June 30, 1964 E. E. ROACH 3,139,040

GAS LIFT SYSTEM FOR WELLS

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Fig. 1

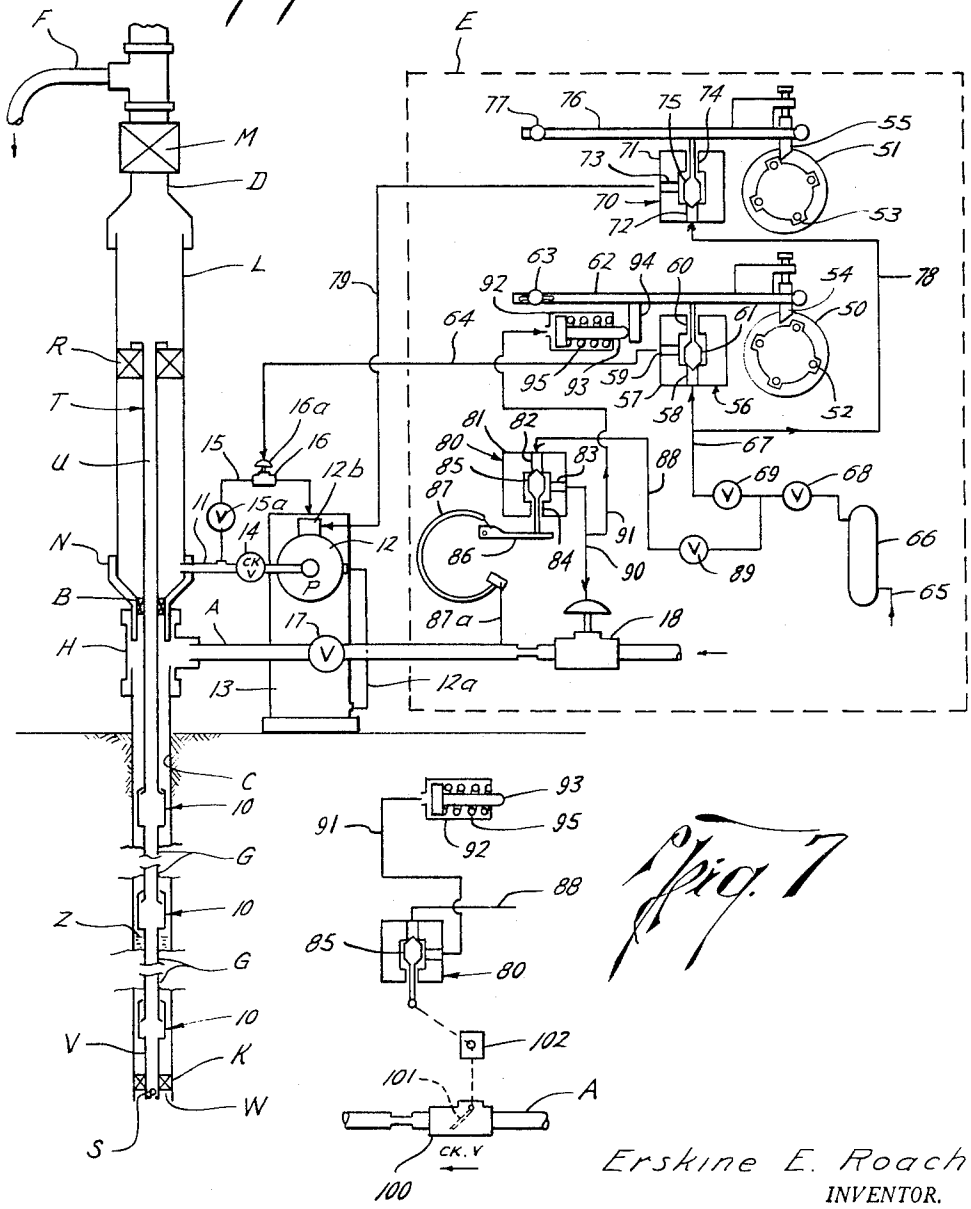


Fig. 7

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Fig. 2

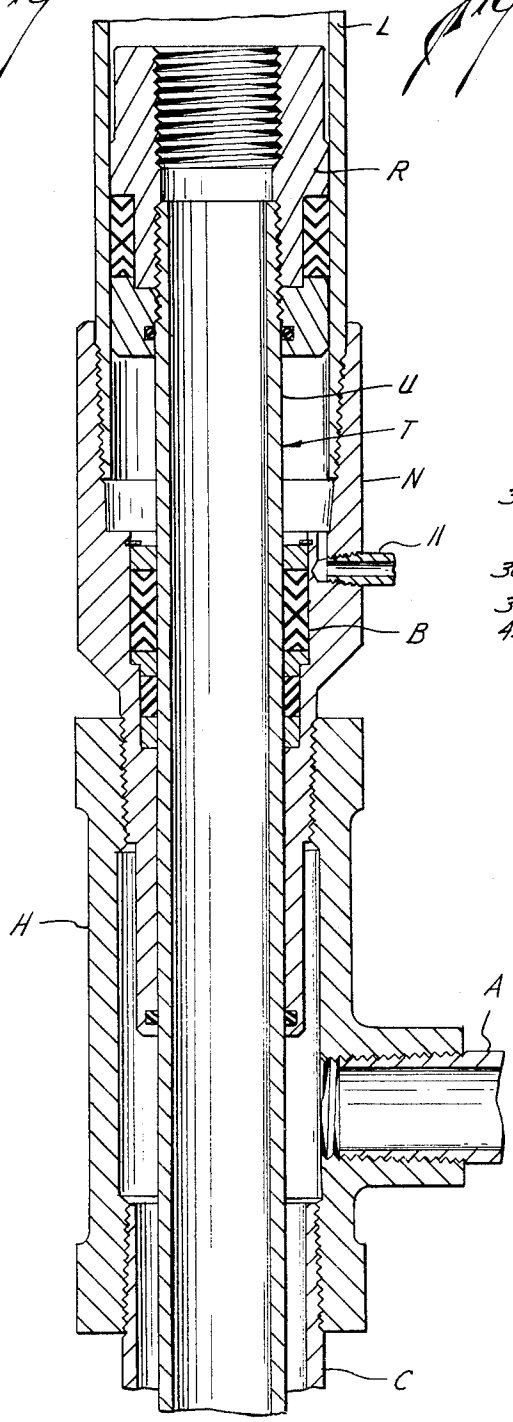
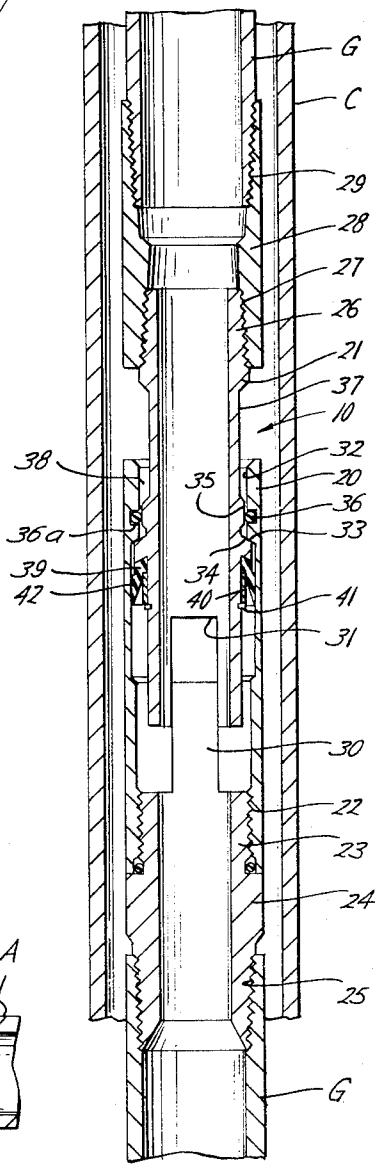


Fig. 3



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Fig. 4

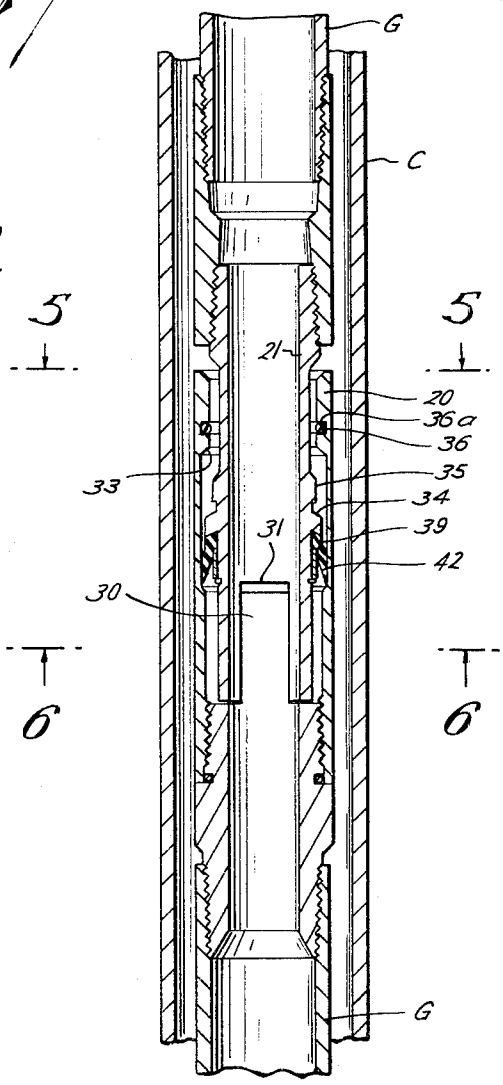


Fig. 5

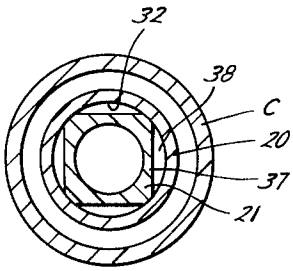
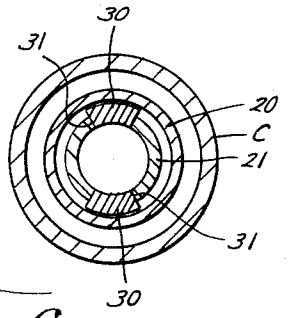


Fig. 6



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United States Patent Office

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GAS LIFT SYSTEM FOR WELLS

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Filed Aug. 7, 1961, Ser. No. 129,861
9 Claims. (Cl. 103—247)

This invention relates to improvements in the gas lift system for producing oil wells.

