GAS LIFTING DUALLY-COMPLETED WELLS

Filed Feb. 14, 1955 5 Sheets-Sheet 1

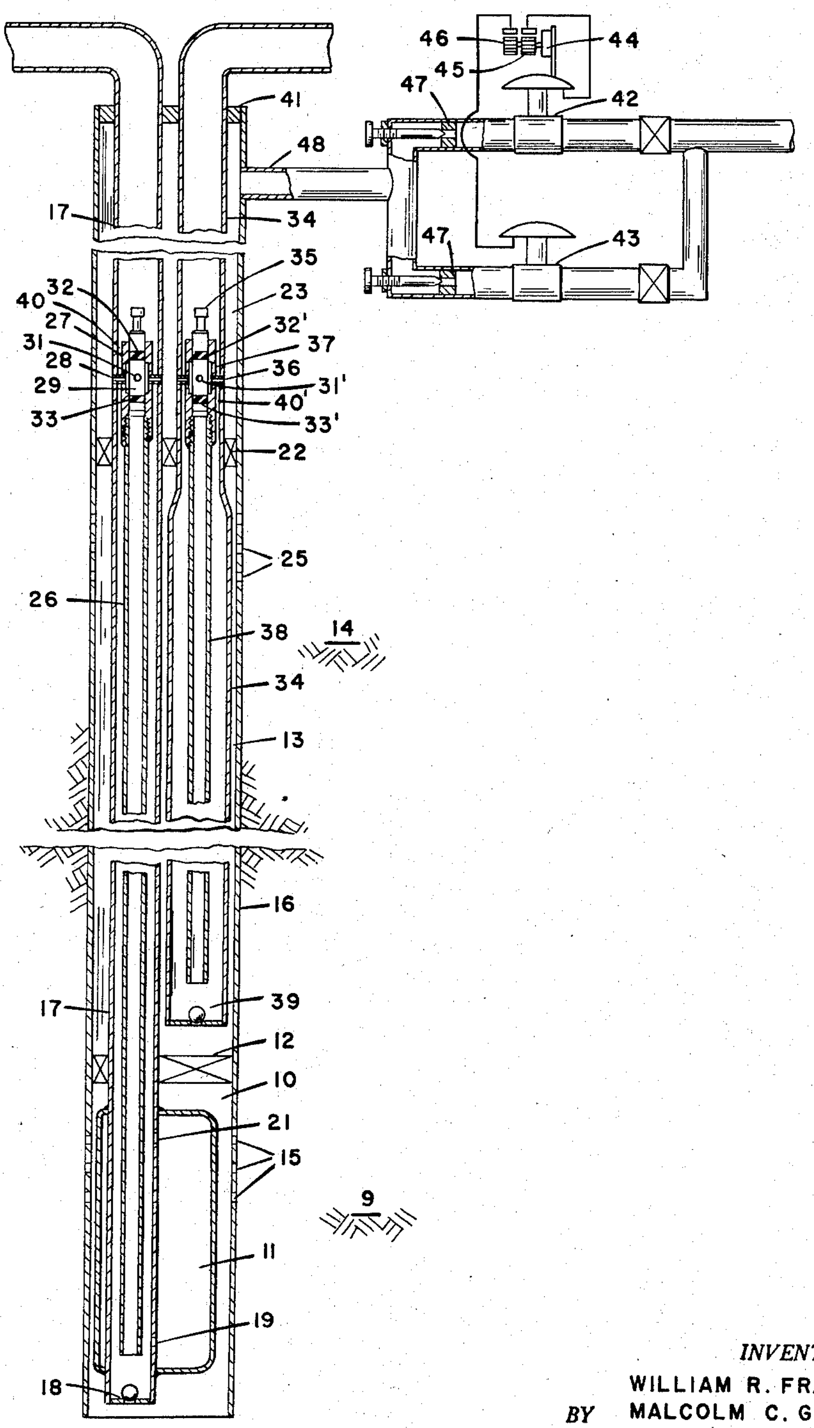

FIG. 1

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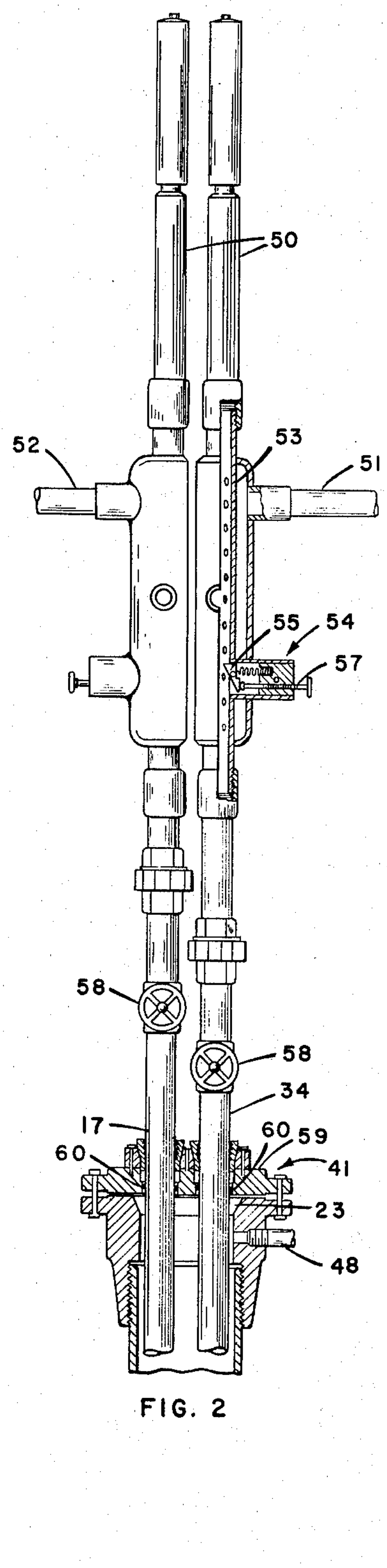

