said string and a position where the passage of said first named member communicates with the passage of said second named member to initiate flow from the lower zone through said string, the port and passage of said second named member being out of communication when the members are in the said two positions, and the members being relatively vertically movable to put the port and passage of said second named member in communication with one another and in communication with the passage of said first named member whereby the flow from one zone may serve to re-establish flow from the other zone.

2. Apparatus for use in a well having two spaced productive zones comprising a tubular production string to be installed in the well, a valve associated with the string including two movably connected members, one secured to the string to move therewith, and means on the other member for fixedly anchoring the same in the well and for sealing off the well between said zones, the first named valve member being movable with the string to positions where either of said zones is exclusively in communication with the string to produce therethrough and being movable with the string to put both of the zones in communication with the string so that flow from one zone may serve to re-establish flow from the other zone.

3. Apparatus for use in a well having two spaced productive zones comprising a tubular production string to be installed in the well, means on the string for packing off the well between said zones and for anchoring the lower portion of the string against movement, and a valve interposed in the string above said means comprising a lower member connected with said means to be anchored thereby, and an upper member movable with the upper portion of the string between the positions where the valve successively places the individual zones in communication with the string to separately produce therethrough and movable to a position where both of said zones communicate with the string so that the flow from one zone may establish flow from the other zone by induction.

4. Apparatus for use in a well having two spaced productive zones comprising a tubular production string to be installed in the well, means on the string for packing off the well between said zones and for anchoring the lower portion of the string against movement, and a valve interposed in the string above said means comprising a lower member connected with said means to be anchored thereby, and an upper member turnable with the upper portion of the string between positions where the valve successively places the individual zones in communication with the upper portion of the string to separately produce therethrough and movable vertically with the upper portion of the string to a position where the valve places both zones in communication with the upper portion of the string so that the flow from one zone may establish flow from the other zone by induction.

5. Apparatus for use in a well having two spaced productive zones comprising a tubular production string to be installed in the well, means on the string for packing off the well between said zones and for anchoring the lower portion of the string against movement, and a valve interposed in the string above said means comprising a lower member connected with said means to be anchored thereby and having a passage communicating with the lower portion of the string to receive flow from the lower zone and a port communicating with the well to receive flow from the upper zone, and an upper member secured to the upper portion of the string and turnable and movable axially relative to the lower member, the upper member having a passage that may be brought into communication with either the port or passage of the lower member by turning of the upper portion of the string to allow either of said zones to separately produce through the upper portion of the string and that may be made to commmunicate with both the port and passage of the lower member by vertical movement of the upper portion of the string so that flow from one zone may establish flow from the other zone by induction.

6. Apparatus for use in a well having upper and lower productive zones comprising a tubular production string to be installed in the well, means on the string for sealing off the well between said zones and for anchoring the adjacent part of the string in the well, and a valve interposed in the string above said means comprising two relatively turnable and relatively axially movable members connected with adjacent opposing sections of the string, opposing end faces on the members, one member having a port leading from its end face to its exterior to communicate with the well above said means and a passage leading from its end face to communicate with the section of the string which extends below said means to communicate with the lower zone, the other member having a passage leading from its face to the interior of that part of the string which extends to the top of the well, the last named passage being selectively movable into register with the port and passage of the first named member upon turning of said last named member so that either zone may flow through the string and said last named passage being adapted to communicate with both the port and said first named passage upon relative axial movement between the members so that the flow from one zone may induce flow from the other zone through the string.

7. Apparatus for use in a well having upper and lower productive zones comprising a tubular production string to be installed in the wall, means on the string for sealing off the well between said zones and for anchoring the adjacent part of the string in the well, and a valve interposed in the string above said means comprising two relatively turnable and relatively axially movable members connected with adjacent opposing sections of the string, opposing end faces on the members, one member having a port leading from its end face to its exterior to communicate with the well above said means and a passage leading from its end face to communi-

cate with the section of the string which extends below said means to communicate with the lower zone, the other member having a passage leading from its face to the interior of that part of the string which extends to the top of the well, the last named passage being selectively movable into register with the port and passage of the first named member upon turning of said last named member so that either zone may flow through the string and said last named passage being adapted to communicate with both the port and said first named passage upon relative axial movement between the members so that the flow from one zone may induce flow from the other zone through the string, and packing means for sealing between said end faces around the mouths of said port and passage of the first named member when the members are together.

8. Apparatus for use in a well comprising a tubular well string, and a valve to be connected between the ends of the well string including two members arranged in end to end relation, means connecting the members for relative turning and for relative axial movement, one member having a single fluid passage, the other member having two separate passages either one of which may be made to communicate with the passage of the first named member at the opposing ends of the members by relative turning movement of the members, means connecting said first named member with a part of the string to have its passage in communication with the string, and means connecting said other member with another part of the string, to have one of its passages communicate therewith so that vertical movement of the string may put all of said passages in communication with one another.

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