

Aug. 10, 1943.

H. P. DE WIT

2,326,442

GAS-LIFT CONTROL

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2 Sheets-Sheet 1

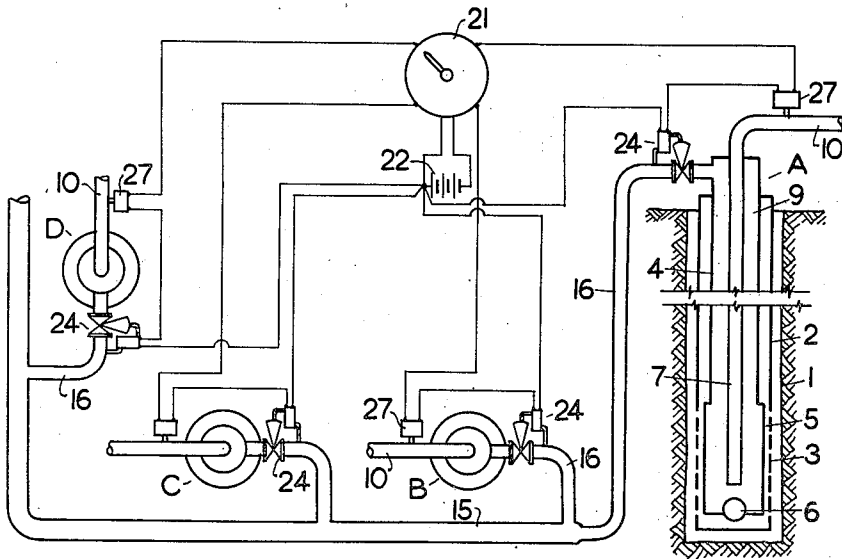


Fig. I

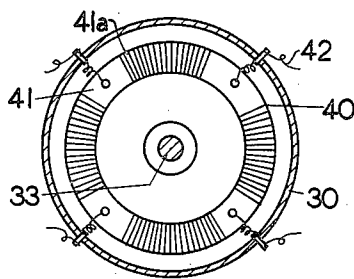


Fig. III

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2 Sheets-Sheet 2

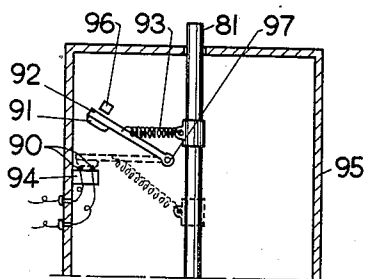


Fig. IV

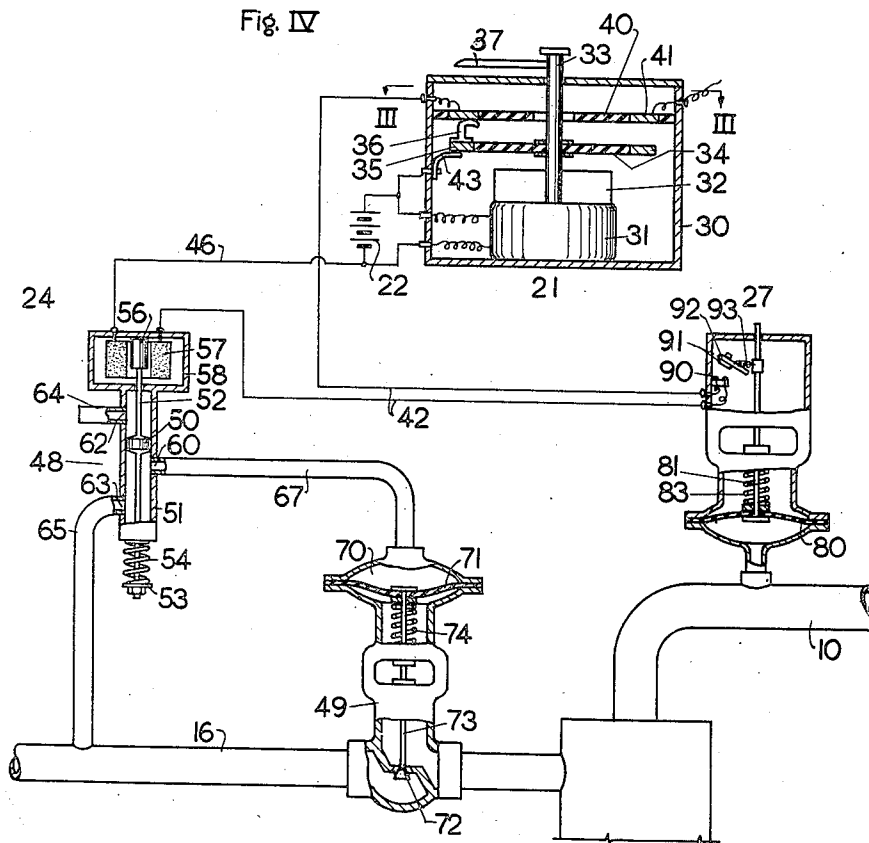


Fig. II

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UNITED STATES PATENT OFFICE

2,326,442

GAS-LIFT CONTROL

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8 Claims. (Cl. 103—240)

This invention relates to an automatic timing device for controlling the flow of oil from a well and pertains more particularly to a device for automatically controlling the intermittent supply of compressed gas to gas-lift pumps.

In most gas-lift devices the duration of the working period, that is, of the time during which gas is supplied to the gas-lift pump, is independent of fluctuations in the pressure of the gas supply and of variations in the quantity of well liquid being raised. Thus, the working period is generally longer than necessary, and the gas consumption is higher than the optimum.

Also, in many gas-lift systems, central gas distributors have been used, which cause the valves controlling the flow of pressure gas to individual wells to open and close in succession, so that the working periods do not coincide, thereby avoiding overlapping working periods which may cause violent pressure fluctuations throughout the system. However, such central control devices are not easily subject to fine control so as to obtain the optimum gas consumption. The working periods for the various wells are generally longer than necessary, and consequently there is some waste of gas.