Current oil well completion practices are tending in the direction of employing small diameter well casings, commonly referred to as "slim hole" or "tubingless" completions. The latter is something of a misnomer, as in many instances, a string of production tubing must be run inside the casing. However, by reason of the relatively small casing, the annular clearance between the tubing and casing becomes so small that when artificial lift becomes necessary, installation of a tubing string having the usual externally mounted gas lift valves thereon becomes impractical. This is particularly true because operators require that sufficient clearance be available for passage of wash pipe over the tubing string.

To meet this condition, pressure loaded injection valves of the tubular concentric type, which may be mounted coaxially in the tubing string, have been designed and used with varying degree of success. These, however, have been found to be subject to various operating and mechanical difficulties and their replacement involves removal of the tubing string with its attendant difficulties and expense.

An early gas lift system, which has been considered obsolete for a number of years, employed a type of valve which was of telescopic construction adapted to be mounted coaxially in the tubing string and provided with port means which were opened and closed in response to vertical reciprocation of the upper portion of the tubing string relative to the lower portion thereof, the latter being anchored in the well bore. Reciprocation of the upper portion of the tubing string was effected at the surface either manually or mechanically in order to open and close the valve ports. As the unloading of the well thus had to be handled manually and as there was no means for effectively seeking out and employing the most efficient injection point with the changing well conditions, the system fell into disrepute and, as noted, has become obsolete.

The present invention is directed to improvements in this early system by which its disadvantages are overcome and the operation rendered fully automatic in opening and closing the valves, in controlling the supply of injection gas, and in locating the most efficient gas injection point for changing well conditions. This improved system permits the use of valves of the telescoping type which do have the advantages that their external dimensions may be held within limits permitting their use in slim casings, and they may be made relatively simple in form and of rugged construction. The present invention is also directed to improvements in the form of the valve itself to improve its operation in a system of the kind herein contemplated.

The improvements contemplated by the present invention embody the employment of a control system adapted to automatically unload a gas lift well employing the telescoping type valves in the tubing string.

In accordance with one embodiment of this invention, the control system comprises a novel combination of a hydraulic actuator for reciprocating the upper portion of the tubing string with time cycle controls and regulators co-operating to automatically unload the production string to the operating valve and to seek out the lowermost point at which gas can be effectively injected into the tubing. The gas lift system herein contemplated may

be employed both for intermitting wells with low production rates and for continuous flow installations which produce large quantities of fluids. In either installation the control system will automatically seek out the most efficient operating point along the valve string at time intervals as set on the time cycle control elements.

Among the other objects of this invention are the provision of a gas lift system which will operate with minimum wastage of power or lifting gas; which is relatively simple in construction; and which is highly efficient in its operation.

Other and more specific objects and advantages will become apparent from the following detailed description when read in conjunction with the accompanying drawing which illustrates useful embodiments in accordance with this invention.

In the drawing:

FIG. 1 is a generally schematic view of the gas lift system in accordance with one embodiment of this invention installed in a well;

FIG. 2 is a fragmentary longitudinal sectional view of the upper end portions of the well casing and flow tubing having the hydraulic actuator connected thereto;

FIG. 3 is a longitudinal sectional view of one of the gas injector valves with the parts in the port-closing position;

FIG. 4 is a view similar to FIG. 3 showing the valve parts in the port-opening position;

FIGS. 5 and 6 are cross-sections taken respectively along lines 5—5 and 6—6 of FIG. 4; and

FIG. 7 is a fragmentary diagrammatic view of a modification of the system.

Referring first to FIG. 1, there is shown a well W lined with a casing C. A casinghead H, in any suitable form such as a T fitting, is mounted on the upper end of casing C and the center arm of the T fitting has connected thereto a pipe A through which power or lifting gas under high pressure may be introduced into the casing from any suitable source (not shown). Mounted in the upper end of casinghead H is an adapter nipple N on which is mounted an upstanding cylinder L, the upper end of which communicates with a discharge pipe D controlled by a master valve M, the fluid leaving valve M passing through discharge fittings F. A string of production tubing T extends into the well through casing C and comprises an upper portion U and a lower portion V connected together by a plurality of longitudinally separated telescoping couplings, each designated generally by the numeral **10**, which comprise the gas injector valves, as will be described in greater detail hereinafter. The valves **10** are spaced apart by nipples G of any suitable length, as may be determined in the known manner for the particular installation. Lower portion V of the flow tubing is fitted with a standing valve S of conventional construction and is secured to the wall of casing C by means of a conventional anchor K to prevent longitudinal movement of lower portion V of the tubing string, and thereby permit relative reciprocation of upper portion U through relative movement between the parts of the telescoping couplings **10**. Upper portion U of the tubing string extends through adapter nipple N, which has a stuffing box, indicated at B, to seal between the tubing and the casing while permitting reciprocation of upper portion U. The latter has mounted about its upper end an annular piston R which extends radially into slidable sealing engagement with the wall of cylinder L. The upper end of tubing T is in open communication with the interior of cylinder L above piston R so that well fluid discharging from tubing T may flow out of the upper portion of cylinder L through discharge conduit D. For reciprocating upper portion U of the tubing string, a suitable hydraulic pressure fluid is supplied to the interior

