

June 22, 1954

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2,681,705

SHUTOFF APPARATUS FOR DUAL PRODUCTION WELLS

Filed June 5, 1951

4 Sheets-Sheet 1

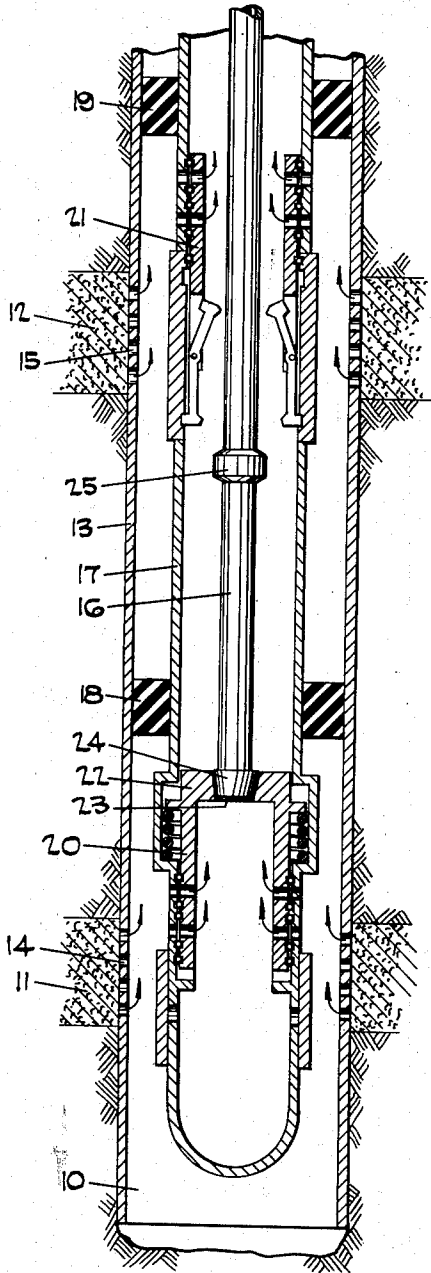


FIG. 1

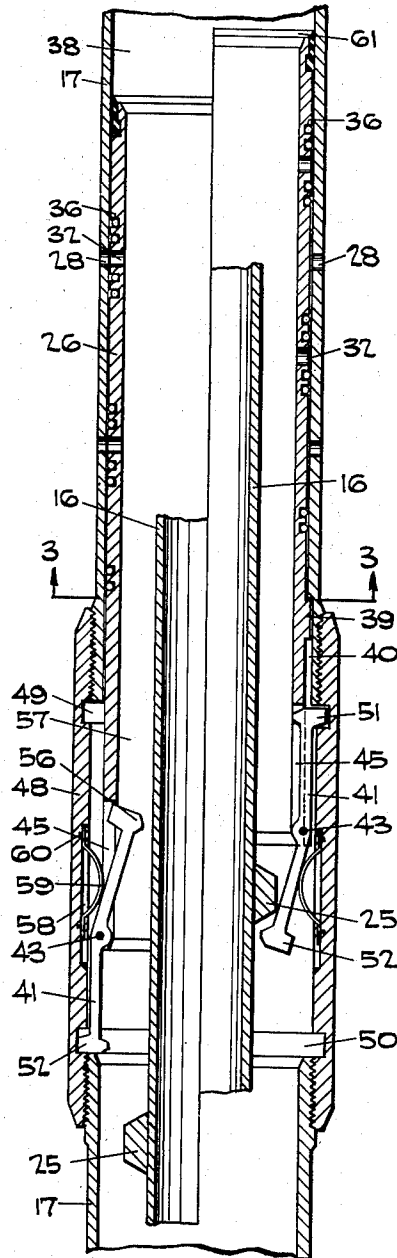


FIG. 2

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4 Sheets-Sheet 2

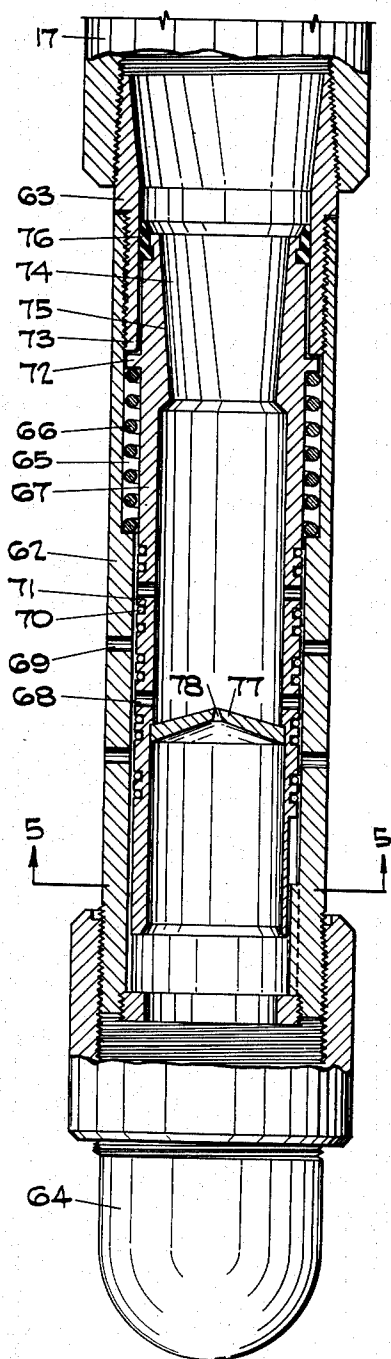


FIG. 4

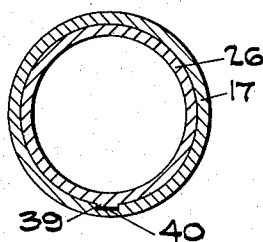


FIG. 3

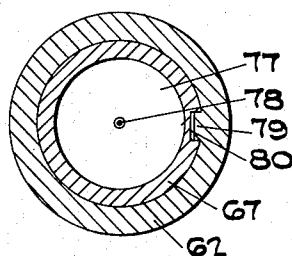


FIG. 5

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4 Sheets-Sheet 3

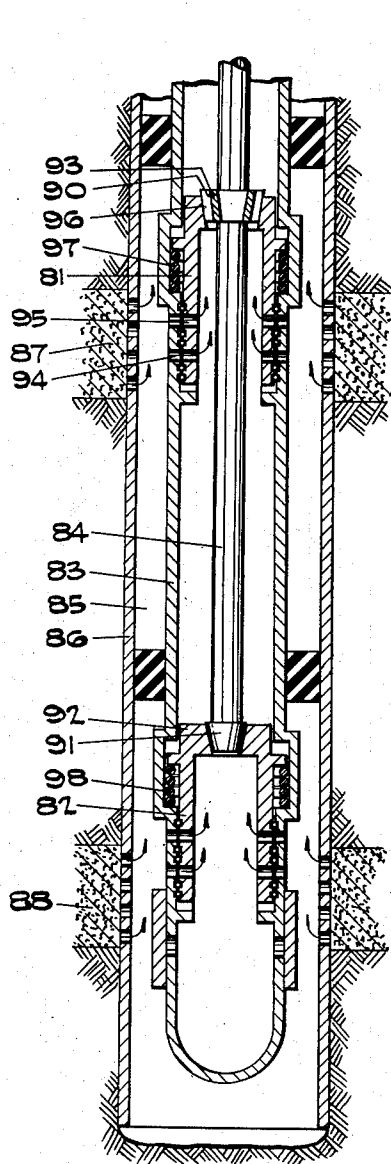


FIG. 6

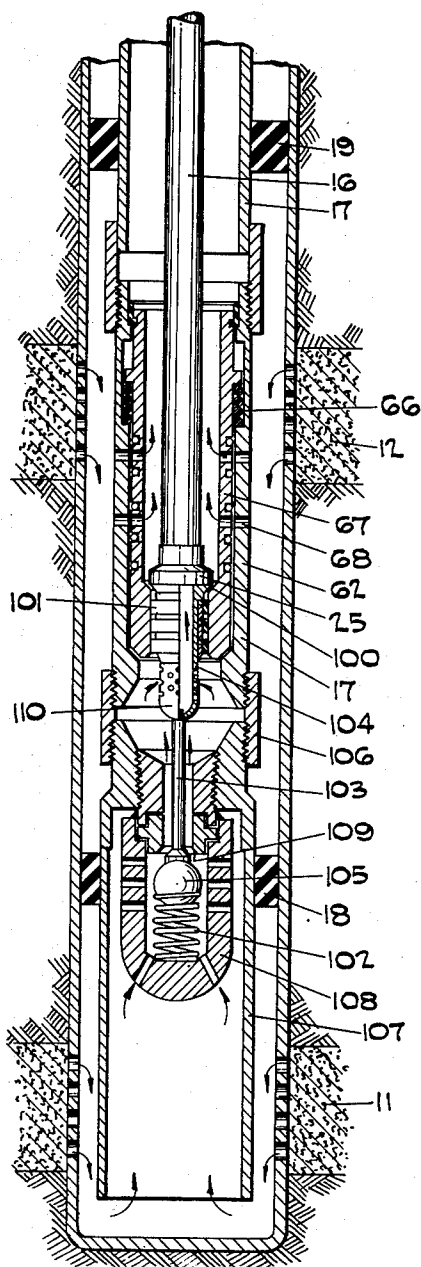


FIG. 7

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4 Sheets-Sheet 4

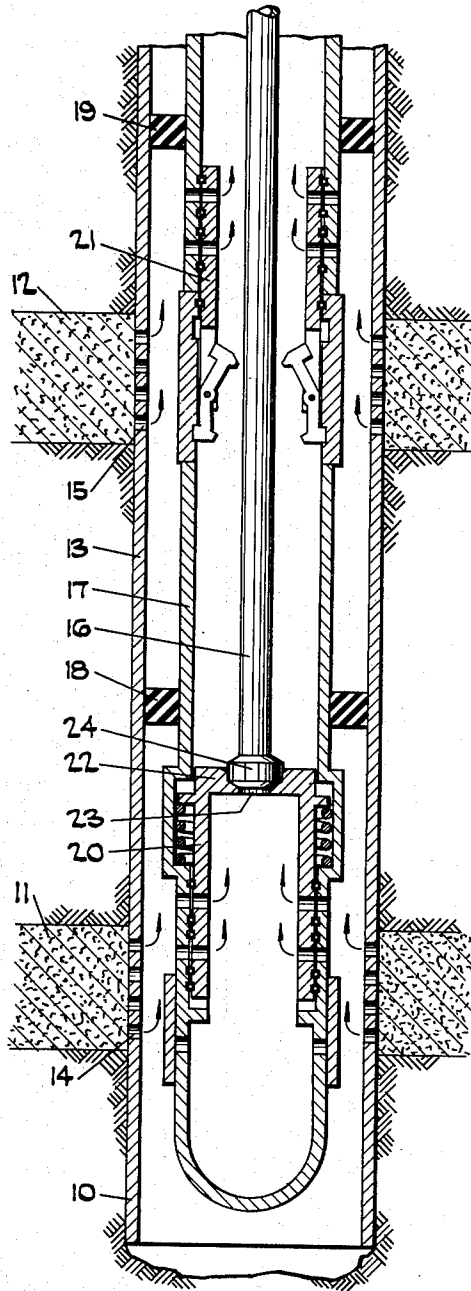


FIG. 8

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UNITED STATES PATENT OFFICE

2,681,705

SHUTOFF APPARATUS FOR DUAL
PRODUCTION WELLS

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Application June 5, 1951, Serial No. 229,937

6 Claims. (Cl. 166-114)