FIG. 2

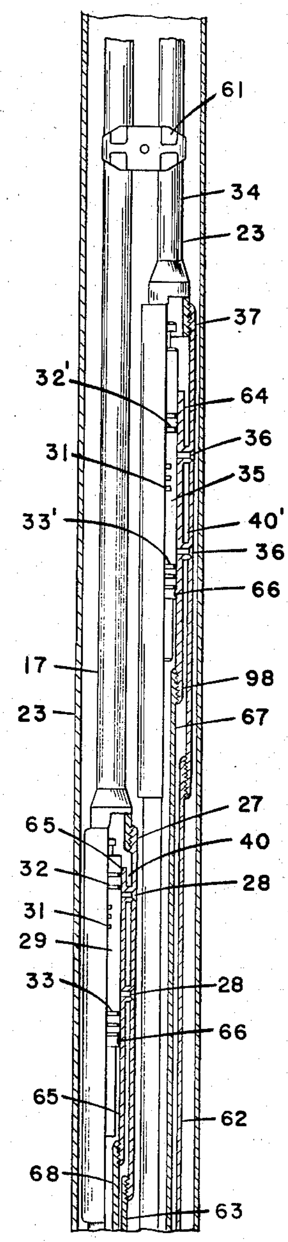

FIG. 3

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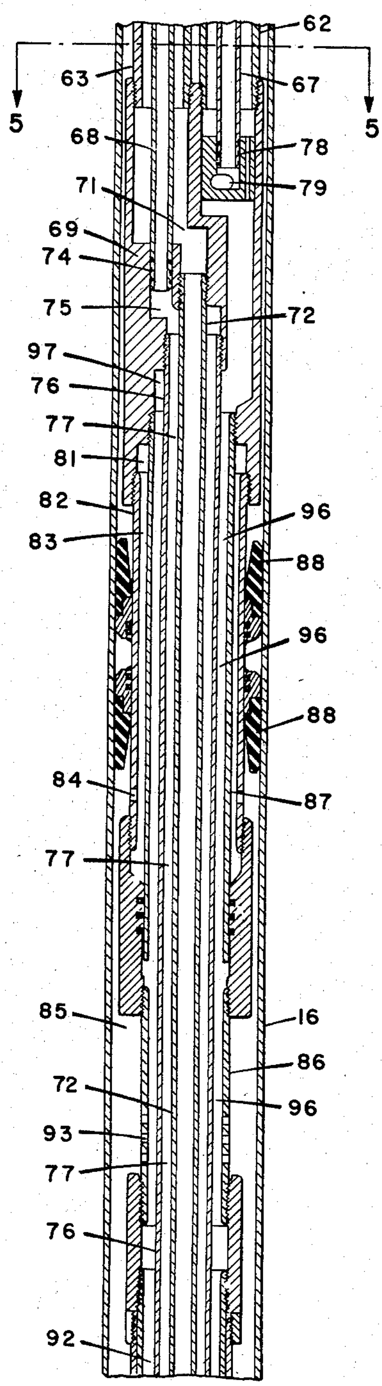

FIG. 4

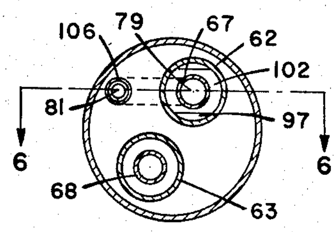

FIG. 5

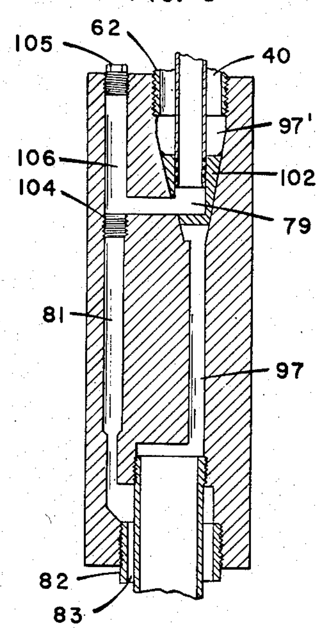

FIG. 6

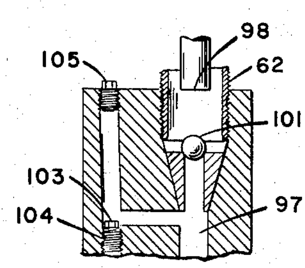

FIG. 6A

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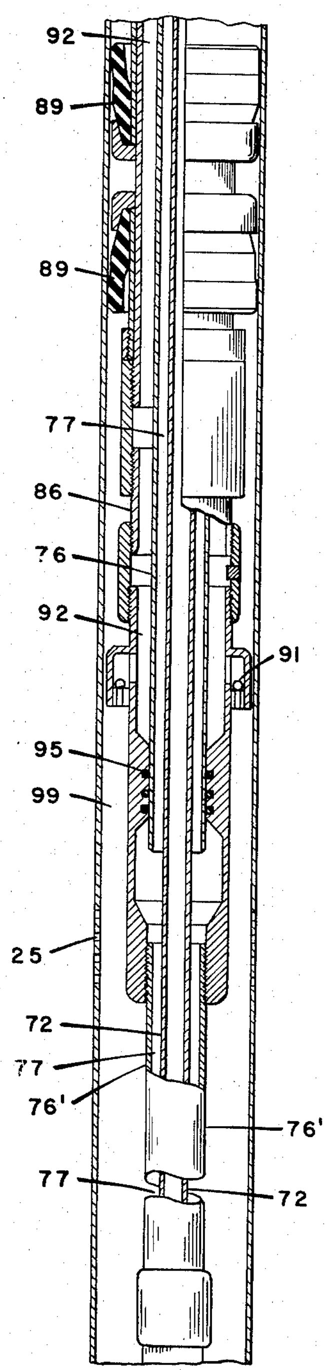