of cylinder L between stuffing box B and piston R through a conduit **11** which is connected to the discharge of a pump **12**, the suction of which is connected, by means of a suction pipe **12***a*, to a reservoir **13** containing a body of suitable hydraulic fluid.

Pump **12** may be of any conventional type and preferably one driven by a conventional pneumatic motor indicated at **12***b*. A check valve **14** is mounted in conduit **11** and arranged to permit pressure fluid to flow toward cylinder L but prevent return flow through pump **12** to the reservoir. A bleed pipe **15** connects at one end to conduit **11** between check valve **14** and cylinder L and at the other end to the upper portion of reservoir **13**. A bleed valve **16**, which is preferably a pneumatically operated motor or diaphragm valve, is mounted in pipe **15** to control the return of pressure fluid from cylinder L to reservoir **13**. A constant flow control valve **15***a* may also be installed in pipe **15**. Bleed valve **16** is preferably normally closed so that upon actuation by suitable actuating fluid, such as air or gas, it will open to permit return of fluid from cylinder L through pipe **15** to reservoir **13**. Pipe A is fitted with a normally closed motor valve **18**, which when actuated by means of pneumatic or other pressure fluid, will open to admit power gas into casing C. A block valve **17** may be installed in pipe A between motor valve **18** and casinghead H.

The hydraulic actuating system comprising pump **12**, reservoir **13**, cylinder L and the other elements connected thereto, is employed to effect reciprocation of upper portion U of the tubing string. Thus, when pressure fluid is discharged into cylinder L beneath piston R, the upper portion of the tubing string will be elevated to its uppermost position and will remain in its elevated position so long as bleed valve **16** stays closed. When bleed valve **16** is opened, pump **12** being stopped, pressure fluid in cylinder L will flow out of the cylinder by gravity assisted by the weight of the tubing imposed through piston R in top of the body of pressure fluid in the cylinder and will discharge through bleed pipe **15** into reservoir **13** under the control of bleed valve **16**. As the presure fluid is bled from cylinder L, the upper portion U of the tubing string will descend through its own weight. Closing of the bleed valve **16** will immediately stop the descent of upper portion U.

Injection valves **10** are so constructed, as will be described more fully hereinafter, that when upper portion U of the tubing string has been moved to its uppermost position, all the valves will be closed and when upper portion U descends, the valves will open, the lowermost valve opening first and the remaining valves opening successively in the upward or descending direction. When upper portion U is moved upwardly toward its uppermost position, the valves will close, the uppermost valve closing first and the succeeding valves closing in descending order.

Operation of the system is under the control of an automatic controller E comprising the apparatus enclosed within the block, indicated by the broken lines in FIG. 1, which will be described more fully herienafter.

As best seen in FIGS. 3 to 6, inclusive, each of the valves **10** comprises an outer body sleeve **20** concentrically surrounding an inner body sleeve **21**, the latter extending into the upper end of outer body sleeve **20** and being axially reciprocable relative thereto. The lower end of outer body sleeve **20** is internally threaded at **22** to receive the externally threaded pin portion **23** of a coupling **24**, the lower end of which defines an externally threaded pin **25** to be received in the upper end of one of the nipples G or in the upper end of tubing portion V, depending upon its location in the tubing string. The upper end portion of inner body sleeve **21** has an externally threaded pin **26** for connection to the lower socket **27** of a coupling **28**, the upper end of which has an internally threaded socket **29** for receiving the lower end of a nipple G or of upper portion U of tubing T, again depending upon the particular location of the valve in the tubing string. A non-rotative, longitudinally slidable connection is provided between the inner and outer body sleeves by means of a pair of diametrically spaced upstanding keys **30—30** formed as extensions of coupling pin **23** slidably receivable in registering longitudinal slots **31—31** formed in the lower end of inner body sleeve **21** (FIG. 6).