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This invention relates to well equipment for controlling the production from a plurality of producing zones in an oil or gas well, and pertains more particularly to means for shutting off the production from a plurality of zones within a well when well production equipment is being serviced, repaired or replaced.

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 each of the several zones may be independently handled and controlled. In the case of naturally flowing multiple zone wells, or in wells where a dual artificial lift installation is employed, it is almost always necessary to "load" the well with oil, water, or drilling mud when down-the-hole equipment is pulled or removed from the well for servicing. The purpose of loading a well in this manner is twofold: To prevent commingling of the products of the two producing zones in the case of dually completed wells, and to eliminate the need of a blowout preventer, when pulling tubing, to control the well in the event that the well tends to "head" or flow naturally during servicing operations. The loading of wells during servicing operations is undesirable in that it is an expensive operation and the producing zones may be damaged or contaminated by contact of loading liquid.

It is therefore a primary object of the present invention to provide means for shutting off well production without the necessity of "loading" or "killing" a well while servicing equipment used in a well having a plurality of producing zones.

Another object of this invention is to provide well equipment for establishing and maintaining a separate or independent flow of fluid from the upper and lower productive zones of a multiple zone well being dually produced.

A further object of this invention is to provide equipment for use in conjunction with two concentric production tubings which provides for the simultaneous production of fluid from spaced productive zones, the production from each zone being handled by one of the production tubings.

Another object of the present invention is to provide well flow control equipment for use in conjunction with two concentric production tubings for producing a multiple zone well, said well flow control equipment being controlled or operated by manipulation of the central or innermost production tubing.