It is therefore an object of this invention to provide a gas-lift system having a central gas supply intermitter or regulator capable of serially spacing the working periods of individual wells, and means associated with each well and responsive to the liquid discharged therefrom for terminating the working period of said well independently of the central intermitter, whereby an economical consumption of pressure gas is insured.

It is another object to provide an intermittent gas-lift system having automatic means for controlling the supply of pressure gas to each well, whereby the need for fine manual adjustment of the working periods of the individual wells is eliminated.

It is another object to provide a gas-lift system attaining the above objects, which system is mechanically simple and advantageously flexible for application to varying field conditions.

Briefly, these and other objects are attained by the present gas-lift control system wherein a central timing device serially spaces the closure or completion of electrical circuits energizing electrically-actuated valves which control the supply of pressure gas to the individual wells, and interrupter means associated with each well adapted to break the electrical circuit and thereby to stop the input of pressure gas for said well in response to flow of oil therefrom.

The present invention will be more clearly understood from the following description of a preferred embodiment taken with reference to the drawings, wherein:

5 Figure I is a diagrammatic view of the present gas-lift system, showing one well in vertical section and the rest of the system in plan view.

10 Figure II is a schematic vertical sectional view of the gas-lift system in relation to an individual well, showing the various working parts in greater detail.

Figure III is a cross-sectional view of the central regulator as taken along the line III—III of Figure II.