FIG. 7

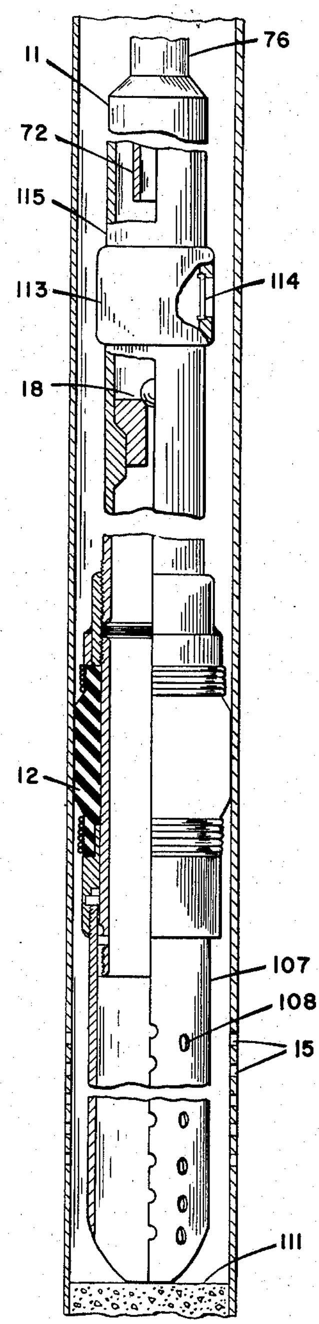

FIG. 8

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GAS LIFTING DUALLY-COMPLETED WELLS

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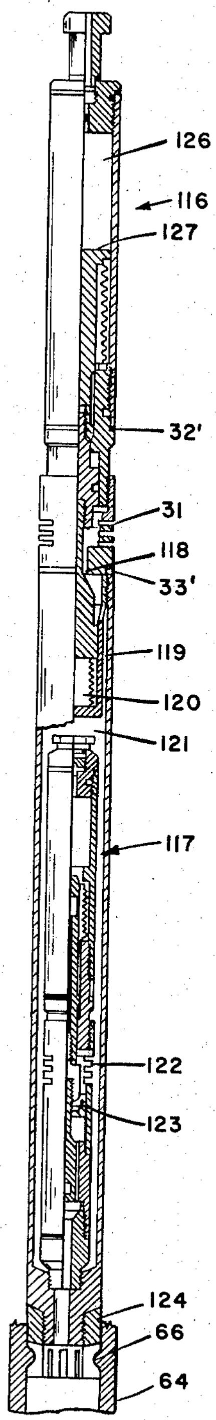

FIG. 9

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2,896,547

GAS LIFTING DUALLY-COMPLETED WELLS

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Application February 14, 1955, Serial No. 487,731

11 Claims. (Cl. 103—238)

This invention relates to an apparatus for completing and producing multiple-zone wells. More particularly, this invention relates to an apparatus for selectively gas lifting two separate producing zones spaced a great distance apart in a dually-completed well.

The use of dual completions for oil wells has been found to be desirable in view of the great economic advantage of completing only one well through which both zones are produced. The artificial lifting apparatus for such dually-completed wells has, however, been found to cause many and varied producing problems not incurred in wells with only one producing zone or where the well fluilds from a number of zones are commingled within the well. Multiple-zone wells have been produced and the production from each zone maintained isolated by the use of two or more concentric tubing strings and also by the use of parallel tubing strings with their inlets adjacent the respective producing zones. The use of concentric tubing strings permits pumping only one of the producing zones. In some cases, however, both zones can be artificially produced using gas lift. Parallel tubing strings are more desirable in most cases in that it is possible to produce two zones both of which tend to deposit paraffin in the tubing. While the use of parallel tubing strings has been proposed, no dual gas lift system has been proposed which permits the selective production of each zone in dually-completed wells where the zones are widely spaced, or particularly where the lower zone has a working liquid level below the upper zone.

It is, therefore, the object of this invention to provide an improved apparatus for producing multiple-zone wells. It is a more specific objective of this invention to provide an apparatus for gas lifting a two-zone well in which the producing zones are spaced a substantial distance vertically in the well. It is still a more specific object of this invention to provide a means for selectively producing separately widely-spaced zones in a dually-completed well employing a common lifting gas supply in the well. These and other objects of this invention will become apparent from the following description in which:

Figure 1 is a schematic diagram of a two-zone well showing means for selectively producing the two widely-spaced producing zones;

Figure 2 is a cross-sectional view of a preferred embodiment of the wellhead apparatus;

Figure 3 is a cross-sectional view of the upper section of the subsurface apparatus and is a lower continuation of the apparatus shown in Figure 2;

Figure 4 is a cross-sectional view of the crossover connection and top of the upper zone accumulation chamber and is a lower continuation of the apparatus shown in Figure 3;

Figure 5 is a cross-sectional view taken on section 5—5 of Figure 4;

Figure 6 is a cross-sectional view of the crossover connection taken on section 6—6 shown in Figure 5;

Figure 6*a* is a cross-sectional view of a modification of the crossover connection shown in Figure 6;

Figures 7 and 8 are cross-sectional views of the lower end of the upper accumulation chamber, and of the packer and lower accumulation chamber, respectively, and are lower continuations in series of the apparatus shown in Figure 4; and,

Figure 9 is a cross-sectional view of one embodiment of a gas lift valve having both upper and lower cutoff pressures.