Another object of this invention is to provide shut-off equipment for wells produced by means

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of the dual gas-lift system described in my co-pending application "Dual Gas-Lift System," Serial No. 177,990, filed August 7, 1950.

These and other objects of this invention will be understood from the following description taken with reference to the accompanying drawing, wherein:

Figures 1, 6, 7 and 8 are vertical views, partly in cross section, of different embodiments of the present invention installed in a well borehole which traverses two producing zones or strata.

Figure 2 is a vertical sectional view of one embodiment of a valve member of the present control apparatus, said view showing the valve in both its open and closed positions.

Figure 3 is a horizontal cross-sectional view taken along the line 3-3 in Figure 2.

Figure 4 is a detailed view, in vertical cross-section of another embodiment of a valve assembly for use with the present well control apparatus.

Figure 5 is a horizontal cross-sectional view taken along the line 5-5 in Figure 4.

Referring to Figure 1 of the drawing, the well control apparatus of the present invention is shown as being positioned in a well borehole 10 which traverses at least two producing zones 11 and 12. The borehole 10 may be cased or uncased but is preferably lined with a casing 13 which is perforated, as at 14 and 15, at the level of the producing formations 11 and 12. In general, the well control apparatus comprises a pair of concentric tubing strings 16 and 17, for conducting fluid from the two productive zones 11 and 12 of the well, and packers 18 and 19 together with sliding sleeve valves 20 and 21 for isolating the fluids from formations 11 and 12 and directing them to separate tubing strings 16 and 17, respectively.

The packers 18 and 19 are carried on the outer tubing string 17 at a level respectively below and above the upper producing formation 12. While in certain embodiments of the present invention the upper packer 19 may be eliminated, it is essential that the lower packer 18 be positioned between the producing formations 11 and 12. The packers 18 and 19 may be of any suitable fixed or expansible type, the latter type being actuated by manipulation of the tubing string 17, by hydraulic action, or by any other method well known in the art.

Additionally, suitable packer or closure means are provided between the tubing strings 16 and 17 at a point below the upper sleeve valve 21 to prevent the intermixing of the fluids from the two producing zones 11 and 12. In the present

embodiment the last-mentioned packer means are formed by the top 22 of the lower sleeve valve 20 which forms an annular fluidtight closure means between the tubings 16 and 17. As shown in Figure 1, the top 22 of the lower sleeve 20 may form a seating nipple having a downwardly tapering bore 23 adapted to receive and seal therein a tapered shoe 24 secured to the lower end of the inner tubing string 16. If necessary, suitable packing material may be provided between nipple 22 and shoe 24 to insure a fluidtight seal. It is realized that an expansible packer, carried on the inner tubing string 16 may be used instead of the packer means formed by the top 22 of the slide valve 20.

As shown in Figure 1, a collar 25 is secured to the outer surface of the inner tubing string 16 for actuating said sleeve valve 21 in a manner which will be described hereinbelow.

The sleeve valve 21 of Figure 1 is shown in detail in Figure 2 as comprising a sleeve member 26 slidably mounted within a section of the outer tubing string 17. The outside diameter of the sleeve member 26 is substantially equal to the inside diameter of the tubing 17 whereby a substantial fluidtight fit is formed between the members 26 and 17. The tubing 17 is provided with a plurality of perforations 28 while the sleeve 26 is provided with an equal number of perforations 32. The two sets of perforations 28 and 32 are spaced to register with each other when the valve sleeve 26 is in its open position. Additionally, the space between the perforations is substantially greater than the size of the perforations whereby the perforations are closed by a slight axial displacement of the sleeve 26 within the tubing 17.

The sleeve member 26 is preferably provided with one or more annular grooves 36 above and below the perforations 32, said grooves being adapted to contain therein suitable sealing elements such as O-rings, piston rings, or any suitable packing material. An effective seal between the sleeve 26 and the tubing 17 prevents well fluid from entering ports 28 and flowing into the bore 38 of the tubing 17 when the sleeve valve is in its closed position, as shown in the right hand half of Figure 2. To insure ports 28 remaining in alignment with port 32 during repeated opening and closing of the sleeve valve, the sleeve is provided with a key 39 fitted for sliding movement in a keyway 40 cut in the wall of the tubing 17 as shown in Figures 2 and 3.

