

March 7, 1950

C. J. COBERLY

2,499,357

TWO-ZONE PUMPING SYSTEM WITH CONTROL VALVE

Filed July 28, 1945

3 Sheets-Sheet 2

Fig. 3

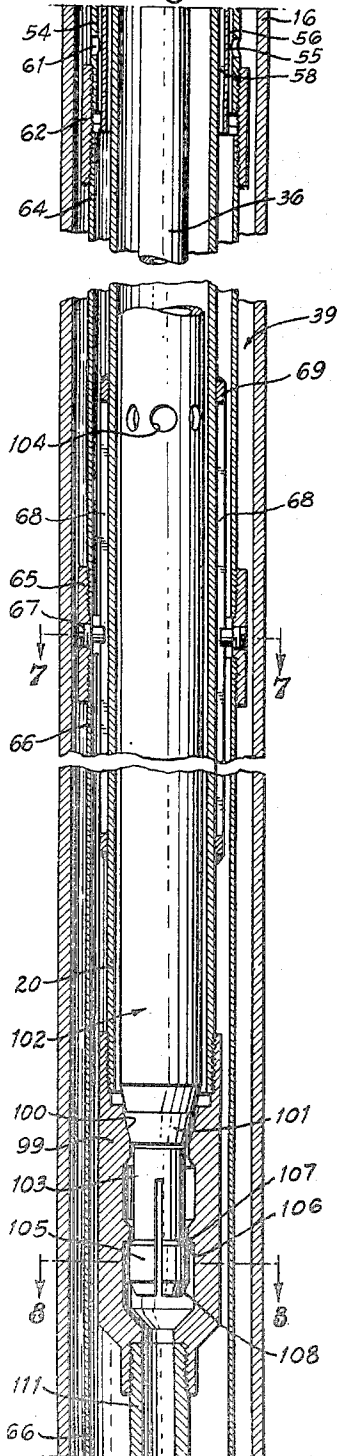


Fig. 4

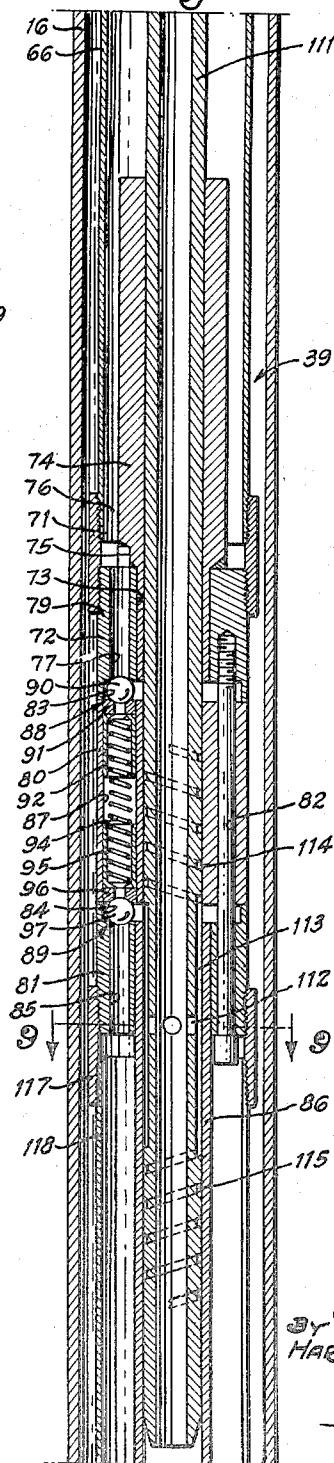
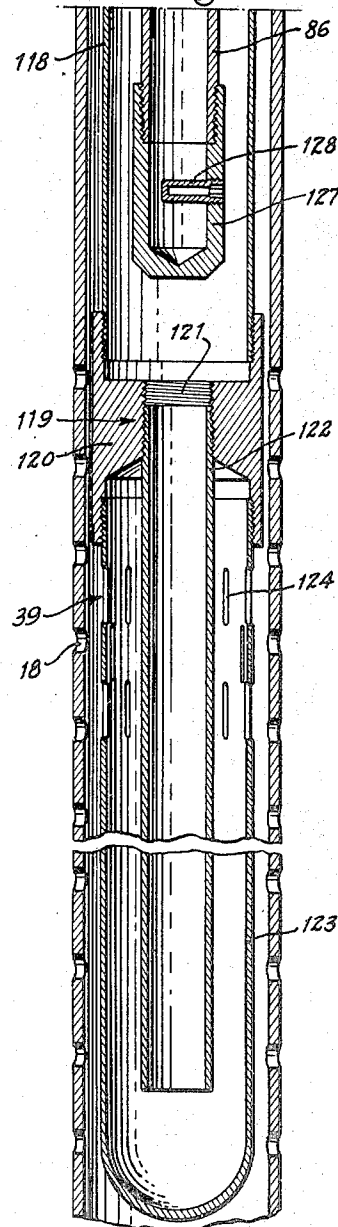