From these drawings it can be seen that this invention in brief comprises an apparatus for producing selectively by gas lift two widely-spaced producing zones exposed in a single well, and, particularly that it relates to producing simultaneously and selectively two zones which may cause paraffin deposition on the tubing and which have low working fluid levels that typically require the use of an accumulation chamber for efficient gas lift production.

Referring now more specifically to Figure 1, a schematic system is shown for producing by gas lift a lower zone **9** in a dually-completed well where this lower zone is produced into a lower section **10** of the well and a lower accumulation chamber **11** and that chamber is emptied intermittently by gas lift. The lower section is isolated by a lower packer **12** from the remainder of the well and from the upper section **13** which extends through the upper zone **14**. Oil produced from lower zone **9** enters the lower section well through lower perforations **15** in the casing **16** and enters the lower zone tubing **17** through standing valve **18**. This oil then flows into the lower accumulation chamber **11** through perforation **19** in the lower zone tubing. As oil enters the accumulation chamber, gas therein is displaced out into the lower zone tubing **17** through a small pressure equalizing port **21** located near the top of the accumulation chamber. This lower zone **9** may be located several hundred feet and may be as much as several thousand feet below the upper zone **14**. Inasmuch as it is considered highly desirable to utilize a common source of gas for gas lifting the two zones so that only one gas supply line down to the upper zone is required, and, inasmuch as production from the two zones must be kept isolated, an upper packer **22** is set in casing **16** above upper zone **14** separating the gas conduit or gas chamber in the annular space **23** from the fluids in the upper section **13**. These fluids enter the upper section through upper casing perforations **25** from the upper zone **14**. The distance between lower packer **12** and upper packer **22** being typically greater than the dynamic or producing liquid level of the lower zone, gas is transferred from above upper packer **22** down through the upper section to the bottom of lower accumulation chamber **11**. This transfer is accomplished by running the small macaroni string **26** down through lower zone tubing **17** from a connection with the annular space **23** above the top packer. This macaroni string is connected with the gas chamber by a lower zone crossover **27** wherein gas from annular space **23** flowing through a gas port **28** enters a pressure operated gas lift valve **29** through an opening **31** in the wall of the valve. This gas lift valve is sealed in the lower zone crossover by an upper packing **32** and a lower packing **33** so that gas entering opening **31** from the gas chamber can be controlled by the gas lift valve and discharged through the lower end of the valve into the macaroni string **26**.

The upper zone **14**, as indicated previously, produces through upper casing perforations **25** into the upper section **13** which may be considered to be an upper zone accumulation chamber. The upper zone tubing **34** which may be enlarged to provide a greater volume extends down into this upper section to any desired distance, The section or chamber is emptied periodically by admitting gas through upper zone gas lift valve 35 into either the top of the chamber or, preferably, the bottom of the tubing. Gas from the gas chamber in annular space 23 flows through a gas port 36 in upper zone crossover 37 into opening 31′ in the upper gas lift valve. Upper packing 32′ and lower packing 33′ cause this gas to be diverted through the opening 31′ into the upper zone gas lift valve 35 where the gas to lift the well fluids from the upper zone is controlled. Gas from the upper gas lift valve flows out of the bottom of the valve below lower packing 33′ and flows, for example, via gas dip tube 38 into the lower end of the upper zone tubing 34. A standing valve 39 may, if desired, be installed in the bottom of the upper zone tubing. Both the upper and lower zone crossovers 37 and 27, respectively, provide annular well-fluid passages 40 around the gas lift valves. Upper zone tubing 34 and lower zone tubing 17 extend in parallel above the crossover fittings through the gas chamber to the surface where they pass through a dual tubing head 41.

Gas is injected into the gas chamber in annular space 23 through one or more pressure controllers which permit selective operation of the upper and lower zone gas lift valves 35 and 29, respectively. Upper zone pressure controller 42 and lower zone pressure controller 43 typically operate in parallel as shown. These pressure controllers are actuated either electrically or pneumatically by a clock-driven intermitter 44 which has separate control disks 45 and 46 for the upper zone controller and the lower zone controller, respectively. Gas flowing through these controllers then passes through chokes 47, which may, if desired, be adjustable, and enters the annular space 23 through gas inlet line 48.

Various means may be provided for selectively producing the two spaced zones in the well with the apparatus shown. Generally this selective control is accomplished by providing gas lift valves which open and may even close at different pressures. Typically, the most productive zone is produced by the gas lift valve having the lower opening pressure. As is well-known, pressure operated gas lift valves, such as the Garrett Oil Tools, Inc., type "W–OBP," by the use of differential areas may have any desired operating pressure range, i.e., may be made to open and close at any desired pressure, provided the opening pressure is higher than the closing pressure, and the opening pressure may be several pounds, typically 50 or more pounds, greater than the closing pressure. "Operating pressure range" as the term is used herein thus refers to the pressure range between the opening and closing pressures for a gas lift valve. Assuming for the purpose of illustration that the lower zone is more productive, lower zone gas lift valve 29 would be set to open at a pressure slightly lower than the opening pressure for upper zone gas lift valve 35. For example, assuming a 500 pound pressure supply of gas is available, lower zone gas lift valve 29 might be set to open at 400 pounds and to close at 350 pounds. Upper zone gas lift valve 35 might then be set to open at, for example, 425 pounds and to close at 325 pounds. It can be seen that each zone cannot only be selectively produced individually, but with this arrangement, both zones can be produced together. For example, with the pressure presettings as assumed above, if pressure in annular space 23 is increased from below 325 pounds at which both valves were closed to 410 pounds, the lower zone valve is opened but the upper zone gas lift valve will not have opened so the lower zone can be produced selectively. Then, if it is desired to produce both zones simultaneously, the pressure in the gas chamber is raised to above the opening pressure for the upper zone gas lift valve to a pressure of, for example, 430 pounds. The ratio of operating time at 410 pounds to time at 430 pounds can be varied to accommodate the actual productivity ratio of the two zones. Periodically, when both zones are pumped off, the pressure is again reduced to below 325 pounds. Under these conditions it can be seen that since, as stated previously, the lower zone is more productive, the two zones can be produced with maximum efficiency—the lower zone being produced for a longer period of time than the upper zone. Alternatively, it can be seen that even with the pressure settings as above specified it is possible selectively to produce the upper zone alone. Thus, if after producing both zones simultaneously, the pressure in the gas chamber within annular space 23 is lowered to a pressure below the closing pressure for the lower zone gas lift valve but above the closing pressure for the upper zone gas lift valve 35, for example, 330 pounds, the upper zone will be selectively produced alone. Obviously, various combinations of valves and valve settings can be arranged to suit the particular conditions in any well. For example, the upper zone gas lift valve may be set to open at a lower pressure and close at a higher or even a lower pressure than the opening and closing pressures for the lower zone gas lift valve. The gas pressure in the gas chamber is controlled as indicated above by the pressure controllers 42 and 43. Since three pressure ranges in the annular space may be desirable for a particular situation, one for no production, one for production of the most productive zone, and one for production of both zones simultaneously, the pressure controllers are operated periodically and the length and frequency of the operating periods are controlled by a prearrangement of the controlled disks 45 and 46, as is well-known in this art.