Affixed to one end of the sleeve member 26 are locking means for limiting its travel or axial displacement within the tubing 17. The locking means comprises at least one and preferably a plurality of rocker elements 41 pivotally mounted by pins 43 in slots 45 in the lower end of the sleeve 26. Threadably secured to the lower end of a tubing section and to the upper end of an adjacent tubing section of the string 17 is a special coupling 48 having a pair of spaced annular grooves 49 and 50 formed in the inner wall. The ends of the rocker element 41 have a hammerhead shape with one face 51 or 52 at each end of the rocker elements adapted to seat within one of the annular grooves 49 or 50. Each rocker element 41 is formed in an angular manner about its pivot pin 43 so that when one end 52 of the rocker is positioned in groove 50 the opposite end 51 is raised from the surface of the coupling 48.

When any rocker has one end 51 raised from the surface of the coupling 48, the inner face

56 of that end extends into the annular space 57 between the sleeve 26 and the inner tubing string 16 at distance sufficient to be engaged by the collar 25 carried on the tubing string 16. Preferably the inner faces 56 of the ends of the rocker element 41 are shaped to form a shoulder against which the collar 25 may act. When the outer face 52 of the rocker 41 is positioned in groove 50, the clearance between that end of the rocker and the inner tubing string 16 is sufficient to permit the passage of the collar 25 therethrough.

In the event that the fluids from the two production zones 11 and 12 may be intermingled temporarily without undue harm, the use of the collar 25 may be omitted and a shoe 24 of suitable size and shape may be employed to open valve 21 as it passes therethrough prior to opening valve 20 when it seats in nipple 22.

A longitudinal recess 58 may be cut in the inner wall of the coupling 48 intermediate the grooves 49 and 50. A suitable spring 59 is mounted in said recess 58, one end of said spring being anchored to the wall of the coupling 48 by a bolt 60. The spring maintains a pressure on one arm of the rocker element 41 at all times thereby forcing the arm into the annular space 57 surrounding the tubing 16 while the other arm is pivoted so that its head 52 is forced into groove 50. As the sleeve 26 and attached rocker element 41 are moved upwardly from the position shown in the left-hand half of Figure 2, the central pivoted portion of the rocker element passes over the spring 59 until it assumes the position shown in the right-hand half of Figure 2.

When the rocker element 41 has its lower end 52 positioned in the lower annular groove 50, as shown in the left-hand section of Figure 2, the sleeve valve is in its open position with the fluid port or perforation 28 in alignment with port 32 in the sleeve 26. Likewise, when the upper end 51 of the rocker element 41 is positioned in the upper annular groove 49, as shown in the right-hand section of Figure 2, the sleeve valve is in its closed position. The sleeve 26 is adapted to travel a distance sufficient to completely close the fluid ports in the tubing 17 as shown. If desired, a rubber wiper element 61 may be secured in any suitable manner to the top of the sleeve element 26 to prevent sand or other solid material from accumulating behind the sleeve 26.

Another type of a sleeve valve of the present invention is shown at 20 in Figure 1 and in more detail in Figure 4. The valve comprises a short section of tubing 62 which may be connected to the lower end of the outer production tubing 17 in any suitable manner, as by being screw-threaded to a reducing nipple 63 which is in turn secured to the tubing 17. The lower end of the tubing section 62 may be closed by coupling a closure cap or plug 64 thereto. An annular recess 65 is provided in the inner wall of the tubing section 62 to contain a compression spring 66 therein.

Mounted for vertical sliding movement within the tubing section 62 is a sleeve 67 having a plurality of fluid port 68 through the wall thereof which is spaced to register with an equal number of fluid port 69 through the wall of the tubing section 62 when the valve assembly is in its open position. Suitable packing means, such as O-ring 70, may be mounted in annular groove 71 in the outer wall of the sleeve 67 above and

below the fluid port 68 therein to form a fluid-tight seal between the sleeve 67 and the tubing section 62.

Affixed to or formed on the outer wall of the sleeve 67 is an annular flange 72 adapted to extend into the annular recess 65 in the inner wall of the tubing section. When the valve structure is assembled, the spring 66 forces said flange 72 up against the lower end 73 of the nipple 63, whereby the fluid ports 68 and 69 are out of alignment and the valve assembly is in its closed position, as shown in Figure 4.