Fig. 5



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3 Sheets-Sheet 3

Fig. 10

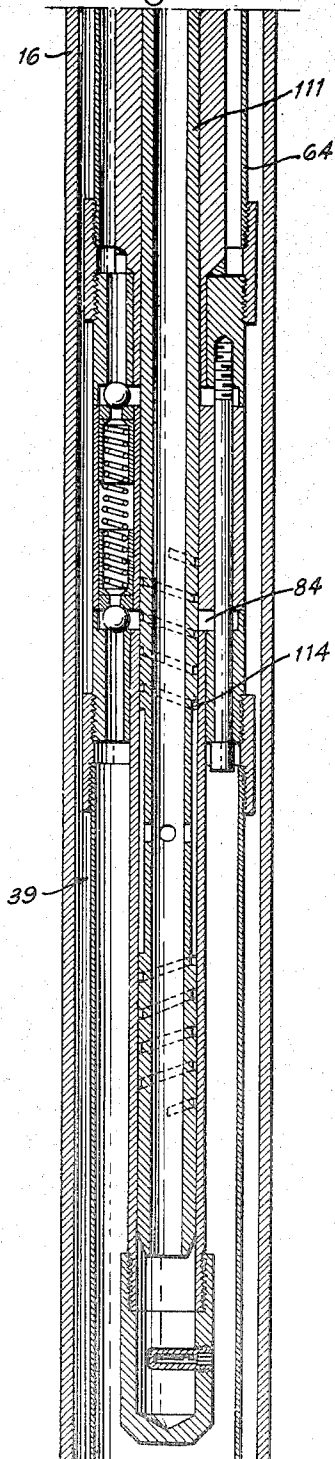


Fig. 11

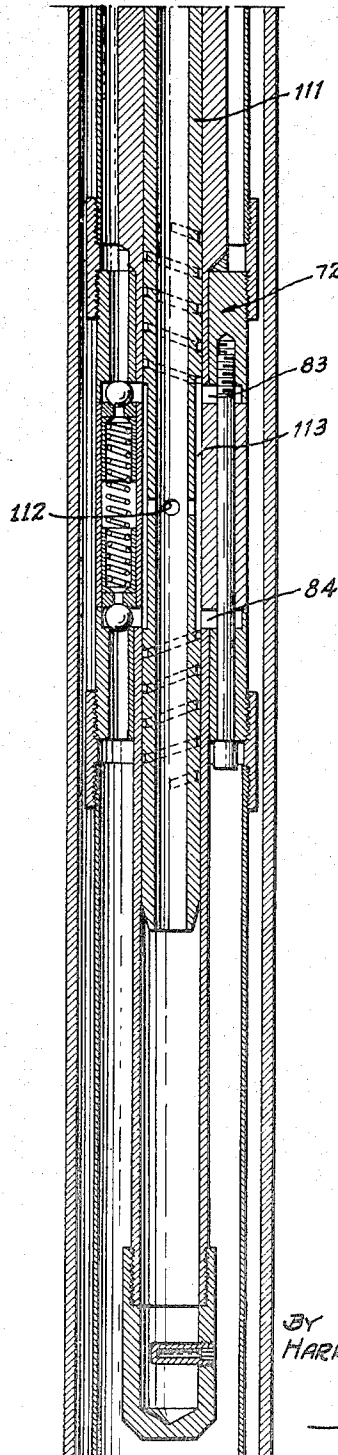
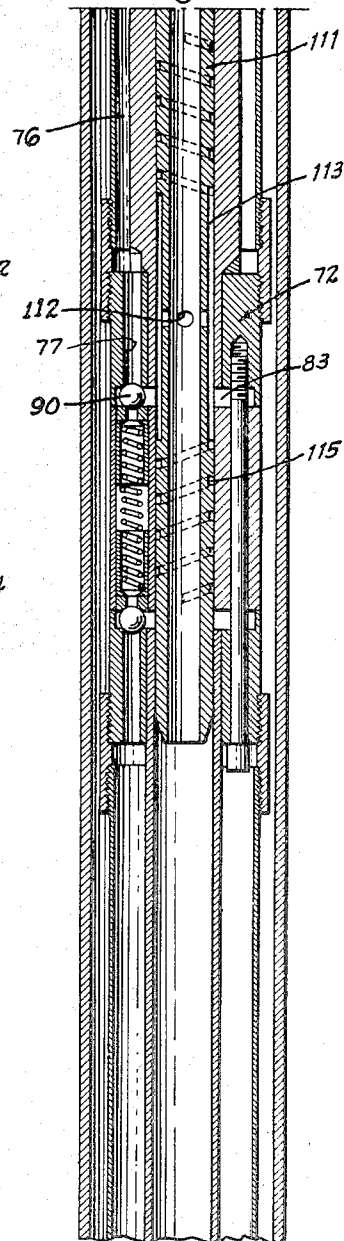


Fig. 12



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TWO-ZONE PUMPING SYSTEM WITH
CONTROL VALVEClarence J. Coberly, Los Angeles, Calif., assignor
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Application July 28, 1945, Serial No. 607,525

30 Claims. (Cl. 103—46)

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My invention relates to the well pumping art, and more particularly to a fluid-operated well pumping device adapted to alternatively pump oil from any one or more of a plurality of producing well strata in a well, as desired.

The invention is of particular utility in the oil industry in the production of oil wells and is particularly useful in combination with a fluid-operated well pump, and, consequently, it will be described in connection therewith, although it will be understood that the invention is susceptible of other uses and I do not intend to be limited to the specific embodiment disclosed and described herein.

Oil wells commonly include several independent strata from which oil may be produced. Usually when an oil well is drilled, it is intended to produce from a particular known stratum, although frequently there are other shallower producing strata in the well but of less desirable characteristics. For example, the shallower strata may be of low productibility, or the oil therefrom may be of inferior quality. Consequently, it is the usual practice to produce from the most desirable stratum until such time as it becomes uneconomical and then to close off such stratum and produce from an upper stratum of the well. Sometimes the oil from several strata is allowed to flow into and mix in the well, and the mixture is produced by pumping or otherwise. Such practices are often undesirable, and it is a primary object of my present invention to provide an apparatus by which several well strata may be separately but alternatively produced, preferably by pumping therefrom, so that the relative production from the several strata may be governed and controlled, as desired.

Another object of the invention is to provide an apparatus and method whereby the flow from several well strata may be mixed in desired proportions, so as to attain a mixture having predetermined characteristics, and then to pump the mixture to the surface of the well by suitable pumping means.

A further object of my invention is to provide a packer in a well between producing strata, separating the same into upper and lower production zones, providing valve means communicating with both zones, and providing a well tubing having an inlet adapted to cooperate with the valve means to connect selectively the inlet with either or both zones.

Other objects and advantages will be apparent from the following specification and the draw-

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ings, which are for the purpose of illustration only, and in which:

Fig. 1 is a diagrammatic view of my invention installed in a well.

Fig. 2 is an enlarged vertical view, partially in section, taken through the upper portion of my device.

Fig. 3 is an enlarged vertical sectional view taken through an intermediate portion of my device, and is a continuation downwardly of Fig. 2.

Fig. 4 is an enlarged vertical sectional view taken through an intermediate portion of my device, and is a continuation downwardly of Fig. 3.

Fig. 5 is an enlarged vertical sectional view taken through the lower portion of my device, and is a continuation downwardly of Fig. 4.

Fig. 6 is a cross-sectional view taken on the line 6—6 of Fig. 2.

Fig. 7 is a cross-sectional view taken on the line 7—7 of Fig. 3.

Fig. 8 is a cross-sectional view taken on the line 8—8 of Fig. 3.

Fig. 9 is a cross-sectional view taken on the line 9—9 of Fig. 4.