Beginning a short distance below its upper end, the bore wall **32** of the outer body **20** is undercut for a portion of its length to define a downwardly facing annular shoulder **33** which slopes downwardly and outwardly to form a valve seat. Inner body **21** is provided at a point intermediate its ends with an external upwardly facing annular shoulder **34** tapered to complement shoulder **33** to form a valve member abutable with shoulder **33** to provide a metal-to-metal seal between the inner and outer body sleeves when the shoulders are in contact with each other. Immediately above shoulder **34** inner body sleeve is provided with a short cylindrical enlargement **35** whose diameter is less than that of shoulder **34** but such as to provide a sliding fit with bore wall **32**. The latter has seated therein, in an annular recess **36***a*, an annular resilient packing **36**, such as a conventional O-ring, in a position to sealingly engage the exterior surface of enlargement **36** when shoulders **33** are in abutting engagement. Enlargement **35** and packing **36** thus form a second or supplemental seal between inner and outer body sleeves **21** and **20**. The length of enlargement **35** is made such that this supplemental seal will be effected for a short length of relative movement between the body sleeves in advance of engagement or disengagement of shoulders **33** and **34**. The surface of the portion **37** of inner body sleeve **20** between enlargement **35** and pin **26** will be made square or of other non-round shape (FIG. 5) to provide substantial clearance spaces **38** between inner body sleeve **20** and bore wall **32**.

An annular packing **39** is mounted about inner body sleeve **20** above the upper ends of slots **31** and immediately below shoulder **34** and is secured in place by means of a clamping sleeve **40** held in place by a lock ring **41** mounted in the exterior of body sleeve **20**. Packing **39** is formed with a depending flexible lip **42** about its exterior adapted to slidably engage the undercut portion of bore wall **32** and form therewith a check valve permitting downward flow of fluid past the lip but sealing tightly with the bore wall when subjected to fluid pressure from below to prevent upward flow of fluid between the inner and outer body sleeves.

In operation of valves **10**, it will be seen that when inner body sleeve **21** is moved downwardly relative to outer body sleeve **20**, shoulder **34** will first dis-engage downwardly from shoulder **33** and when this movement has continued for an additional short distance, enlargement **35** will move downwardly past packing **36**, thereby opening the annular space between the inner and outer body sleeves to passage of fluid flowing downwardly through spaces **38**. The fluid thus passing between the body sleeves will flow past the check valve formed by lip **42** and will pass through slots **31** in the inner body sleeve into the bore thereof or around the lower end of inner body sleeve into the bore thereof. Thence, the fluid will flow into the bore of the tubing string and upwardly therethrough into cylinder L above piston R and thence through master valve **19** and discharge fittings F to storage or other disposal. The open position of the valve is illustrated in FIG. 4.

Upward movement of the inner body sleeve in response to upward movement of upper portion U of the tubing string will return the valve to the closed position shown in FIG. 3. Upward movement of the inner body sleeve from the open position of FIG. 4 toward the closed position of FIG. 3, will first bring enlargement **35** into sealing engagement with packing **36**, effecting an initial seal, after which continued upward movement of the inner

body sleeve will bring shoulder 34 into seating engagement against seat shoulder 33 completing the shut-off through the valve.

Automatic controller E includes first and second clock-driven timing wheels 50 and 51, respectively, of generally conventional construction, carrying respective series of timing cams 52 and 53, which cooperate with related cam followers 54 and 55, respectively, for actuating the various control elements at time intervals determined by the relative position and arcuate length of the cams, as is conventional in devices of this character.

Timing wheel 50 controls a first pilot valve, designated generally by the numeral 56, comprising a casing 57 having inlet and outlet ports 58 and 59, respectively, a bleed port 60 and a valve member 61 which is movable between positions opening and closing communication between inlet port 58 and outlet port 59. When valve member 61 is in the position closing communication between the inlet and outlet ports, bleed port 60 will be open, as seen in FIG. 1. It will be understood that when valve member 61 is in the position opening communication between the inlet and outlet ports, it will close bleed port 60. Valve member 61 is secured in pendent position from an intermediate point on a weight bar 62, one end of which is pivoted at 63 and the other end of which carries the cam follower 54. With this arrangement it will be seen that the weight bar will normally tend to urge valve member 61 into the position closing communication between inlet and outlet ports 58 and 59 and opening bleed port 60 and will be moved to the communication-opening position when cam follower 54 is caused to ride up over one of the cams 52. A conduit 64 connects outlet port 59 to motor 16*a* of bleed valve 16. A pipe 65 connected to a suitable source of pneumatic fluid, such as high pressure gas or air (not shown) delivers such fluid through a trap 66 and thence through a line 67 to inlet port 58. A high pressure regulator 68 and a low pressure regulator 69 may be interposed in line 67 to step down the pressure of the penumatic fluid to that required for operation of pilot valve 56.

A second pilot valve, designated generally by the numeral 70, is controlled by timing wheel 51. Pilot valve 70 is substantially identical in form and operation to pilot valve 56, comprising a casing 71 having an inlet port 72, an outlet port 73, a bleed port 74, and a valve member 75 movable in casing 71 between positions opening and closing communication between the inlet and outlet ports. Valve member 75 is dependently supported from an intermediate point on a weight bar 76, one end of which is pivoted at 77 and the other end carries cam follower 55. As in the case of pilot valve 56, weight bar 76 manually urges valve member 75 into the communication-closing position, shown in FIG. 1, but moves the valve member to the communication-open position when cam follower 55 is caused to ride up and over a cam 53. A line 78 connects inlet port 72 to line 67 at a point between pilot valve 56 and low pressure regulator 69 so that both pilot valves will be supplied with pneumatic pressure fluid from a common source and at a uniform pressure. Conduit 79 connects outlet port 73 to pneumatic motor 12*b*.