The bore 74 at the top of the sleeve 67 is tapered to form a seating shoulder 75 adapted to cooperate with the tapered shoe 24 (Figure 1) carried at the lower end of the inner production tubing 16. The upper end of the sleeve 67 may be provided with a rubber wiper ring 76 which prevents sand from accumulating behind the sleeve 67. Likewise, in order to prevent sand and foreign matter from settling below the valve assembly and interfering with its operation, an upwardly-pointing cone-shaped disk 77 may be secured to the inner wall of the sleeve 67 below the lowermost fluid port 68 therein to catch sand which would otherwise settle to the bottom and hinder the downward movement of sleeve 67. Preferably, a small hole 78 is provided in the apex of the disk whereby the pressures on either side of said disk 77 will be equalized when the valve sleeve 67 slides up and down. Fluid entering the port 68 just above the disk 77 washes the upper face of the disk 77 and prevents the accumulation of sand thereon. In order to maintain the port 68 of the sleeve 67 in vertical alignment with the port 69 of the tubing section 62, the latter is provided with a key 79 which extends inwardly to fit into a vertical keyway 80 cut in the outer wall of the sleeve 67, as shown in Figures 4 and 5.

The apparatus of the present invention finds application in many control systems in wells traversing at least two production zones which are produced through concentric production tubings. The present system is especially useful when used in a well being produced by gas lift wherein the gas lift equipment is carried by the innermost of two concentric production tubings as disclosed in my co-pending patent application entitled: "Dual Gas-Lift System," Serial No. 177,990, filed August 7, 1950. Thus, when the innermost production tubing 16 which carries the gas lift equipment (not shown) is removed from the well for servicing of said gas lift equipment, valve 20 is immediately closed when an upward pull is applied to the tubing 16 to remove its weight from the seating nipple 22 at the top of the valve.

As described with regard to Figure 4, when the weight of the production tubing 16 (Figure 1) is removed from the seating shoulder 75 (Figure 4) of the sleeve 67, the compression spring 66 acting against the flange 72 of the sleeve 67 raises the latter so that the fluid port 68 is out of register with the port 69 and the valve is thus closed. As the inner production tubing is raised higher, the collar 25 (Figures 1 and 2) is also raised until it contacts the end 56 of the rocker element 41 (Figure 2) which is raised together with the sleeve 26 of the valve from the position shown on the left-hand side of Figure 2 to that shown on the right-hand side at which time the valve is closed. The inner tubing string 16 may then be removed from the well while the production from the upper

zone 12 (Figure 1) is isolated between casing 13, tubing 17 and packers 18 and 19. At the same time the production from the lower zone 11 is contained between casing 13 and tubing 17 below packer 18. Hence, it will be seen that by employing the present well control equipment the production from the two zones 11 and 12 is prevented from intermingling while gas lift equipment (not shown) carried on the inner production tubing 16 is removed from the well for servicing.

An alternate method of utilizing well shutoff valve described hereinabove with regard to Figures 1 and 5 is illustrated diagrammatically in Figure 6. In this embodiment, the present well control equipment comprises a pair of sleeve valves 81 and 82 slidably mounted for limited vertical movement within the outer tubing 83 of concentric production tubings 83 and 84.

The sleeve valves 81 and 82 of the embodiment illustrated in Figure 6 are both of the type shown in Figure 4 and described hereinabove. Both sleeve valves 81 and 82 are provided with tapered seats for receiving tapered shoes 90 and 91 carried by the inner tubing 84 in spaced relationship. While the lower shoe 91 is solid in structure to form fluidtight packer means with the top 92 of the lower sleeve valve 82, the upper shoe 90 has a plurality of vertical fluid ports therethrough or is in the form of a spider having a plurality of tapered ribs 93. The spaces between the ribs 93 serve as fluid passageways allowing fluid entering ports 94 in the tubing 83 and port 95 in the open sleeve valve 81 to flow up the production tubing 84.

The diameter of the tapered seat 95 in the upper sleeve valve 81 is necessarily greater than that of the lower shoe 91 thus allowing the latter to pass through the sleeve 81. The spacing between the shoes 90 and 91 carried by the inner tubing 84 is identical with the spacing between the sleeve valves 81 and 82. Thus, when the inner tubing 84 is run into the well, the shoes 90 and 91 contact the tapered seats of the sleeve valves 81 and 82 simultaneously to open the valves at the same time as the weight of the tubing 84 forces the sleeves 81 and 82 downwardly compressing springs 97 and 98. Upon subsequently raising the tubing 84, the action of the springs 97 and 98 forces the sleeves 81 and 82 upwardly to close the valves.

It is readily apparent from the above that the present well control apparatus may likewise be modified to comprise two sleeve valves identical with the valve 21 instead of two valves identical with valve 20, as shown in Figure 6. Two valves of this type may be successively operated by a single collar 25 carried by the inner tubing string, or they may be simultaneously operated by providing the tubing with a pair of spaced collars.