By employing parallel tubing strings for producing dually-completed wells, the tubing from each zone can be cleaned without pulling the tubing. That is, a paraffin scraper may be lowered into the tubing and down to the gas lift valve which is typically at a depth greater than the depth at which paraffin commences to precipitate and deposit on the tubing walls. While various kinds of paraffin scrapers may be employed, the free piston, or plunger, as disclosed, for example, in U.S. Patent 2,688,928 is considered highly satisfactory and preferred since no special fittings or connections in the well are required. By attaching suitable liquid separator or lubricator connections to the tops of the two tubing strings it will be seen that both zones may be produced by gas lift employing the free piston without further modification and without withdrawing and modifying the subsurface well apparatus. Furthermore, by employing parallel tubing strings in these dually-completed wells, wire-line-removable gas lift valves and kick-off valves can be used to advantage. For example, it may be desirable to change the pressure setting on the operating gas lift valves or to repair them, and this would be difficult, if not impossible, in a system employing concentric tubing strings.

Referring now to Figures 2 to 9 for the description of a preferred embodiment of our invention, we have shown, in addition to the fundamentals shown in Figure 1, improved means for selectively producing spaced producing zones and for operating free pistons in both tubing strings of a dually-completed well. Reference will be made first to Figure 2 showing a wellhead connection suitable for installation of free pistons as described above.

Lubricators 50 are placed at the top of each string of tubing 17 and 34 for the purpose of absorbing the energy of the impact due to arrival of the free pistons at the surface under high velocity. Separate outlets from the strings of tubing to upper zone flow line 51 and lower zone flow line 52 are provided below the lubricators. Each outlet includes a perforated liner 53 which permits the free piston to pass freely and allows the liquids ahead of and the gases behind the free piston to escape into the flow line. A free piston catcher 54, comprising a spring-actuated latch 55 and an operating lever 57 which selectively inactivates the latch, is adapted to catch the free piston when it arrives at the surface. Full opening valves **58** are placed in each string of tubing between the outlet connection and the tubing head **41** so that either zone may be shut in while the other is producing. The bonnet **59** of the tubing head has two spaced outlets **60** through which the two strings of tubing pass and means such as slips and packing provided for supporting the tubing and sealing the tubing in the openings so that pressure may be maintained in annular space **23**. Gas is injected into the common gas chamber in this annular space through gas inlet line **48**.

These two strings of tubing are then extended downward from the tubing head to the crossover assemblies as shown in Figure 3. In most cases, the two strings of tubing are connected together by clamps **61**. Upper zone tubing **34** is threaded into upper zone crossover **37** and extension **62**, and lower zone tubing **17** is threaded into the lower zone crossover **27** and extension **63**. These upper and lower crossovers have central mandrels **64** and **65**, respectively, which receive the gas lift valves. The mandrels are connected with the annular space **23** by gas ports **36** and **28**. The mandrels extend above and below these gas ports for a sufficient distance to provide space for an upper packing **32** and a lower packing **33** on the gas lift valves, which together prevent lifting gas from bypassing the valve and cause the gas to enter the valve openings **31**. The gas lift valves are supported at the lower end on shoulders **66** in the mandrels which stop the valves with the opening **31** in position opposite the gas ports **36** and **28**. Gas from the upper zone gas lift valve **35** is discharged into a small diameter tube **67** which is connected to the bottom of mandrel **64** in upper crossover **37**. Similarly, gas from lower gas lift valve **29** is discharged into a tube **68** which is connected to the bottom of mandrel **65** in lower zone crossover **27**.

Referring now to Figures 3 and 4, the two strings of tubing and the gas tubes from the discharge of the two gas lift valves are connected into the top of crossover connection **69**. The lower zone crossover **27** connects the lower zone tubing **17** to the passage **71** which then connects to the lower zone dip tube **72**. This tube, as shown hereinafter in Figure 7, extends to the bottom of the lower zone accumulation chamber **11**. The lower zone gas tube **68** connects through a packed slip joint connection **74** with a lower zone gas passage **75** in the crossover connection to a lower zone gas line **76** which conducts gas from the lower zone gas lift valve **29** through the annular space **77** between the lower zone gas line and the dip tube **72** to the top of the lower zone accumulation chamber. Gas from the upper gas lift valve **35** passes down through small diameter tube **67** which is connected to the cross-over connection with a packed slip joint connection **78** and flows through passages **79** and **81** (see Figures 5 and 6), which are connected with upper zone gas line **82**, to annular space **83**, thence through a gas port **84** into the top of the upper accumulation chamber **85**. The upper accumulation chamber is formed in the annular space between the casing **16** and the upper zone dip tube **86** by providing an upper packer or packers **88**, which are mounted on upper zone gas line **82** above gas port **84**, and lower packer or packers **89** which are mounted on upper zone dip tube **86**. Oil or other liquid production from the upper zone entering upper zone casing perforations **25** flows through the annular type standing valve **91** and into the upper accumulation chamber through annular space **92** and perforations **93**. The annular space **92** between lower zone gas line **76** and upper zone dip tube **86** is closed at the bottom by packed slip joint **95**.