Fig. 10 is a vertical sectional view, similar to Fig. 4, but showing the parts in a second adjustment position.

Fig. 11 is a vertical sectional view, similar to Fig. 4, but showing the parts in a third adjustment position.

Fig. 12 is a vertical sectional view, similar to Fig. 4, but showing the parts in a fourth adjustment position.

Referring to the drawings, Fig. 1 shows an oil well 15 having a casing 16 set therein in the customary manner, the casing having perforations 17 disposed to register with an upper producing well stratum A, and having perforations 18 therein adapted to register with a lower producing well stratum B. The upper end of the casing 16 is provided with a casing head 19 through which a production tubing 20 extends downwardly into the well, passing through a well packer 22. Valve means 23 and timing means 24 are provided, for a purpose to be described hereinafter.

The specific construction of the casing head 19 forms no part of the present invention, being described in detail and covered in my copending application, Serial No. 607,524, filed on July 28, 1945, to which reference is hereby made. The casing head 19, however, includes a hydraulic jack mechanism 25, also specifically disclosed in my

above depending application, which supports the production tubing 20 for vertical movement relative to the casing 16. The hydraulic jack mechanism 25 is adapted to be supplied with operating fluid under relatively high pressure through a jack supply pipe 26 which is alternately connected to a high pressure supply tubing 27 through branch pipe 29 or to a discharge tubing 33 through a branch pipe 28, the branch pipes being provided with diaphragm type control valves 31 and 30, respectively, adapted to be actuated by suitable timing mechanism 24. The valve means 23, including the control valves 30 and 31, as will be understood alternatively connects the jack supply pipe 26 with the high pressure supply tubing 27 and with the discharge tubing 33. The discharge tubing 33 is connected, as by a suitable nipple 34, to the upper end of the hydraulic jack mechanism 25 so as to communicate with the upper end of the production tubing 20, the other end of the discharge tubing leading to a suitable point of use or disposal (not shown). The high pressure supply tubing 27, likewise, is connected by a suitable nipple 35 to the upper end of a high pressure tubing 36 which extends downwardly within the production tubing 20, the other end thereof being adapted to be connected to a suitable source of high pressure operating fluid (not shown), such as a triplex pump or the like. The high pressure supply tubing 27 and the discharge tubing 33 are preferably made of flexible material, as the hydraulic jack mechanism 25 raises and lowers the nipples 34 and 35, as will be described hereinafter.

The well packer 22, as shown in Fig. 2, is of any suitable type well known in the art, having a sealing means 37 forming a fluid-tight seal with the inner walls of the casing 16 and dividing the casing into an upper well zone 38 communicating through the perforations 17 with the upper producing well stratum A and a lower well zone 39 communicating through the perforations 18 with the lower producing well stratum B. The well packer 22 is retained in any desired position in the casing 16 by means of outwardly projecting slips 41, as is well known in the art, and is provided at its upper end with a collar 42 having a tubular extension 43 to which is threaded an upwardly projecting sleeve 44, which provides an annular space 45 around the production tubing 20. As will be noted, the sleeve 44 preferably extends upwardly into the upper well zone 38 to a point substantially above the uppermost level 46 of liquid in the upper well zone. The tubular extension 43 is provided at its lowermost portion with an annular groove 47 which communicates with a plurality of longitudinal passages 48 extending through the collar 42, as best shown in Fig. 6. The collar 42 is provided with an internal shoulder 50 on which seats an annular packing ring 51, preferably formed of resilient material, such as rubber, which is held in position by a follower ring 52 preferably press-fitted into the bore of the collar 42 to somewhat expand the ring 51 to form a fluid-tight seal with the exterior of the production tubing 20. The exterior of the follower ring 52 is relieved to form an annular passage 53 communicating between the longitudinal passages 48 and the annular space 45.

Also threadedly secured to the collar 42 is an outer tubular member 54 which extends downwardly through the well packer 22. Also threaded into the collar 42 is an inner tubular member 55 which is concentric with the outer tubular mem-

ber 54 but spaced therefrom to form an annular space 56 communicating with the lower ends of the longitudinal passages 48. As will be noted, the inner tubular member 55 is of larger diameter than the production tubing 20 so as to provide an annular space 58 therebetween, the upper end of which communicates through an annular groove 59 and a radial port 60 with the lower end of the upper well zone 38 below the liquid level 46. As will be noted in Fig. 3, the lower end of the inner tubular member 55 extends below the lower end of the outer tubular member 54, the lower end of the outer tubular member being provided with circumferentially spaced radial ports 61.

As shown in Fig. 3, the lower end of the outer tubular member 54 is connected through a suitable collar 62 to the upper end of an upper tube 64, the lower end of which is in turn connected by a stop collar 65 to a downward continuation 66 of the upper tube 64. As best shown in Figs. 3 and 7, the stop collar 65 is provided with a plurality of inwardly extending stop screws 67, the inner ends of which project into trackways 68 formed in guide members 69 suitably fixed, as by welding, longitudinally to the outer face of the production tubing 20, the trackways being closed at their upper and lower ends to cooperate with the stop screws 67 to limit vertical movement of the production tubing relative to the well packer 22.

As best shown in Fig. 4, the lower end of the continuation 66 of the upper tube 64 is connected by a suitable collar 71 to an upper valve plug 79 having a bore 73 in which is fixed, as by welding or otherwise, a sleeve 74 which extends upwardly within the continuation 66. The sleeve 74 is relieved at 75 to provide communication through an annular space 76 provided between the exterior of the sleeve and the interior of the continuation 66, and an upper valve passage 77 formed in the upper valve plug 79. The lower end of the upper valve plug 79 engages the upper end of a central valve plug 80, the lower end of which in turn engages a lower valve plug 81, the upper, central, and lower valve plugs forming a valve means 72 of the invention, being held in end-to-end relation by bolts 82 circumferentially spaced as best shown in Fig. 9.

The upper valve plug 79 is provided at its lower end with a valve chamber 83, and the lower valve plug 81 is provided at its upper end with a valve chamber 84, the latter communicating with a lower valve passage 85. The central valve plug 80 is provided with a plurality of circumferentially spaced longitudinal valve chambers 87 each of which is provided with an upper check valve 88 and a lower check valve 89. The upper check valve 88 includes a ball valve member 90 which, in the position shown in Fig. 4, is adapted to close the lower end of the upper valve passage 77, the ball valve member being seated on a supporting ring 91 which is axially movable in the valve chamber 87, the supporting ring being engaged by a follower cup 92. The ball valve member 90 is normally held in seated position to close the lower end of the upper valve passage 77 by the upper end of a compression spring 94, the lower end of which engages in a lower follower cup 95 which in turn engages a lower valve ring 96 engaging the upper face of a ball valve element 97 of the lower check valve 89 to normally retain the ball valve element in seated position and closing the upper end of the lower valve passage 85.