An alternate arrangement of well shutoff valves according to the present invention is illustrated in Figure 7. The upper shutoff valve in this apparatus comprises a sleeve valve 67 similar to that described with reference to Figure 4, said sleeve valve 67 being actuated by a spring 66 to close ports 68 in tubing section 62. The lower end of the sleeve 67 is provided with an internal seating shoulder 100 on which the collar 25 seats to open the valve 67. Sealing rings or cups 101 are carried on the outer surface of the inner string 16 below the collar 25 for forming a seal between the inner and outer

strings 16 and 17 at a point below the upper producing formation 12.

Secured to the lower end of the outer tubing 17 by means of a collar 105 is a tubular member 107 which serves as an extension of the outer tubing. A packer 18 is carried by the outer tubing 17 or its extension 108 at a point below the upper producing zone 12. If desired, a second packer 19 is positioned on the outer tubing string above the producing zone. Fixedly secured within the outer tubing extension 107 is a perforate valve cage 108 having a seat 109 formed within the upper part thereof which is adapted to seat a ball 105. A spring 102 is positioned within the cage 108 below the ball 105 and normally seats the ball 105 against the valve seat 109 thus maintaining the valve in a normally closed position.

The ball valve may be opened by a rod 103 attached to the lower end of the seating shoe 104 by a perforate cap 110 which permits the flow of oil into the inner tubing string 16. The rod 103 is of sufficient length to push and hold the ball 105 off its seat when the collar 25 has seated on shoulder 100 and opened sleeve valve 67. When the inner tubing string 16 is removed for pulling and servicing of equipment, sleeve valve 67 is returned to its closed position by spring 66 shutting in the top zone 12 while the rod 103 is withdrawn with the tubing string 16 allowing spring 102 to force the ball 105 up against seat 109 and thus shut in the bottom zone 11. This arrangement of valves 67 and 105 has been found to be especially convenient in that, by employing a weak spring 102, fluid standing in the inner tubing 16 may be drained therefrom as the tubing is pulled from the well thus eliminating the spilling of oil around the derrick as the sections of tubing string are uncoupled.

I claim as my invention:

1. Apparatus for use in a well having two vertically spaced productive zones, said apparatus comprising a pair of concentrically spaced production tubings extending into the well with the lower ends thereof positioned below the upper production zone, the outer production tubing being closed at its lower end, a packer carried on the outer tubing to seal off the well between said productive zones, first and second fluid port means through the walls of said outer tubing disposed above and below the packer, first and second sleeve valve means each having a bore therethrough and slidably mounted for limited axial movement on the inner walls of said outer tubing adjacent said first and second port means, respectively, said movement bringing said first and second sleeve valve means into and out of register with said first and second fluid port means in said tubing, means comprising at least one member exteriorly carried on the inner tubing and extending outwardly therefrom for opening and closing said first sleeve valve means upon axial movement of said inner tubing in opposite directions, said means being adapted to actuate and pass through the first sleeve valve means and subsequently engage and actuate said second sleeve valve means, and closure means in the annular space between said production tubings at a point intermediate said first and second port means.

2. Apparatus for use in a well having two vertically spaced productive zones, said apparatus comprising a pair of concentrically spaced production tubings extending into the well with the

lower ends thereof positioned below the upper production zone, the outer tubing being closed at its lower end, a packer carried on the outer tubing to seal off the well between said productive zones, first and second fluid port means through the walls of said outer tubing disposed above and below the packer, first and second sleeve valve means slidably mounted for limited axial movement on the inner walls of said outer tubing adjacent said first and second port means, respectively, said movement bringing said first and second sleeve valve means into and out of register with said first and second fluid port means in said tubing, means comprising at least one member exteriorly carried on the inner tubing and extending outwardly therefrom for opening and closing said first sleeve valve means upon axial movement of said inner tubing in opposite directions, said means being adapted to actuate and pass through the first sleeve valve means and subsequently engage and actuate said second sleeve valve means, closure means in the annular space between said production tubings at a point intermediate said first and second port means, and an axial bore through said closure means in register with said inner production tubing.