Oil in this upper accumulation chamber is emptied periodically by injecting gas into the upper end through gas port **84** displacing liquids out through perforations **93** into the annular space **96**, which is connected by passages **97** and **97′** in the crossover connection to the annular fluid passage **40′** through the upper zone crossover **37**. This upper zone production then flows through upper zone tubing **34** through perforated liner **53** in the surface connections and into upper zone flow line **51**.

In some instances, where an upper accumulation chamber is not considered necessary, i.e., where the upper zone is more productive or has a higher working fluid head, the crossover connection as described above can be used in a slightly modified form. More specifically, when an upper accumulation chamber is not employed, the upper zone gas is discharged from the gas lift valve **35** around the lower end **98** of mandrel **64** into the upper zone crossover extension **62** to lift the upper zone fluids via the fluid passage **40** directly into the upper zone tubing **34**. In this embodiment upper zone accumulation chamber lower packers **89** and the upper zone dip tube **86** on which they are mounted are not required so the liquid from the upper zone enters upper zone casing perforations **25** and passes through annular space **99** between casing **16** and lower zone gas line **76**, up through passage **97** and a standing valve **101** which replaces the bridge **102** as shown in Figure 6*a*. The passage **81** may then, if desired, be isolated from passage **79** by inserting a plug **103** in the threads **104**. This plug is inserted by removing plug **105** and, being smaller than the diameter of channel **106**, it is lowered and threaded into position to close the passage **81**. Upper zone packers **88** on the upper zone gas line **82** are generally employed in this embodiment to isolate the lifting gas in annular space **23** from the upper zone production in annular space **99**. Obviously, the standing valve **101** may in some cases be attached, as is well-known in the art, to the upper zone gas lift valve **35** so that it can be pulled for repair whenever the gas lift valve is pulled. Alternatively, means may be provided on the standing valve for pulling it separately after the gas lift valve has been pulled.

Referring again to Figure 7 and particularly to the method of producing liquids from the lower zone **9**, lifting gas from the common gas chamber in annular space **23** passes through gas ports **28** in lower zone crossover **27**, flowing through gas lift valve **29**, mandrel **65**, tube **68**, passage **75** in the crossover connection and annular space **77** into the top of lower accumulation chamber **11**. Liquid from the lower zone **9** enters the lower section **10** of the well through lower casing perforations **15** and enters the lower zone anchor **107** through perforations **108**. A packer **12** which may be of the anchor type or in some cases a wire-line retrievable packer is set at any point in the well between the upper and lower casing perforation by applying weight on the lower zone gas line extension **76′** after the anchor strikes the bottom plug **111**. Liquid from the lower zone, after entering perforations **15** and **108**, flows up through packer **12** and lower zone standing valve **18** and thence into the lower end of the lower zone accumulation chamber **11**. A drain fitting **113**, having, for example, a pressed-in shear disk **114**, may be placed in the lower zone accumulation chamber housing **115** above lower zone standing valve **18**. The shear disk may be ruptured by the application of above-normal operating pressure when it is desired to prevent swabbing the well in case cup-type packers are used and to drain liquid out of the accumulation chamber as the producing equipment is pulled from the well. Periodically, as discussed above, gas is injected into the top of the accumulation chamber, displacing liquid out of the chamber up through lower zone dip tube **72** which extends to near the bottom of the lower zone accumulation chamber **11**. Lower zone production then flows up through this dip tube, passage **71**, annular fluid passage **40** and lower zone tubing **17** to the surface where it is discharged through flow line **52**.

In order to eliminate flow valve interference between the upper and lower gas lift valves and to provide for selective production from the upper and lower zones, a special gas lift valve may be used instead of either lower zone pressure-operated gas lift valve **29** or upper zone pressure-operated gas lift valve **35**. In the following description, only the upper gas lift valve **35** is, for brevity of explanation, replaced by a special pressure-operated gas lift valve shown in Figure 9. This special gas lift valve comprises an upper pressure-closing gas lift valve **116** connected in series with a pressure-opening gas lift valve **117**. This special valve is placed in upper zone crossover **37** resting on shoulder **66** with gas opening **31** between upper packing **32'** and lower packing **33'** in communication with gas ports **36** so that gas from annular space **23** is admitted through the pressure-closing valve **118** whenever the pressure in annular space **23** is below a predetermined value. This gas flowing through valve **118** passes down through annular space **119** around the dash pot **120** to an enclosed chamber **121** and thence to the gas entrance port **122** of the pressure-opening gas lift valve **117**. Gas passes through pressure-opening valve **123** when the pressure in chamber **121** is above a predetermined value, thence out of the bottom of this special gas lift valve through a landing nipple **124** into the mandrel **64** and small diameter tube **67**. Pressure-closing valve **116**, of which various types are available, for example, the Garrett Oil Tools, Inc., type "P" reverse-acting valve, is normally maintained open by a high gas pressure in pressure chamber **126**. As pressure is increased in annular space **23** to a value greater than a predetermined closing value, valve **118** is closed due to the differential pressure across piston **127**. This shuts off the gas supply to the pressure-opening valve **117** and to the upper zone accumulation chamber. Gas valve **117** is, as indicated previously, a pressure-opening-type gas lift valve of which various designs are available commercially, for example, the Garrett Oil Tools, Inc., type "OBP" junior valve. When valve **118** is open as shown in Figure 9 and the pressure in annular space **23** and chamber **121** is above the opening pressure for valve **123**, both valves are open and gas passes from annular space **23** through gas lift valves **116** and **117** into upper zone gas line **82** and thence into the top of the upper zone accumulation chamber **85**. As pressure is further increased in annular space **23**, valve **118** is closed, thus providing a limited operating pressure range for the special valve at the lower limit of which valve **123** is closed and at the upper limit of which valve **118** is closed. Thus, it can be seen that depending upon the gas pressure maintained in annular space **23**, when this special gas lift valve is operated in parallel with the lower zone pressure-actuated valve **29**, interference between the two can be eliminated and the upper and lower zones can be selectively produced.