As shown in Fig. 3, the lower end of the pro-

duction tubing 20 is threaded into a tubular valve seat element 99 provided with a conical valve seat 100 in the upper portion thereof. The conical valve seat 100 is adapted to receive in seating relation the lower tapered end 101 of a fluid-operated pump unit 102 of any suitable type well known in the art, the fluid-operated pump unit having a pump inlet member 103 at the lower end thereof adapted to convey well fluid into the pump unit to be pumped thereby outwardly through suitable discharge ports 104 into the production tubing 20 through which the well fluid is pumped upwardly to the surface of the ground, the fluid-operated pumping unit being actuated by operating fluid under relatively high pressure supplied to it through the high pressure tubing 36 which is suitably connected thereto. The pump inlet member 103 is provided with an enlarged knob 105 at the lower end thereof adapted to engage beneath an annular shoulder 106 formed in the bore of the valve seat element 99, the knob 105 being provided with suitable beveled faces 107 and 108 to facilitate its passage past the shoulder 106, the knob also being split, as best shown in Fig. 8, to provide four spring fingers 110.

Threaded into the lower end of the tubular valve seat element 99 is a tubular selector valve element 111 extending downwardly therefrom and into and through the sleeve 74, making a relatively close sliding fit therewith, and also into a lower sleeve 86 secured in the lower valve plug 81 and with which it similarly makes a close sliding fit. The lower end of the tubular selector valve element 111 is provided with a plurality of circumferentially spaced radial ports 112 which communicate with an annular channel 113 formed on the periphery of the tubular selector valve element 111, the upper end of the annular channel being connected to an upper helical groove 114, and the lower end of the channel being connected to a lower helical groove 115. As will be noted, the helical groove 114 is reduced in cross-sectional area as it extends upwardly, and the helical groove 115 is reduced in cross-sectional area as it extends downwardly.

As shown in Fig. 4, the lower end of the lower valve plug 81 is threadedly connected by means of a collar 117 to a lower tube 118. As shown in Fig. 5, the lower tube 118 is threaded into the upper end of a gas anchor 119 which includes a collar 120 having a threaded bore 121 into which is threaded a cylindrical element 122 which extends downwardly to a point adjacent the lower end of a bull plug 123 also threaded to the collar 120, the upper end of the bull plug being provided with perforations 124. As will be understood, the perforations 124 communicate with the lower well zone 39. Also, as shown in Fig. 5, the lower end of the lower sleeve 86 is provided with a closure element 127 having a frangible plug 128 threaded into one wall thereof, the plug being adapted to be broken by a suitable weight dropped downwardly through the lower sleeve 86 to permit fluid within the sleeve to exhaust into the lower tube 118.

In installation, the well packer 22 is assembled on the lower end of the production tubing 20 so that the packer is supported on the production tubing by engagement of the stop screws 67 with the upper ends of the trackways 68. The production tubing, with the well packer 22 attached, is then lowered into the well, and the well packer 22 is set at a point between two producing well strata of the well, such as A and B, as shown in

Fig. 1. The manner of setting the well packer at the desired point in the well is well known in the art, and therefore is not described herein. The fluid-operated pump unit 102 with its high pressure tubing 36 may be assembled in the production tubing 20, in the position shown in Fig. 3, before the production tubing is lowered into the well, or, if desired, the production tubing with the well packer 22 attached may be first lowered into the well and the pump may later be lowered through the production tubing into the seated position shown in Fig. 3. This, obviously, is a matter of choice with the operator.

In operation, if it is desired to pump at full capacity from the lower well zone 39, the production tubing 20 is vertically positioned relative to the well packer 22, as is shown in Figs. 2 to 5, inclusive, of the drawings, which position may be termed a first operating position. As will be noted, in the first operating position the annular channel 113 on the tubular selector valve element 111 registers directly with the lower valve chamber 84, but does not register with the upper valve chamber 83. Well liquid from the lower zone 39 flows through the perforations 124 of the bull plug 123 and downwardly therein and around the cylindrical element 122, passing to the lower end of the cylindrical element and upwardly therethrough into the lower tube 118, and any gas liberated from the well liquid in the bull plug tends to rise upwardly around the element 122 and discharge back into the lower well zone through the perforations 124, acting as a gas anchor. Such well liquid in the element 122 flows upwardly through the lower tube 118 and through the lower valve passages 85, raising the ball valve elements 97 from their seats in the upper ends of the valve passages and against the action of the compression springs 94 to permit the well liquid to flow into the lower valve chamber 84 and thence into the annular channel 113 on the tubular selector valve element 111. Well liquid in the annular channel 113 flows radially inwardly through the radial ports 112 into the tubular valve element 111 and upwardly therethrough into the tubular selector valve seat element 99, from which it may be lifted by the fluid-operated pump unit 102 and discharged therefrom through the discharge ports 104 into the production tubing 20 to be pumped upwardly to the surface of the ground. The pumped liquid discharges through the nipple 34 into the discharge tubing 33, through which it is carried to a suitable point of disposal or use. The fluid-operated pump unit 102 is actuated by operating fluid under high pressure delivered thereto through the high pressure supply tubing 27, the nipple 35, and the high pressure tubing 36, in a manner well known in the art. Thus, when the parts are in the first operating position, as described, well liquid is pumped only from the lower well zone 39, but the communication therewith is wide open so that the fluid-operated pump unit 102 may pump at its full rated capacity.

If it is desired to reduce the production rate from the lower well zone 39, without decreasing the operating capacity of the fluid-operated pump unit 102, the production tubing is lowered so as to lower the tubular selector valve element 111 to the position shown in Fig. 10, which may be termed a second operating position. In the second operating position, as will be noted, the upper helical groove 114 on the periphery of the tubular selector valve element 111 registers with the lower valve chamber 84, and since the helical groove

is relatively small in cross-sectional area, only a relatively small volume of flow of well liquid can be produced through the helical groove. Since the cross-sectional area of the helical groove 114 is reduced as it extends upwardly, production from the lower well zone 39 may be varied within desired limits by varying the point of registry of the upper helical groove 114 with the lower valve chamber 84.