15 Figure IV is an enlarged detailed view of a preferred embodiment of the interrupter switch mechanism.

20 The gas-lift control system of the present invention is described in relation to a pump having a displacement chamber and an eduction tube, although the present device may be applied equally well to other intermittent gas-lift pumps. Referring to well A shown in vertical section in Figure 1, a casing 2 having a perforated liner 3 attached to the lower end thereof is placed in a borehole 1. Depending within the casing 2 is a tubing string 4 having at the bottom thereof an enlarged portion forming a displacement chamber 5. An inwardly-opening check valve 6 is provided in the lower portion of chamber 5 to permit well liquid to accumulate therein. Extending downwards through the tubing string 4 and into the displacement chamber is an eduction tube 7. In operation, liquid from the producing formations surrounding the borehole is allowed to flow through the perforations of the liner 3 into the chamber 5 through the check valve 6 when the pressure in chamber 5 is sufficiently reduced; the accumulated liquid is then lifted through the eduction tube 7 by compressed gas supplied from a gas supply pipe 16 to the annular space 9 between the tubing string 4 and eduction tube 7; the check valve 6 in the lower portion of the chamber 5 closes to avoid applying high pressures to the producing formations, which may cause production losses; the well liquid and the gas raising said liquid are discharged from the eduction tube 7 through discharge or oil flow line 10 attached thereto at the well head.

55 To effect this operation of the elements described or their equivalents which, in combination, may be referred to as a gas-lift pump, the pressure gas or working fluid in the pipe or line 16, which communicates with the gas supply header 15, is alternately admitted into the annu-

lar space 9 and shut off therefrom by means of an electrically-operated control valve 24. In the general arrangement of the present gas-lift control system, as shown in Figure I, the operation of the control valve 24 for each well is controlled by the combination comprising an electrically-operated central timing device or regulator 21, which also governs the operation of the control valves 24 in a plurality of wells B, C, D, etc., an electrical current source 22 and, for each well, a current interrupter 27 actuated by or responsive to the liquid flow or discharge in line 10 and adapted to break the electrical current actuating the control valve 24 in response to a flow of oil from the discharge line 10.

Referring to Figures II and III showing the various parts in more detail, a preferred embodiment of the central intermitter or regulator 21 comprises a housing 30, an electric motor 31 connected to the electrical source 22 which may comprise a cell, storage battery, or the terminals of any suitable power supply system, and clock-work or escapement means 32 or the like adapted to regulate the rotation of the motor shaft 33. Attached to the shaft 33 and rotatable therewith is a disk 34, or other suitable means, provided with an insulated ring 35 in its outer circumferential portion. An electrical contact 36 attached to the insulated ring 35 is carried in a circular path by the rotation of the disk 34 and makes contact with a stationary ring 40 having suitably spaced sector contacts 41 between insulating sectors 41a, as shown more clearly in Figure III. To each contact 41 is connected an electrical conduit 42 leading to a gas-injection control valve 24. By means of a stationary contact 43 attached to the wall of the housing 30 and held against the rotating ring 35, electrical current may pass from the electrical current source 22 through the stationary contact 43, the rotating ring 35, the rotating contact 36, and one of the insulated contacts 41 in the stationary ring 40 through the electrical conductors 42 comprising contacts 90-91 to an electrically-operated valve 24. Suitable connections may also be provided between the electrical current source 22 and each control valve 24 through the ground. For example, when the distance from the central regulator 21 to the valve 24 is greater than about 400 feet, the conductor 46 may be eliminated by grounding the lower terminal of the source 22 and the left-hand terminal of valve 24. If desired, the upper end of the motor shaft 33 may be terminated outside the housing 30 and fitted with a pointer 37 to indicate which well is being produced at the moment by the position of the pointer in relation to a dial or markings (not shown) formed on the adjacent upper surface of the housing. Instead, signal lights (not shown) may be provided in series with the various circuits to the wells for the same purpose. It is to be noted that the length of the contact sectors 41 may be varied to roughly set the length of the gas admission periods for the different wells and that, further, the various contacts 41 may be combined, if desired, into groups or combinations for timing the gas injection periods to suit individual well requirements.