As an example of the operation of such valves in parallel, assume that lower zone gas lift valve **29** is set to open with a gas pressure within the common gas chamber in annular space **23** of 530 p.s.i. and to close when the pressure drops to 480 p.s.i. Assume also as to the upper zone system that the pressure-closing valve **116** is set to close at a pressure of 520 p.s.i. and to open when the pressure drops to 490 p.s.i. Assume further that the pressure-opening gas lift valve **117** is set to open when the gas pressure in the chamber **121** is above 500 p.s.i. and to close when that pressure is below 480 p.s.i. Under these conditions, both gas lift valve **29** and valve **123** are closed and no gas is admitted to produce either the upper or lower zones until the gas pressure in annular space **23** is raised to 500 p.s.i. Upper zone pressure controller **42** is opened by clock-driven intermitter **44** at predetermined time intervals to increase the pressure in annular space **23** to a pressure in the range 500 to 520 p.s.i., typically 510 p.s.i. At this pressure, gas is admitted to the upper zone accumulation chamber and that zone is produced. After a predetermined time, as previously set on clock-driven intermitter **44** and space-controller disk **46**, lower zone pressure controller **43** is opened to raise the gas pressure in annular space **23** to a pressure greater than 530 p.s.i., typically 540 p.s.i. At this pressure upper zone gas lift valve **29** opens and pressure-closing valve **116** closes so that gas is admitted only to the lower zone accumulation chamber **11** to produce the lower zone. After a preselected time interval, controller disks **45** and **46** move to close upper zone pressure controller **42** and lower zone pressure controller **43** so that the pressure declines to 480 p.s.i., the pressure at which both gas lift valves are closed.

Various modifications of these operating conditions will be apparent depending upon the producing characteristics of the respective zones. For example, in some cases only one pressure controller may be required and the ratio of producing time intervals for the two zones may be controlled by a choke **47**. Thus, the pressure controller may be set to open periodically and to build up a pressure in annular space **23** sufficient to open the highest pressure-opening gas lift valve. For example, assuming the various valve settings referred to in the example above, the pressure would be built up to 530 p.s.i., the pressure at which the lower zone gas lift valve **29** opens. As this pressure rises to 530 pounds, it passes through the pressure range under which the upper zone special gas lift valve is open, namely 500 to 520 p.s.i. The period of time required to pass through this pressure range, 500 to 520 p.s.i., is controlled by the choke **47**. Under the assumed conditions of equal production from upper and lower zones, the pressure controller would accordingly be set to remain open for a period approximately two times as long as the period required for the pressure in annular space **23** to pass through the operating pressure range for the gas lift valve controlling admission of gas to the upper zone accumulation chamber. Equal amounts of gas would thus be admitted to produce each zone selectively. The ratio of gas admission periods and the length of either or both can obviously be controlled with the apparatus shown.

It will also be apparent that with dual pressure controllers, as described above, other combinations can be provided so that either the upper zone or the lower zone can be selectively produced, or both zones can be produced simultaneously. Furthermore, by proper design of the space-controller disks **45** and **46**, the upper or the lower zones may be selectively produced with several producing cycles for one of the zones to each producing cycle for the other zone. For example, if the lower zone is more productive, gas may be injected into the lower zone accumulation chamber for a short period to unload that chamber and the cycle may be repeated at time intervals as required to produce the lower zone most efficiently. If the upper zones does not make sufficient production to be produced efficiently each time the lower zone is produced, the upper zone gas lift valve might be opened by upper zone pressure controller **42** only on alternate cycles or on every third or fourth cycle that the lower zone pressure controller is actuated.

Thus, it can be seen that by this invention means have been provided for selectively lifting with a common gas supply down to the upper zone, a multiplicity of widely-spaced zones in a well, that the invention is susceptible of a wide variety of embodiments and that it is not limited by the explanation of certain embodiments which has been given merely for the purpose of description. Instead, this invention should be construed to be limited only by the scope of the appended claims.

We claim:

1. An apparatus for separately producing widely-spaced upper and lower zones in a multiple-zone producing well comprising a gas chamber including a lower packer in the upper end of said well, packer means in said well between and isolating an upper section of said well through

said upper zone from a lower section of said well through said lower zone, a gas inlet to said gas chamber, a gas conduit from said gas chamber through said upper section to said lower section, a lower zone tubing extending from said lower section up through said upper section and said gas chamber, first valve means at the inlet of said gas conduit to admit gas selectively from said gas chamber through said gas conduit into said lower section and lift well fluids from said lower section through said lower zone tubing, an upper zone tubing extending from said upper section up through said gas chamber, a fluid passage between said gas chamber and said upper section of said well, and second valve means in said fluid passage to admit gas selectively from said gas chamber into said upper section and lift well fluids from said upper zones through said upper zone tubing.

2. An apparatus according to claim 1 wherein said first valve means and said second valve means includes at least one pressure-actuated gas lift valve.