When it is desired to pump well liquid solely from the upper well zone 38, the production tubing 20 is raised relative to the well packer 22 so as to raise the tubular selector valve element 111 relative to the tubular valve element 72 to the position shown in Fig. 12, in which the annular channel 113 on the periphery of the tubular selector valve element 111 registers directly with the upper valve chamber 83. This may be termed a third operating position of the device. Well liquid from the upper well zone 38 then flows inwardly through the radial port 60 and downwardly through the annular space 58 into the upper tube 64, through which it passes downwardly around the production tubing 20, the tubular valve seat element 99, and the tubular selector valve element 111 into the annular space 76, flowing therefrom downwardly through the upper valve passages 77 to force downwardly the ball valve members 90 to permit the well liquid to pass into the upper valve chamber 83, from whence it passes through the annular channel 113 into the tubular selector valve element 111 through the radial ports 112 and is pumped to the surface of the ground, as hereinabove described. As will be understood, in the third operating position full production may be had from the upper well zone 38. As will also be understood, by further raising the production tubing 20 and the tubular selector valve element 111 relative to the tubular valve element 72, the lower helical groove 115 may be brought into registry with the upper valve chamber 83 to reduce the production flow, as desired, from the upper well zone 38 by reason of the reduced cross-sectional area of the helical groove 115.

When it is desired to pump well liquid from both the upper well zone 38 and the lower well zone 39 simultaneously, the production tubing is moved relative to the well packer 22 so as to position the tubular selector valve element 111 relative to the tubular valve element 72, as shown in Fig. 11, which may be termed a fourth operating position. In the fourth operating position, the annular channel 113 spans both the upper valve chamber 83 and the lower valve chamber 84 so that well liquid from both the upper and lower well zones 38 and 39 may be simultaneously drawn into the annular channel 113 and through the radial ports 112 into the interior of the tubular selector valve element 111, in which it mixes to a certain extent, to be pumped upwardly as a mixture to the surface of the ground by the fluid-operated pump unit 102. Thus, well fluid may be produced from both the upper and lower well zones simultaneously when the parts are in the fourth operating position described, which is an important feature in some well installations.

Various other operating positions may be attained, if desired, by adjustment of the vertical position of the tubular selector valve element 111 relative to the tubular valve element 72. For example, it may be desired to produce a full capacity production from one zone and simultaneously mix therewith a relatively small production from the other zone. This is readily accomplished by positioning the tubular selector valve element 111 so

that the annular channel 113 communicates directly with one of the valve chambers 83 or 84 but so that only one of the sets of helical grooves 114 or 115 communicates with the other valve chamber, thus permitting full production from the one zone while throttling the production from the other. In this manner liquid from the upper and lower well zones may be mixed in any desired proportions before being pumped to the surface of the ground, which is a valuable feature of the invention where the liquids in the two well zones differ widely in characteristics.

To raise or lower the production tubing 20 relative to the well packer 22, the hydraulic jack mechanism 25 is operated by admitting fluid under pressure thereto or permitting the same to discharge therefrom, as will be understood by those skilled in the art. When it is desired to raise the production tubing 20, operating fluid under high pressure is permitted to pass through the branch pipe 29 and the jack supply pipe 26 to the hydraulic jack mechanism 25, the control valve 31 being open and the control valve 30 being closed by the valve means 23. The valve means 23 may be operated alternatively in a predetermined sequence by the timing means 24, which may be of any suitable type well known in the art. Similarly, when it is desired to lower the production tubing 20 relative to the well packer 22, operating fluid in the hydraulic jack mechanism 25 is allowed to exhaust therefrom through the jack pipe 26 and the branch pipe 28 into the discharge tubing 33, the control valve 31 being closed and the control valve 30 being open. The timing means 24 may be omitted, if desired, and the valve means 23 controlled manually.

As shown in Figs. 3 and 2, the upper end of the upper tube 64 is at all times in open communication with the upper well zone at a point above the liquid level 46 therein through the annular space 56, the longitudinal passages, and the annular space 45 of the sleeve 44. This is to permit gas accumulating in the upper end of the upper tube 64 to discharge therefrom, thus preventing the accumulation of gas in the tube 64. The upper end of the lower well zone 39 also communicates directly through the radial ports 61 with the annular space 56 to permit gas to discharge from the upper end of the lower well zone.

The fluid-operated pump unit 102 may be separately removed from the production tubing 20 by raising the high pressure tubing 36, the spring fingers 110 being pressed inwardly by the engagement of the beveled face 107 with the shoulder 106 to free the pump inlet member 103 from engagement with the tubular valve seat element 99. This permits the fluid-operated pump unit 102 to be separately removed from the production tubing 20 for replacement or repair. Removal of the production tubing 20 from the well may be accomplished readily by simply raising the same upwardly until the stop screws 67 engage the lower ends of the trackways 68, further movement of the production tubing exerting an upward thrust on the well packer 22 to release the same from engagement with the casing 16, so that the well packer 22 is removed from the well with the production tubing, as is well known in the art. Since the production tubing may be filled with well liquid when it is desired to remove the same, it is frequently desirable to first remove the fluid-operated pump unit 102, as described above, following which a weight may be dropped downwardly through the production tubing to pass through the tubular selector valve element 111

and break off the frangible plug 128, thus permitting the well liquid in the production tubing to drain downwardly therefrom and outwardly through the opening formed by the breaking of the frangible plug, following which the production tubing may be raised without also raising the well liquid normally therein.

Although I have shown and described a preferred embodiment of my invention, it will be understood that certain parts and elements thereof are merely representative of other parts and elements which may be substituted therefor without the exercise of invention, and consequently I do not intend to be limited to the embodiment shown, but desire to be afforded the full scope of the following claims.

I claim as my invention:

1. In a fluid-operated well pumping device, the combination of: packer means adapted to be set in a well between an upper and a lower producing well stratum so as to separate the well into an upper well zone communicating with said upper stratum and a lower well zone communicating with said lower stratum; fluid-operated pumping means associated with said packer means and having a pump inlet, said pumping means being adapted to pump well liquid upwardly through said well; and means communicating between said pump inlet and said zones for opening communication between said pump inlet and either of said zones alternatively or both of said zones simultaneously in response to relative movement between said pump and said packer.