The gas control valve 24 may be any suitable electro-magnetic valve or the like. For example, in a preferred mechanism a solenoid-operated pilot valve 48 controls a diaphragm-motor valve 49 which, in turn, controls the passage of gas supply through the gas injection line 16. The pilot valve 48 may comprise a valve 50, a valve

casing 51, a valve stem 52 extending through the ends of the casing 51, a spring-restraining plate 53 attached to one end of the valve stem 52, a spring 54 compressed between the end of the casing 51 and the plate 53, an armature 56 attached to the other end of the valve stem 52, and a solenoid 57 surrounding the armature 56. The solenoid 57 and armature 56 may be encased in a protective housing 58, if desired. The valve casing 51 is provided with a centrally spaced port 60 and two offset ports 62 and 63. Attached to offset port 62 is a vent pipe 64 and to port 63 is a conduit 65 communicating with gas supply line 16. A conduit 67 is connected to the central port 60 and leads to the diaphragm chamber 70 of the diaphragm-motor valve 49. When current is applied to the solenoid 57, the armature 56 and the valve stem 52 and valve 50 attached thereto are moved against the action of spring 54 to a position with the valve 50 between the vent port 62 and the diaphragm port 60, whereby fluid communication between the gas supply port 63 and diaphragm port 60 is provided. When the solenoid 57 is not energized, the valve is moved to the other side of the diaphragm port 60 by the action of the spring 54 whereby the pressure in the diaphragm chamber 70 is released through port 62 and vent line 64.

The diaphragm-motor valve 49 may be of any suitable type adapted to open when pressure is applied to one side of its diaphragm and may, in a preferred form, comprise diaphragm chamber 70, a diaphragm 71, a valve 72 connected to the diaphragm 71 by means of a valve stem 73, and a spring 74 acting against the lower side of the diaphragm 71 and tending to close the valve 72.

In the electrical circuit, such as in conductor 42, from the central regulator 21 to the control valve 24 is a normally closed circuit interrupter 27 adapted to break the electrical circuit in response to a certain condition (pressure, impact, rate of flow, etc.) in the discharge line 10 due to flow of liquid or oil therethrough. For example, a suitable arrangement comprises a diaphragm 80 exposed to the pressure in the flow line 10 near the well head, a stem 81 attached at one end to the diaphragm 80, a normally closed switch operatively connected to the other end of the stem 81, and a spring 83 acting against the low pressure side of the diaphragm 80 and tending to close the switch. The switch is preferably adapted, for example, by means of a toggle arrangement, to open at a predetermined high pressure and to return to closed position at a predetermined lower pressure. In a preferred form, as shown in Figure IV, the switch may comprise a pair of stationary contacts 90 terminating the break in the electrical conductor 42, a movable contact 91 adapted to bridge said pair of stationary contacts 90 and carried at one end of an arm 92 pivoted at the other end on a shaft 97 carried by the housing 95, and a toggle spring 93 linking the center of the arm 92 to the stem 81. The contacts 90 are supported on a bracket 94 extending from the inner wall of the switch housing 95. The swing of the pivoted arm 92 is limited in one direction by the contacts 90 and bracket 94 and in the other direction by a stop 96. By suitably adjusting or selecting the springs 83 and 93, the opening and closing pressures of the switch can be controlled.

In operation of the gas-lift control system of the present invention, the central regulator 21, control valve 24 and interrupter means 27 are arranged as described hereinabove. The rota-

tion of the contact 36 pressing against the spaced contacts 41 of the ring 40 causes the completion of the electrical circuits to the various control valves 24 in a predetermined sequence, whereby only one well at a time draws on the supply of pressure gas and violent fluctuations in the pressure of the gas supply are avoided. On completing the electrical circuit from the electrical current source 22 through stationary contact 43, rotating ring 35 and contact 36, one of the individual contacts 41 in the ring 40, electrical conductor 42 and the closed interrupter switch 90—93 to the solenoid 57, the armature 56 with the valve stem 52 and valve 50 attached thereto are caused to be moved into diaphragm-actuating position by the energization of the solenoid 57. With the valve 50 in this position, pressure gas passes from the gas supply line 16 through the small pipe 65, the valve casing 51, the diaphragm port 60 and the conduit 67 into the diaphragm chamber 70, wherein the pressure acts upon and depresses the diaphragm 71 and thereby causes the valve 72 attached to the diaphragm 71 by means of stem 73 to be opened against the action of the spring 74.