A third pilot valve, designated generally by the numeral 80, controls the operation of motor valve 18 and comprises a casing 81 having an inlet port 82, an outlet port 83, a bleed port 84, and a valve member 85 movable between positions opening and closing communication between the inlet and outlet ports. Valve member 85 is operatively connected to a pivoted lever 86 having an operative connection to one end of a conventional Bourdon tube 87, the other end of which is operatively connected by means of a tube 87*a* to gas supply pipe A at a point downstream of motor valve 18. Expansion and contraction of Bourdon tube 87 serves to move valve member 85 between its operative positions, as will be described more fully hereinafter. A line 88 connects inlet port 82 to line 67 at a point between high and low pressure regulators 68 and 69, and a separate low pressure regulator 89 may be mounted in line 88 to regulate the pressure of the pneumatic fluid going to pilot valve 80. A line 90 connects outlet port 83 to the motor 18*a* of motor valve 18. A conduit 91 connects into line 90 and leads into one end of a cylinder 92 which enclose a shift piston 93 which projects through the opposite end of cylinder 92 for engagement with a cam lug 94 secured to weight bar 62 at a point between pivot 63 and valve member 61, the arrangement being such that when piston 93 is moved outwardly of cylinder 92 (to the right in FIG. 1) the pressure of the piston on cam lug 94 will urge weight bar 62 upwardly about pivot 63 causing valve member 61 to shift from the position closing communication between inlet port 58 and outlet port 59 to the position open such communication. The outward movement of piston 93 is resisted by a coil spring 95 suitably mounted between the piston and cylinder 92.

The above-described system operates in the following manner: It will be assumed that at the beiginning of a cycle, piston R will be in its uppermost position, at which upper tubing portion U will have been elevated sufficiently so that all of the valves 10 will be in their closed positions. Timing wheel 50 will operate through engagement of one of its cams 52 with follower 54 to actuate pilot valve 56 by raising weight bar 62 so as to shift valve member 61 to its upper position opening inlet port 58 to communication with outlet port 59 while closing vent port 60. Actuating gas from line 67 will then flow through line 64 to motor 16*a* of bleed valve 16, opening the latter and allowing hydraulic fluid to bleed back from cylinder L through pipes 11 and 15 into reservoir 13. As the hydraulic fluid bleeds back into the reservoir, piston R lowers slowly thereby lowering upper tubing portion U which causes valve 10 to open. The lowermost valve 10 will open first, the other opening in ascending order as tubing portion U continues to descend.

A fluid level Z will normally be present in the casing annulus which will ordinarily submerge one or more of the injection valves, and the casing above fluid level Z will be filled with power gas under pressure previously supplied through pipe A. As the valves open in response to the lowering of tubing portion U, the first to open above fluid level Z will start to pass gas into the tubing string to lift the well fluid therein to the surface. The passage of gas from the casing annulus will cause a pressure drop in the casing which will be immediately sensed by Bourdon tube 87 which will then operate to actuate pilot valve 80 by moving valve member 85 to the open position placing ports 82 and 83 in communication. This will permit actuating gas to flow from pipe 88 into pipe 90 opening motor valve 18 and thereby permitting power gas to flow into the casing. At the same time, some of the actuating gas will flow through pipe 91 into cylinder 92 and cause piston 93, acting through cam lug 94, to shift weight bar 62 in a direction to move pilot valve member 61 to the position closing communication between ports 58 and 59 (FIG. 1) and stopping the flow of actuating gas to motor 16*a*, thereby allowing bleed valve 16 to close and immediately stopping further descent of the tubing string. The tubing string will thus remain open at the first valve which has admitted the gas and lifting gas will continue to feed into the tubing from the casing annulus. After a pre-determined time interval, as set on timing wheel 51, pilot valve 70 is actuated, valve member 75 being thereby moved to the position opening communication between ports 72 and 73 and passing actuating gas from pipe 78 to pipe 79 and thence to pump motor 12*b*. The latter will start pump 12 which will begin pumping pressure fluid from reservoir 13 through pipe 11 into cylinder L which will raise piston R and tubing portion U. As the latter ascends, the injection valves will start to close in descending order from the uppermost valve. When the operating valve closes, the pressure in the casing starts to build up.

This will be immediately sensed by Bourdon tube 87 which will operate to close pilot valve 80 causing motor valve 18 to shut off further flow of gas to the casing. The cycle is completed when piston R reaches the top of its stroke. At the same time that pilot valve 80 is closed, actuating gas will be cut off from shift piston 93, relieving the pressure on cam lug 94 and leaving valve member 61 in position for upward movement in response to the contact of the next timing cam 52 with cam follower 54 to initiate repetition of the cycle.