2. In a fluid-operated well pumping device, the combination of: packer means adapted to be set in a well between an upper and a lower producing well stratum so as to separate the well into an upper well zone communicating with said upper stratum and a lower well zone communicating with said lower stratum; fluid-operated pumping means associated with said packer means and having a pump inlet, said pumping means being adapted to pump well liquid from said port and upwardly through said tubing; and means between said pump inlet and said zones for opening communication between said pump inlet and either of said zones alternatively or both of said zones simultaneously, including means constructed and arranged so that communication may be opened between said pump inlet and both of said zones in any desired relative proportion in response to relative movement between said pump and said packer.

3. In a fluid-operated well pumping device, the combination of: packer means adapted to be set in a well between an upper and a lower producing well stratum so as to separate the well into an upper well zone communicating with said upper stratum and a lower well zone communicating with said lower stratum; a tubing adapted to extend downwardly into said well and having an inlet port; fluid-operated pumping means in said tubing and having a pump inlet communicating with said inlet port, said pump being adapted to pump well liquid from said port upwardly through said tubing; and means for opening communication between said inlet port and either of said zones alternatively or both of said zones simultaneously.

4. In a fluid-operated well pumping device, the combination of: packer means adapted to be set in a well between an upper and a lower producing well stratum so as to separate the well into an upper well zone communicating with said

upper stratum and a lower well zone communicating with said lower stratum; a tubing adapted to extend downwardly into said well and having an inlet port; fluid-operated pumping means in said tubing and having a pump inlet communicating with said inlet port, said pump being adapted to pump well liquid from said port and upwardly through said tubing; means for opening communication between said inlet port and either of said zones alternatively or both of said zones simultaneously in response to movement of said tubing relative to said packer means; and means for so moving said tubing.

5. In a fluid-operated well pumping device, the combination of: packer means adapted to be set in a well between an upper and a lower producing well stratum so as to separate the well into an upper well zone communicating with said upper stratum and a lower well zone communicating with said lower stratum; a tubing adapted to extend downwardly into said well and having an inlet port; fluid-operated pumping means in said tubing and having a pump inlet communicating with said inlet port, said pump being adapted to pump well liquid from said port and upwardly through said tubing; means for opening communication between said inlet port and either of said zones alternatively or both of said zones simultaneously in response to vertical movement of said tubing relative to said packer means; and means for so moving said tubing vertically.

6. In a fluid-operated well pumping device, the combination of: packer means adapted to be set in a well between an upper and a lower producing well stratum so as to separate the well into an upper well zone communicating with said upper stratum and a lower well zone communicating with said lower stratum; a tubing adapted to extend downwardly into said well and having an inlet port; fluid-operated pumping means in said tubing and having a pump inlet communicating with said inlet port, said pump being adapted to pump well liquid from said port and upwardly through said tubing; means for opening communication between said inlet port and either of said zones alternatively or both of said zones simultaneously in response to vertical movement of said tubing relative to said packer means; means for so moving said tubing vertically; and stop means between said tubing and said packer means and adapted to limit vertical movement of said tubing relative to said packer means.

7. In a fluid-operated well pumping device, the combination of: packer means adapted to be set in a well between an upper and a lower producing well stratum so as to separate the well into an upper well zone communicating with said upper stratum and a lower well zone communicating with said lower stratum; a tubing adapted to extend downwardly into said well and having an inlet port; fluid-operated pumping means in said tubing and having a pump inlet communicating with said inlet port, said pump being adapted to pump well liquid from said port and upwardly through said tubing; connecting means between said tubing and said packer means for opening communication between said inlet port and said upper well zone when said tubing is in a first position relative to said packer means, and opening communication between said inlet port and said lower well zone when said tubing is in a second position relative to said packer means, and opening communication between said

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inlet port and both of said zones when said tubing is in a third position relative to said packer means; and means for selectively moving said tubing relative to said packer means to any of said positions.

8. In a well pumping device, the combination of: packer means adapted to be set in a well between an upper and a lower producing well stratum so as to separate the well into an upper well zone communicating with said upper stratum and a lower well zone communicating with said lower stratum; a tubing adapted to extend downwardly into the well and having an inlet port; pumping means in said tubing having a pump inlet communicating with said inlet port, said pump being adapted to pump well liquid from said port and upwardly through said tubing; and means for opening communication between said inlet port and either of said zones alternatively or both of said zones simultaneously.

9. In a well pumping device, the combination of: packer means adapted to be set in a well between an upper and a lower producing well stratum so as to separate the well into an upper well zone communicating with said upper stratum and a lower well zone communicating with said lower stratum; a tubing adapted to extend downwardly into the well and having an inlet port; pumping means in said tubing having a pump inlet communicating with said inlet port, said pump being adapted to pump well liquid from said port and upwardly through said tubing; means for opening communication between said inlet port and either of said zones alternatively or both of said zones simultaneously in response to vertical movement of said tubing relative to said packer means; and means for so moving said tubing vertically.

10. In a well apparatus, the combination of: packer means adapted to be set in a well between an upper and a lower producing well stratum so as to separate the well into an upper well zone communicating with said upper stratum and a lower well zone communicating with said lower stratum; a tubing adapted to extend downwardly into the well and having an inlet port; and means for opening communication between said inlet port and either of said zones alternatively or both of said zones simultaneously.

11. In a well apparatus, the combination of: packer means adapted to be set in a well between an upper and a lower producing well stratum so as to separate the well into an upper well zone communicating with said upper stratum and a lower well zone communicating with said lower stratum; a tubing adapted to extend downwardly into the well and having an inlet port; and means for opening communication between said inlet port and either of said zones alternatively or both of said zones simultaneously, including means constructed and arranged so that communication may be opened between said inlet port and both of said zones in any desired relative proportion.

12. In a well apparatus, the combination of: packer means adapted to be set in a well between an upper and a lower producing well stratum so as to separate the well into an upper well zone communicating with said upper stratum and a lower well zone communicating with said lower stratum; a tubing adapted to extend downwardly into the well and having an inlet port; first passage means communicating with said upper well zone; second passage means communicating with said lower well zone; first

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check valve means in said first passage adapted to permit a flow of fluid from said upper well zone through said passage but preventing a reverse of flow of fluid; second check valve means in said second passage adapted to permit a flow of fluid from said lower well zone through said passage but preventing a reverse flow of fluid; and means for opening communication between said inlet port and either of said passages alternatively.