3. Apparatus for use in a well having two vertically spaced productive zones, said apparatus comprising a pair of concentrically spaced production tubings extending into the well with the lower ends thereof positioned below the upper production zone, the outer production tubing being closed at its lower end, a packer carried on the outer tubing to seal off the well between said productive zones, first and second fluid port means through the walls of said outer tubing disposed above and below the packer, first and second sleeve valve means slidably mounted for limited axial movement on the inner walls of said outer tubing adjacent said first and second port means, respectively, said movement bringing said first and second sleeve valve means into and out of register with said first and second fluid port means in said tubing, an annular member exteriorly affixed to the inner tubing and having a diameter larger than that of the inner tubing for opening and closing said first sleeve valve means upon axial movement of said inner tubing in opposite directions, said annular member being adapted to actuate and pass through the first sleeve valve means and subsequently engage and actuate said second sleeve valve means, closure means in the annular space between said production tubings at a point intermediate said first and second port means, and an axial bore through said closure means in register with said inner production tubing.

4. Apparatus for use in a well having two vertically spaced productive zones, said apparatus comprising a pair of concentrically spaced production tubings extending into the well with the lower ends thereof positioned below the upper production zone, the outer production tubing being closed at its lower end, first and second packers carried on the outer tubing to seal off the well above and below the upper productive zone, first and second fluid port means through the walls of said outer tubing disposed above and below the lower packer, first and second sleeve valve means slidably mounted for limited axial movement on the inner walls of said outer tubing, said movement bringing said sleeve valve means into and out of register with said first and second fluid port means in said tubing, lock-

ing means carried by said first sleeve valve means and extending into the bores thereof for limiting the movement of said valve means, an annular member exteriorly affixed to the inner tubing and extending outwardly therefrom for contacting said locking means to open and close said valve means upon axial movement of said inner tubing in opposite directions, said annular member being adapted to actuate and pass through the first sleeve valve means and subsequently engage and actuate said second sleeve valve means, closure means in the annular space between said production tubings at a point intermediate said first and second port means, and an axial bore through said closure means in register with said inner production tubing.

5. Apparatus for use in a well having two vertically spaced productive zones, said apparatus comprising a pair of concentrically spaced production tubings extending into the well with the lower ends thereof positioned below the upper production zone, the outer production tubing being closed at its lower end, first and second packers carried on the outer tubing to seal off the well above and below the upper productive zone, first and second fluid port means through the walls of said outer tubing disposed above and below the lower packer, upper and lower spring-loaded sleeve valve means slidably mounted for limited axial movement on the inner walls of said outer tubing, said movement bringing said sleeve valve means into and out of register with said first and second fluid port means in said tubing, locking means carried by said upper valve means and extending into the bore thereof for limiting the movement of said valve means, a collar exteriorly affixed to the inner tubing and extending outwardly therefrom for contacting said locking means to open and close said upper valve means upon axial movement of said inner tubing in opposite directions, said collar being adapted to actuate and pass through the upper sleeve valve means and subsequently engage and actuate said lower sleeve valve means, closure means affixed to the top of the lower sleeve valve means for closing the annular space between said production tubings, an axial bore through said closure means in register with said inner production tubing, a shoe carried on the lower end of said inner production tubing and adapted to seat within the axial bore of said closure means, said lower

sleeve valve means being opened by axial movement of said inner tubing when said shoe is seated in said closure means.

6. Apparatus for use in a well having two vertically spaced productive zones, said apparatus comprising a pair of concentrically spaced production tubings extending into the well with the lower ends thereof positioned below the upper production zone, the outer production tubing being closed at its lower end, first and second packers carried on the outer tubing to seal off the well above and below the upper productive zone, first and second fluid port means through the walls of said outer tubing disposed above and below the lower packer, upper and lower sleeve valves slidably mounted for limited axial movement on the inner axial walls of said outer tubing, said movement bringing said sleeve valves into and out of register with said first and second fluid port means in said tubing, spring-loaded locking means carried by said upper sleeve valve to limit the movement of said valve, an annular member exteriorly affixed to the inner tubing and having a diameter greater than said tubing for contacting said locking means to open and close said upper valve upon axial movement of said inner tubing in opposite directions, said annular member being adapted to actuate and pass through the upper sleeve valve means and subsequently engage and actuate said lower sleeve valve means, closure means affixed to the top of the lower sleeve valve for closing the annular space between said production tubings at a point above said second port means, an axial bore through said closure means in register with said inner production tubing, an outwardly extending flange affixed to the lower sleeve valve, an annular recess in the inner wall of the outer tubing above said second port means, said flange being mounted for limited axial sliding movement within said recess, and spring means mounted in said recess and bearing against said flange for normally closing said lower sleeve valve, said valve being opened by axial movement of the lower end of the inner tubing thereagainst.

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