From the foregoing, it will be seen that the above-described system comprises the combination with a series of telescoping-type valves in a tubing string, of a control arrangement by which a well will be automatically unloaded to an operating valve and which will, during each cycle, seek out the lowermost point at which the gas may be injected into the tubing. The described system may be used in both an intermitting well with a low producing rate, or in a continuous flow installation which produces large quantities of fluid. The control system described will automatically seek out the most efficient operating point at predetermined time intervals which may be set into the cycle timers of the automatic controller. Where the system is employed in an intermitting gas lift installation which requires intermittent operation, the location of the most efficient operating point is effected at the beginning of each cycle. In the case of a continuous flow installation, the time cycle controller is set to hunt, at periodic intervals, the lowermost injection point. This time may be set by the operator according to the well's producing characteristics.

Whether the well is an intermittent well or a constant flow well, the same sequence of operations is employed, except that in the case of the continuous flow installation, timer 51 is set so as not to start within a short period after the input gas commences to flow into the casing. Instead, the time is set so that the gas will be allowed to flow continuously into the casing and the well permitted to operate on constant flow for a major portion of each day. Timer 51 will then be employed to periodically search for the best operating level. This is done by setting timer 51 to permit pump 12 to start at some predetermined interval after the well has been flowing for some time, perhaps several hours, in order to move piston R to the top of its stroke. Thereupon, after a pre-determined and usually very short time, the above-described sequence of steps starting with actuation of pilot valve 56 is begun. This continuous flow arrangement is then comparable to an intermitting flow which is set to cycle perhaps only once or twice per day.

By means of the above-described arrangement, not only is the operation of the well conducted automatically, but the operation will be conducted at maximum efficiency with respect to the use of lifting gas, thereby greatly reducing any gas wastage.

It will be evident that various means other than that described above may be used to control the flow of gas into the well and the operation of the lift piston for controlling the valve settings.

FIG. 7 illustrates, diagrammatically, another modification which may be employed in lieu of the Bourdon tube 87 and motor valve 18. In this modification, a swing check valve 100 is substituted for motor valve 18, the valve being arranged so that its flapper element 101 will swing open when the downstream pressure falls. A sensing element 102 of any conventional design, which is adapted to sense the movement of flapper element 101, is employed to connect the latter to valve member 85 of pilot valve 80. With this arrangement, when gas begins to flow from the casing into the tubing, the resultant drop in pressure in the casing will cause flapper element 101 to swing to the open position allowing gas to flow toward the well. The movement of the flapper will be transmitted to sensing element 102 which will cause valve member 85 to move to the open position, causing shift piston 93 to be actuated in exactly the same manner as previously described.

It will be understood that numerous arrangements, which well-known, may be employed to respond to the drop in pressure in the casing in order to actuate the controller. These may include, in addition to the Bourdon tube and the check valve-controlled pilot valves previously described, bellows-controlled pilot valves, differential pressure devices, and the like.

Also, other arrangements than that described may be employed to terminate each cycle. In cases where the casing holds a large volume of gas, the volume of gas injected into the tubing which will be sufficient to drop the casing pressure enough to actuate control valve 18 and shift piston 93 will also be sufficient to lift the fluid in the flow string to the surface. In such cases, the second timing wheel 51 and its pilot may be eliminated and line 79 connected to line 91. With this arrangement, upon the drop in pressure in the casing, which moves shift piston 93 to close bleed valve 16, pump 12 will be started and will raise the tubing to close the operating valve.

Another alternative is the provision of a pressure sensing element, such as another Bourdon tube, connected to the flow tubing. This element, upon sensing an increase in tubing pressure produced by the rise of the production fluid to the surface, could be connected to the pilot system in any suitable manner, which will be obvious to those skilled in this art, to activate pump 12 or to override timer 51.

Many other alterations and modifications will be evident to those skilled in the art and are deemed to be within the scope of the appended claims without departing from the spirit of this invention.

What I claim and desire to secure by Letters Patent is:

1. In a gas lift system for wells having a casing, a conduit for supplying lifting gas under pressure to the interior of the casing, a flow pipe string inside the casing comprising a lower section anchored against movement and an upper section reciprocable relative to the lower section, telescoping coupling means connecting said sections, said coupling means defining port means adapted to open and close in response to reciprocation of said upper section, fluid pressure-actuated means connected to said upper section for reciprocating the same, first time-responsive means operably connected to the fluid-actuated means to periodically cause said upper section to move downwardly to open said port means to thereby admit lifting gas into the flow pipe string from the casing, means operable in response to the resulting pressure drop in the casing to hold said upper pipe string section in said port-opening position and to cause gas to flow from said conduit into the casing, and second time-responsive means operable periodically to cause said upper section of the pipe string to move upwardly to the port-closing position.

2. In a gas lift system according to claim 1, wherein said fluid pressure-actuated means includes a cylinder enclosing the upper end of the upper section of said pipe string, a piston mounted about said upper end for reciprocating the same in said cylinder, and means for supplying pressure fluid to said cylinder.