13. In a fluid-operated well pumping device, the combination of: packer means adapted to be set in a well between an upper and a lower producing well stratum so as to separate the well into an upper well zone communicating with said upper stratum and a lower well zone communicating with said lower stratum; fluid-operated pumping means associated with said packer means and having a pump inlet, said pumping means being adapted to pump well liquid upwardly through said well; means communicating between said pump inlet and said zones for opening communication between said pump inlet and either of said zones alternatively or both of said zones simultaneously in response to relative movement between said pump and said packer; and passage means providing communication between the upper end of said lower well zone and said upper well zone at a point above the liquid level therein for the exhaust of gas from said lower well zone.

14. In a well pumping device, the combination of: packer means adapted to be set in a well between an upper and a lower producing well stratum so as to separate the well into an upper well zone communicating with said upper stratum and a lower well zone communicating with said lower stratum; a tubing adapted to extend downwardly into the well and having an inlet port; pumping means in said tubing having a pump inlet communicating with said inlet port; means for opening communication between said inlet port and either of said zones alternatively or both of said zones simultaneously; and passage means providing communication between the upper end of said lower well zone and said upper well zone at a point above the liquid level therein for the exhaust of gas from said lower well zone.

15. In a well apparatus, the combination of: packer means adapted to be set in a well between an upper and a lower producing well stratum so as to separate the well into an upper well zone communicating with said upper stratum and a lower well zone communicating with said lower stratum; a tubing adapted to extend downwardly into the well and having an inlet port; means for opening communication between said inlet port and either of said zones alternatively or both of said zones simultaneously; and passage means providing communication between the upper end of said lower well zone and said upper well zone at a point above the liquid level therein for the exhaust of gas from said lower well zone.

16. In a well pumping device, the combination of: packer means adapted to be set in a well between an upper and a lower producing well stratum so as to separate the well into an upper well zone communicating with said upper stratum and a lower well zone communicating with said lower stratum; an outer tubular member fixed relative to and extending downwardly below said packer means into said lower well zone; a tubing extending downwardly through said packer means and into said outer tubular member so as to form a longitudinal space therebetween, said tubing

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having an inlet port, the upper end of said space communicating with said upper well zone and the lower end of said space communicating with said lower well zone; pumping means in said tubing and having a pump inlet communicating with said inlet port, said pump being adapted to pump well liquid from said port and upwardly through said tubing; means for opening communication between said inlet port and the upper end of said space when said tubing is in a first vertical position relative to said tubular member and with the lower end of said space when said tubing is in a second vertical position relative to said tubular member; and means for selectively moving said tubing vertically to either of said positions.

17. In a well pumping device, the combination of: packer means adapted to be set in a well between an upper and a lower producing well stratum so as to separate the well into an upper well zone communicating with said upper stratum and a lower well zone communicating with said lower stratum; an outer tubular member fixed relative to and extending downwardly below said packer means into said lower well zone; a tubing extending downwardly through said packer means and into said outer tubular member so as to form a longitudinal space therebetween, said tubing having an inlet port, the upper end of said space communicating with said upper well zone and the lower end of said space communicating with said lower well zone; pumping means in said tubing and having a pump inlet communicating with said inlet port, said pump being adapted to pump well liquid from said port and upwardly through said tubing; means for opening communication between said inlet port and the upper end of said space when said tubing is in a first vertical position relative to said tubular member and with the lower end of said space when said tubing is in a second vertical position relative to said tubular member; and means for selectively moving said tubing vertically to either of said positions. said pump inlet being a substantial distance below the upper level of liquid in said lower well zone when said tubing is in its uppermost said position.

18. In a well pumping device, the combination of: packer means adapted to be set in a well between an upper and a lower producing well stratum so as to separate the well into an upper well zone communicating with said upper stratum and a lower well zone communicating with said lower stratum; an outer tubular member fixed relative to and extending downwardly below said packer means into said lower well zone; a tubing extending downwardly through said packer means and into said outer tubular member so as to form a longitudinal space therebetween, said tubing having an inlet port, said space communicating with the lower end of said upper well zone to permit liquid in said upper well zone to flow into said space, the upper end of said space also separately communicating with said upper well zone at a point above the uppermost liquid level in said upper well zone to permit gas in the upper end of said space to discharge into said upper well zone; pumping means in said tubing and having a pump inlet communicating with said inlet port, said pump being adapted to pump well liquid from said port and upwardly through said tubing; means for opening communication between said inlet port and the upper end of said space when said tubing is in a first vertical position relative to said tubular member and with the lower end of said space when said tubing is in a second vertical position relative to said tubular member; 75

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and means for selectively moving said tubing vertically to either of said positions.

19. In a well pumping device, the combination of: packer means adapted to be set in a well between an upper and a lower producing well stratum so as to separate the well into an upper well zone communicating with said upper stratum and a lower well zone communicating with said lower stratum; an outer tubular member fixed relative to and extending downwardly below said packer means into said lower well zone; a tubing extending downwardly through said packer means and into said outer tubular member so as to form a longitudinal space therebetween, said tubing having an inlet port, said space communicating with the lower end of said upper well zone to permit liquid in said upper well zone to flow into said space, the upper end of said lower well zone communicating with said upper well zone at a point above the uppermost liquid level in said upper well zone to permit gas in the upper end of said lower well zone to discharge into said upper well zone; pumping means in said tubing and having a pump inlet communicating with said inlet port, said pump being adapted to pump well liquid from said port and upwardly through said tubing; means for opening communication between said inlet port and the upper end of said space when said tubing is in a first vertical position relative to said tubular member and with the lower end of said space when said tubing is in a second vertical position relative to said tubular member; and means for selectively moving said tubing vertically to either of said positions.