Pressure gas then flows through the thus-opened valve 72 down the annular space 9 to the displacement chamber 5 and forces the accumulated liquid up the education tube 7 and out the discharge line 10. The flow of oil through the discharge line causes an increase in the pressure on the diaphragm 80 of the circuit interrupter 27. The pressure-responsive upward movement of the diaphragm 80 moves the switch arm 92 attached thereto by stem 81 into open position at a predetermined pressure against the action of the spring 83, whereby the electrical circuit through line 42 from the central regulator 21 to the solenoid 57 of the control valve 24 is broken. The armature 56 is then no longer pulled upward by the magnetic field of the solenoid and the valve 50 is moved to the opposite side of the diaphragm port 60 by the action of the spring 54, whereby the ports 62 and 60 are in communication and the pressure in the diaphragm chamber 70 is vented to the atmosphere through vent conduit 64. With the release of pressure in the chamber 70, the diaphragm 71 is moved upward and the valve 72 is closed by the action of spring 74. Thus, the supply of pressure gas to the gas-lift pump is shut off at the optimum time, that is, when the oil flows from the discharge or flow line 10.

The gas then remaining in the annular space 9 expands, thereby further lifting the liquid in the education tube 7, and finally escapes through the discharge line 10. During the expansion of the remaining pressure gas in the annular space 9 and its exhaustion from the gas-lift pump, the continued rotation of the ring 35 causes the electrical circuit to the control valve 24 of the well concerned to be broken. Thereafter, the pressure against the diaphragm 80 of the circuit interrupter 27 drops to a predetermined low pressure, at which the spring 83 re-closes the switch after overcoming the pressure in the line 10 and, with the preferred form, also the delayed action of the toggle-type switch 90—93. It is preferable that the difference between opening and closing pressures of the circuit interrupter 27 should be substantial in order to avoid accidental closing of the circuit due to pressure pulsations. Then this well again passes through the stage of accumulation of well liquids in the chamber 5 while a similar series of actions are automatically ef-

ected in series on the other wells connected to the central regulator 21.

By means of the present gas-lift control system the most economical gas consumption is obtained.

The present control system likewise eliminates the necessity of frequent attendance of an operator to adjust the length of the contacts 41 in the central regulator 21. Rather, the gas supply is automatically shut off at the optimum time, either by the central regulator 21 or, if the lifting operation is effected in a time shorter than that for which the central regulator had been adjusted, by the circuit interrupter 27 in response to a flow of oil out through the discharge line 10. In other words, the working period is roughly adjusted in the central regulator 21 by the length of the contact 41 and the fine adjustment to the optimum is obtained by the action of the circuit interrupter 21. In addition to effecting a decrease in gas consumption, the present control system increases crude oil production by increasing the liquid accumulation time and thereby increasing the volume of oil raised in each operation of the gas-lift pump.

I claim as my invention:

1. In an intermittent gas-lift system comprising a plurality of wells, a source of supply of pressure gas, and for each well a displacement chamber for liquid to be lifted, pressure conduit means communicating with said pressure gas source for admitting said gas to said chamber, an electrically operated valve in said pressure conduit means for controlling the flow of said gas, and conduit means from said chamber for discharging from said well the liquid raised by said gas, a control system comprising a source of electric current, a circuit for each well connecting said electric source to the electrically operated valve for said well, a time-responsive intermitter common to said circuits for cyclically making and breaking said circuits in a predetermined sequence, and a normally closed interrupter at each well operated by the liquid discharged therefrom for breaking the circuit for each well.

2. In an intermittent gas-lift system comprising a plurality of wells, a supply of pressure gas, valve-controlled conduit means for each well for admitting said gas to said wells, and conduit means for discharging from each well the liquid raised by said gas, a control system comprising an intermitter for controlling the cyclical opening and closing of the valves admitting the gas to the several wells, and an interrupter at each well operated by the liquid discharged therefrom for controlling the closing of the valve admitting the pressure gas to said well.

3. In an intermittent gas-lift system comprising a plurality of wells, a supply of pressure gas, valve-controlled conduit means for each well for admitting said gas to said wells, and conduit means for discharging from each well the liquid raised by said gas, a control system comprising a time-responsive intermitter for controlling the cyclical opening and closing of the valves admitting the gas to the several wells in a predetermined sequence, and an interrupter at each well operated by the liquid discharged therefrom for controlling the closing of the valve admitting the pressure gas to said well.