3. In a gas lift system according to claim 2, wherein said last-mentioned means comprises a pressure fluid reservoir, a discharge conduit having a pump therein for delivering pressure fluid from said reservoir to said cylinder, a return conduit from said cylinder to said reservoir, and a bleed valve in said return conduit operably connected to said first time-responsive means.

4. In a gas lift system for wells having a casing, a conduit for supplying lifting gas under pressure to the interior of the casing, a flow pipe string inside the casing comprising a lower section anchored against movement and an upper section reciprocable relative to the lower section, a plurality of vertically spaced telescoping coupling means connecting said sections, each of said coupling means including relatively movable portions defin-

ing flow ports adapted to open and close in response to reciprocation of said upper section, the several flow ports being arranged to open sequentially in ascending order in response to downward movement of said upper section and to close sequentially in descending order in response to upward movement of said upper section, fluid-pressure actuated means connected to said upper section for reciprocating the same, a first time-responsive means operable to periodically activate said fluid-pressure actuated means to cause said upper section to descend to a position opening that flow port which will first admit lifting gas into the tubing string from the casing, flow-control means in said conduit operable in response to the resulting pressure drop in the casing to admit lifting gas from said conduit into the casing, a pressure-responsive means operably connected to said first time-actuated control means and operable in response to said pressure drop to stop the descent of said upper section at said position to hold said flow port in the open position, and a second time-responsive means operable at a pre-determined interval after actuation of said first time-responsive control means to activate said fluid-pressure actuated means to move said upper section upwardly to a position closing said port means to thereby stop admission of gas into the flow pipe string, and into the casing.

5. In a gas lift system according to claim 4, wherein said fluid-pressure actuated means includes a cylinder enclosing the upper end of the upper section of said pipe string, a piston mounted about said upper end for reciprocating the same in said cylinder, and means for supplying pressure fluid to said cylinder.

6. In a gas lift system according to claim 5, wherein said last-mentioned means comprises a pressure fluid reservoir, a discharge conduit having a pump therein for delivering pressure fluid from said reservoir to said cylinder, a return conduit from said cylinder to said reservoir, and a bleed valve in said return conduit operably connected to said first time-responsive means.

7. In a gas lift system for wells having a casing, a conduit for supplying lifting gas under pressures to the interior of the casing, and a control valve in the conduit, a flow pipe string inside the casing and comprising a lower section anchored against movement and an upper section reciprocable relative to the lower section, telescoping coupling means connecting said sections, said coupling means including port means adapted to open and close in response to reciprocation of the upper section of the flow pipe string relative to the lower section thereof, fluid pressure-actuated means connected to said upper section for reciprocating the same, a first time-actuated control means operable to periodically activate said fluid pressure actuated means to move said upper section of the flow pipe string to a position opening said port means to thereby admit lifting gas into the flow pipe string from said casing, a pressure-responsive means operably connected to said control valve and to said first control means operable in response to a drop in pressure in the casing resulting from said admission of lifting gas into the flow string to open said control valve to permit flow of gas from said conduit into said casing and to simultaneously actuate said first control means to maintain said upper section of the flow pipe string in the position opening said port means, and a second time-actuated control means operable at a pre-determined interval after actuation of said first control means to actuate said fluid pressure-actuated means to move said upper section of the flow pipe string to a position closing said port means to thereby stop admission of gas into the flow pipe string and permit the pressure in the casing to increase, said pressure-responsive means being actuated by said pressure increase to close said control valve.

8. In a gas lift system for wells having a casing, a conduit for supplying lifting gas under pressure to the interior of the casing, a flow pipe string inside the casing comprising a lower section anchored against movement and an upper section reciprocable relative to the lower section, telescoping coupling means connecting said sections, said coupling means defining a gas injection valve having port means adapted to open and close in response to reciprocation of said upper section, fluid pressure-actuated means connected to said upper section for reciprocating the same, first time-responsive means operably connected to the fluid-actuated means to periodically cause said upper section to move downwardly to a position opening said port means to thereby admit lifting gas into the flow pipe string from the casing, means operable in response to the resulting pressure drop in the casing cooperating with said fluid pressure-actuated means to stop the downward movement of said upper section whereby to hold said upper pipe string section in said port-opening position and to admit lifting gas from said conduit to the casing, and second time-responsive means operable on said fluid pressure-actuated means after a pre-determined time interval to raise said upper section of the pipe string to the port-closing position.

9. In a gas lift system according to claim 8, wherein said gas injection valve comprises concentric inner and outer sleeves having space therebetween to define flow passage means, an internal annular shoulder in the bore of the outer sleeve, an external annular shoulder on the inner sleeve, said shoulders being abuttable in response to relative longitudinal movement between the sleeves in one direction to form a metal-to-metal seal between the sleeves to close said passage means, and to separate upon relative movement of the sleeves in the opposite direction to open said passages, annular packing mounted between the sleeves on one side of said shoulder to form an auxiliary slidable seal between the sleeves, and a lip-type flexible seal between the sleeves on the opposite side of said shoulders to define a one-way check valve for said passage means.

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