20. In a well pumping device, the combination of: packer means adapted to be set in a well between an upper and a lower producing well stratum so as to separate the well into an upper well zone communicating with said upper stratum and a lower well zone communicating with said lower stratum; an upper tubular member secured to said packer means and extending downwardly therefrom, the interior of said tubular member communicating with said upper well zone; an annular collar secured to the lower end of said tubular member and having a longitudinal bore, said collar including a first passage communicating between a first port in said bore and the interior of said tubular member, and including a second passage communicating between a second port in said bore and the lower end of said collar; a lower tubular member secured to the lower end of said collar and extending downwardly therefrom into said lower well zone; gas anchor means connected to the lower end of said lower tubular member and adapted to permit a flow of well liquid from said lower well zone into said lower tubular member; a tubing extending downwardly through the well and through said packer means, said tubing having a pump seat in the lower end thereof; a tubular inlet element secured to the lower end of said tubing and extending downwardly into said bore, said inlet element having an inlet port adapted to register with either said first or second ports in response to movement of said inlet element relative to said collar; pumping means in said tubing and adapted to seat on said pump seat, said pumping means having a pump inlet communicating with said inlet port, said pump being adapted to pump well liquid from said port and upwardly through said tubing; and means for moving said tubing so as to move said inlet element relative to said collar to register said inlet port with said first or second port as desired.

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21. In a well producing device, the combination of: means for mixing in a well the production flow from a plurality of producing well strata so as to attain a flow mixture having predetermined characteristics; means for controlling the relative proportions of the production flows of said mixture; and means for pumping said mixture to the surface of the ground.

22. In a well producing device, the combination of: means for mixing in a well the production flow from a plurality of producing well strata so as to attain a flow mixture having predetermined characteristics; adjustable controlling means for controlling the relative proportions of the production flows of said mixture; means for adjusting said controlling means from the surface of the ground; and means for pumping said mixture to the surface of the ground.

23. In a well pumping device, the combination of: packer means adapted to be set in a well between an upper and a lower producing well stratum so as to separate the well into an upper well zone communicating with said upper stratum and a lower well zone communicating with said lower stratum; a tubing adapted to extend downwardly into the well and having an inlet port; pumping means associated with said tubing and having a pump inlet communicating with said inlet port, and having a pump outlet communicating with the interior of said tubing above said inlet port, said pumping means being adapted to pump well liquid from said inlet port into and upwardly through said tubing; and means for opening communication between said inlet port and either of said zones alternatively or both of said zones simultaneously in response to relative movement between said packer means and said tubing.

24. In a well pumping device, the combination of: packer means adapted to be set in a well between an upper and a lower producing well stratum so as to separate the well into an upper well zone communicating with said upper stratum and a lower well zone communicating with said lower stratum; pumping means associated with said packer means and having a pump inlet, said pumping means being adapted to pump well liquid upwardly through said well; valve means operatively connected to said pumping means, said valve means being operable in response to vertical movement of said pumping means to connect selectively said pump inlet with said upper well zone, with said lower well zone, or with both of said zones in desired proportions; and means for moving said pumping means vertically.

25. In a well pumping device, the combination of: packer means adapted to be set in a well between upper and lower well-fluid-producing strata thereof to separate the well into upper and lower zones respectively communicating with said upper and lower producing strata; pumping means adapted to be set in the well and having an inlet, said pumping means being adapted to pump well fluid from said inlet upwardly in the well to the surface; selector valve means disposed adjacent said packer means for connecting said inlet in fluid communication with either of said zones of the well independently of the other, or with both of said zones simultaneously; and means for actuating said selector valve means.

26. In a well pumping device, the combination of: packer means adapted to be set in a well between upper and lower well-fluid-producing strata thereof to separate the well into upper

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and lower zones respectively communicating with said upper and lower producing strata; pumping means associated with said packer means and having an inlet, said pumping means being adapted to pump well fluid from said inlet upwardly in the well to the surface; selector valve means for connecting said inlet in fluid communication with either of said zones of the well independently of the other, or with both said zones simultaneously; and fluid-operated means for actuating said selector valve means.

27. In a fluid-operated well pumping device, the combination of: packer means set in a well between upper and lower well-fluid-producing strata thereof and separating the well into upper and lower zones respectively communicating with said upper and lower producing strata; power and production tubing means set in the well and respectively adapted to convey operating fluid under pressure downwardly into the well and fluid upwardly therefrom; fluid-operated pumping means disposed in the well and provided with an intake for operating fluid under pressure, an inlet for well fluid, and an outlet, said intake communicating with said power tubing means to admit operating fluid under pressure into said pumping means to operate it, and said outlet communicating with said production tubing means to discharge fluid from said pumping means into said production tubing means; selector valve means for providing fluid communication between said inlet and either of said zones independently of the other, or both of said zones simultaneously; and fluid-operated means for actuating said selector valve means.

28. In a fluid-operated well pumping device, the combination of: packer means set in a well between upper and lower well-fluid-producing strata thereof and separating the well into upper and lower zones respectively communicating with said upper and lower producing strata; power and production tubings set in the well and respectively adapted to convey operating fluid under pressure downwardly into the well and fluid upwardly therefrom, at least one of said tubings being movable vertically in the well; fluid-operated pumping means disposed in the well and provided with an intake port for operating fluid under pressure, an inlet port for well fluid, and a discharge port, said intake port communicating with said power tubing to admit operating fluid under pressure into said pumping means to operate it, and said discharge port communicating with said production tubing to discharge fluid from said pumping means into said production tubing; selector valve means movable vertically in the well to provide fluid communication between said inlet port and either of said zones independently of the other, or both of said zones simultaneously, said selector valve means being operatively connected to said one tubing so as to be movable vertically therewith; and means connected to said one tubing for moving said one tubing and said selector valve means vertically.

29. A well pumping device as defined in claim 28, wherein said pumping means is carried by said one tubing.

30. In a well pumping device, the combination of: packer means adapted to be set in a well between upper and lower well-fluid-producing strata thereof to separate the well into upper and lower zones respectively communicating with said upper and lower producing strata; pumping means adapted to be set in the well

and having an inlet, said pumping means being adapted to pump well fluid from said inlet upwardly in the well to the surface; selector valve means disposed adjacent said packer means for connecting said inlet in fluid communication with either of said zones of the well independently of the other, or with both of said zones simultaneously; and operating means operable from the surface of the ground and extending from the surface downwardly through the well and operatively connected to said selector valve means for actuating said selector valve means.

CLARENCE J. COBERLY.

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Certificate of Correction

Patent No. 2,499,357

March 7, 1950

CLARENCE J. COBERLY

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows:

Column 6, line 46, strike out the word "selector" and insert the same before "valve" in line 45, same column; column 9, lines 44 and 45, for "from said port and upwardly through said tubing" read *upwardly through said well*; line 46, before "between" insert *communicating*; column 12, line 4, strike out "of" before "flow"; column 14, line 39, for "communicating" read *communicating*;

and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 27th day of June, A. D. 1950.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.