3. An apparatus according to claim 2 including pressure regulator means in said gas inlet to said gas chamber periodically to change the pressure in said gas chamber and admit gas selectively to at least one of said sections.

4. An apparatus according to claim 1 wherein said first valve means comprises a first pressure-actuated gas lift valve and said second valve means comprises a second pressure-actuated gas lift valve, said first pressure-actuated gas lift valve and said second pressure-actuated gas lift valve having different operating pressure ranges whereby said valves may be operated to admit gas selectively and produce at least one of said zones separate from the other.

5. An apparatus according to claim 4 including pressure regulator means in said gas inlet to said gas chamber periodically to change the pressure in said gas chamber to the operating pressure range of each of the pressure-actuated gas lift valves.

6. An apparatus according to claim 1 wherein said lower zone tubing and said upper zone tubing are side by side in said gas chamber.

7. An apparatus for separately producing widely-spaced upper and lower zones in a multiple-zone producing well comprising a gas chamber in the upper part of said well, said gas chamber including an upper packer isolating said gas chamber from an upper section of said well opposite said upper zone, a lower packer isolating said upper section from a lower section of said well opposite said lower zone, a lower zone tubing extending from the surface down through said gas chamber, said upper packer, said upper section and said lower packer into said lower section, an upper zone tubing beside said lower zone tubing and extending from the surface through said gas chamber and through said upper packer into said upper section, a first fluid passage from said gas chamber into said lower section, a first pressure-actuated gas lift valve in said first fluid passage, a second fluid passage from said gas chamber into said upper section, a second pressure-actuated gas lift valve in said second fluid passage, means including a gas inlet to said gas chamber at the surface to inject gas into said gas chamber, and a pressure controller in said gas inlet to said gas chamber for periodically changing the pressure in said gas chamber, said first pressure-actuated gas lift valve and said second pressure-actuated gas lift valve having different operating pressure ranges whereby the pressure in said gas chamber may be changed periodically to operate said gas lift valves and admit gas selectively to produce each of said upper and said lower zones.

8. An apparatus according to claim 7 including a lower zone accumulation chamber in said lower section, said lower zone tubing extending into said accumulation chamber and having an inlet near the bottom of said accumulation chamber, a well fluid inlet in said accumulation chamber, and a standing valve in said well fluid inlet to admit well fluids into said accumulation chamber but to prevent well fluids from being discharged from said accumulation chamber back into said lower section when gas is injected into said accumulation chamber by said first pressure actuated gas lift valve.

9. An apparatus according to claim 8 wherein said pressure controller comprises a first clock controlled valve means in said gas inlet to said gas chamber for periodically admitting gas into said gas chamber within the operating pressure range in which said first pressure-actuated gas lift valve operates, and a second clock controlled valve means in said gas inlet to said gas chamber for periodically admitting gas to said gas chamber within the operating pressure range at which said second pressure-actuated gas lift valve operates.

10. An apparatus according to claim 9 wherein said second pressure-actuated gas lift valve comprises in series a pressure-closing valve and a pressure-opening valve, the exhaust of said pressure-closing valve being connected to the intake of said pressure-opening valve so that said gas from said gas chamber passes first through said pressure-closing valve and then through said pressure-opening valve, said pressure-closing valve having a closing pressure lower than the opening pressure of said first pressure-actuated gas lift valve and said pressure-opening valve having a lower opening pressure than the closing pressure of said pressure-closing valve whereby said upper zone may be selectively produced as the pressure in said gas chamber is raised to the operating pressure of said first pressure-actuated gas lift valve and whereby gas injection through said second pressure-actuated gas lift valve is stopped when the pressure is raised to open said first gas lift valve.

11. An apparatus for separately producing well fluids from upper and lower zones in a dually-completed well comprising a casing in said well extending down through said lower zone, lower perforations in said casing to admit well fluids from said lower zone into a lower section of said casing, upper perforations in said casing to admit well fluids from said upper zone into an upper section of said casing, a lower packer between said lower perforations and said upper perforations, a gas chamber in said casing above said upper perforations, said gas chamber including an upper packer in said casing isolating said upper section from said gas chamber, a tubing head on the upper end of said casing closing the upper end of said gas chamber, a gas inlet line to said tubing head, a clock-controlled pressure regulator in said gas inlet line adapted periodically to inject gas into said gas chamber at different pressures, a crossover connection located in the lower end of said gas chamber, a lower zone tubing extending from the surface through said tubing head down into a lower zone well fluid passage in said crossover connection, an upper zone tubing extending from the surface parallel to said lower zone tubing through said tubing head down through said gas chamber and into an upper zone well fluid passage in said crossover connection, a lower zone pressure-actuated gas lift valve in the lower end of said lower zone tubing, an upper zone pressure-actuated gas lift valve in the lower end of said upper zone tubing, said upper and said lower gas lift valves having different operating pressures, a gas inlet to each of said lower zone gas lift valve and said upper zone gas lift valve from said gas chamber, a lower zone gas line extending through said upper section and down into said lower section, an outlet from said lower zone gas lift valve extending down through a lower zone gas passage in said crossover connection into said lower zone gas line, an outlet from said upper zone gas lift valve extending down through an upper zone gas passage in said crossover connection into said upper section, a dip tube ex-

tending from within said lower section below the normal working fluid level of said lower zone up through said upper section and connecting to said lower zone well fluid passage in said crossover connection, said dip tube extending concentrically down through said lower zone gas line, an upper zone dip tube extending from below the normal working fluid level of said upper zone within said upper section into said upper zone well fluid passage in said crossover connection, whereby the well fluids from each of said lower and upper zones may be selectively gas lifted without commingling the well fluids from the two zones and whereby by controlling the pressure in said gas chamber with said clock-controlled pressure regulator said lower end of said upper zones can be selectively produced.

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