4. In an intermittent gas-lift system comprising a plurality of wells, a supply of pressure gas, conduit means between said pressure gas supply and each of said wells for admitting said gas thereinto, an electrically operated valve in each of said pressure conduit means for controlling

the flow of said gas, and conduit means for discharging from each well the liquid raised by said gas, a control system comprising a source of electric current, a circuit for each well connecting said source to the electrically operated valve for said well, an intermitter for cyclically making and breaking said circuits, thereby controlling the cyclical opening and closing of said valves, a normally closed interrupter in each circuit adapted to break said circuit, thereby controlling the closing of said valve independently of the intermitter, and means actuated by the liquid discharged from the well controlled by said circuit for opening said interrupter.

5. In an intermittent gas-lift system comprising a plurality of wells, a supply of pressure gas, conduit means between said pressure gas supply and each of said wells for admitting said gas therinto, an electrically operated valve in each of said means for controlling the flow of said gas, and conduit means for discharging from each well the liquid raised by said gas, a control system comprising a source of electric current, a circuit for each well connecting said source to the electrically operated valve for said well, a time-responsive intermitter for cyclically making and breaking said circuits in a predetermined sequence, thereby controlling the cyclical opening and closing of said valves, a normally closed interrupter in each circuit adapted to break said circuit, thereby controlling the closing of said valve independently of the intermitter, and means actuated by the liquid discharged from the well controlled by said circuit for opening said interrupter.

6. In an intermittent gas-lift system comprising a plurality of wells, a supply of pressure gas, conduit means between said pressure gas supply and each of said wells for admitting said gas therinto, an electrically operated valve in each of said means for controlling the flow of said gas, and conduit means for discharging from each well the liquid raised by said gas, a control system comprising a source of electric current, a circuit for each well connecting said source to the electrically operated valve for said well, a time-responsive intermitter for cyclically making and breaking said circuits in a predetermined sequence, thereby controlling the cyclical opening and closing of said valves, a normally closed interrupter in each circuit adapted to break said circuit, thereby controlling the closing of said valve independently of the intermitter, and

means responsive to the pressure in the liquid discharge conduit of the well controlled by said circuit for opening said interrupter.

7. In an intermittent gas-lift system comprising a plurality of wells, a supply of pressure gas, conduit means between said pressure gas supply and each of said wells for admitting said gas therinto, an electrically operated valve in each of said means for controlling the flow of said gas, and conduit means for discharging from each well the liquid raised by said gas, a control system comprising a source of electric current, a circuit for each well connecting said source to the electrically operated valve for said well, a time-responsive intermitter common to said circuits for cyclically making and breaking said circuits in a predetermined sequence, thereby controlling the cyclical opening and closing of said valves, a normally closed interrupter in each circuit adapted to break said circuit, thereby controlling the closing of said valve independently of the intermitter, and means responsive to the pressure in the liquid discharge conduit of the well controlled by said circuit for opening said interrupter, and resilient means adapted to overcome a predetermined lower pressure in said conduit for closing said interrupter.

8. In an intermittent gas-lift system comprising a plurality of wells, a source of supply of pressure gas, and for each well a displacement chamber for liquid to be lifted, pressure conduit means communicating with said pressure gas source for admitting said gas to said chamber, an electrically operated valve in said pressure conduit means for controlling the flow of said gas, and conduit means from said chamber for discharging from said well the liquid raised by said gas, a control system comprising a source of electric current, a circuit for each well connecting said electric source to the electrically operated valve for said well, a time-responsive intermitter common to said circuits for cyclically making and breaking said circuits in a predetermined sequence, a normally closed interrupter in each circuit adapted to break said circuit, thereby controlling the closing of said valve independently of the intermitter, and means actuated by the liquid discharged from the well controlled by said circuit for holding said interrupter in open position when liquid is discharged from the well.

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