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OIL WELL CONTROL SYSTEM

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2 Sheets-Sheet 1

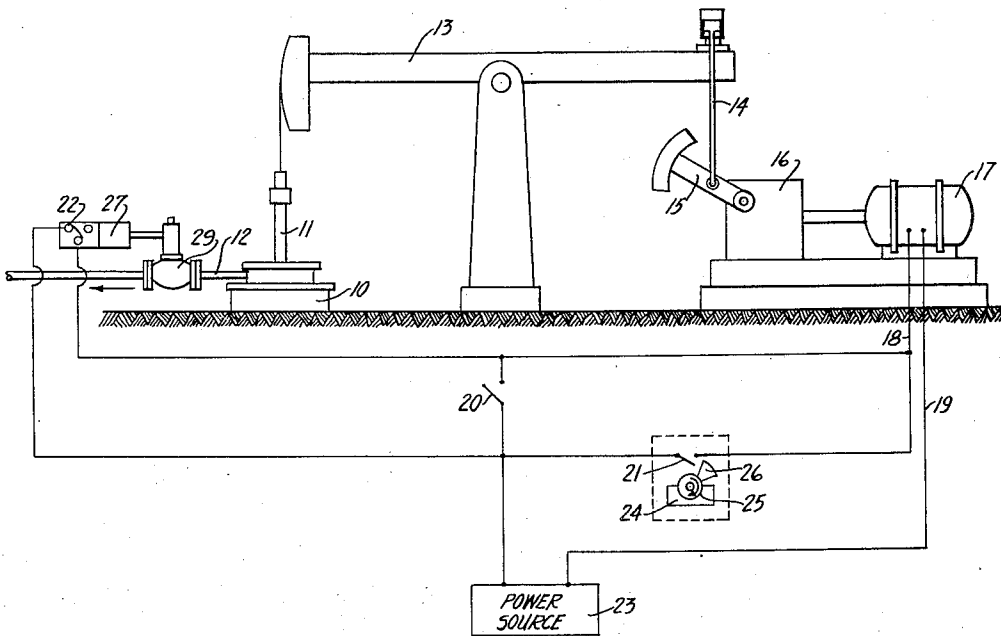


FIG. 1

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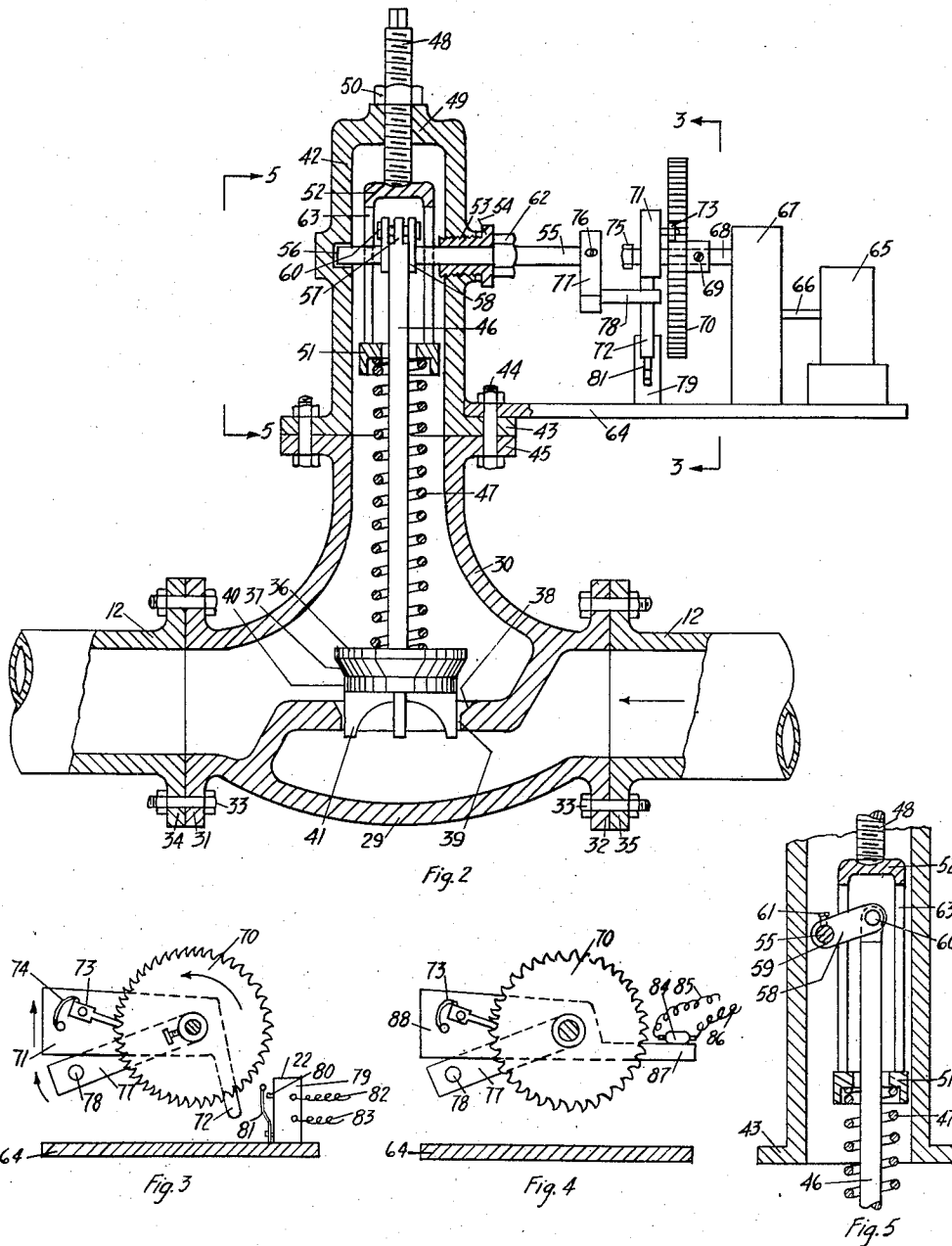
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OIL WELL CONTROL SYSTEM

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5 Claims. (Cl. 103—25)

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This invention pertains to a system for controlling the operation of oil well pumps, and relates more particularly to an automatic system for the control of electrically driven pumps in wells producing small quantities of fluid.

In many wells, especially during the later stages of their exploitation, the quantity of fluid entering the borehole from the formation is often less than that which can be readily handled by the pumping equipment, that is, the volumetric capacity of the pumping equipment installed at the well is such that a sustained operation thereof results in pumping the well "off" or dry. Under these conditions, it is usual to produce such wells by intermittent pumping, so that the fluid is permitted to accumulate in the borehole during pump shut-down periods, and is exhausted from the well during alternate pump operation periods.

Such intermittent operation of the well pumping equipment may be controlled either manually, whereby the pump is started and stopped by hand for each operating period, or automatically, whereby the pump is started and stopped at predetermined set intervals by a time-responsive mechanism, such as an electrically or spring driven clock.

The disadvantages of manual pump control methods, involving the hazards of the human element, are obvious. The main disadvantage of most automatic time-responsive mechanisms is that they are adjusted to shut off and stop the pump after a certain time interval. If the time interval is not accurately determined for each well, the pumping period may be prematurely cut off at a time when considerable oil remains in the borehole, thus lowering the efficiency of the pumping operations, or the pumping period may be cut off only long after the borehole has been pumped substantially dry, thus increasing the wear on the pumping equipment and wasting power.

It is, therefore, an object of this invention to provide a well-pumping control system wherein the duration of the pumping period is automatically adjusted to the amount of fluid available for pumping from a well during said pumping period.

It is also an object of this invention to provide a well-pumping control system wherein the operation of the pump is automatically stopped when the fluid in the borehole is depleted.

Another object of this invention is to provide a system wherein each pumping period is started by an automatic time-responsive device, and is terminated by an automatic device responsive to well conditions.

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

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Figure 1 is a diagrammatic sketch illustrating the component parts of the present system;

Figure 2 is a view, partly in cross-section, of the flow-responsive device and pump shut-off element of the present system;

Figures 3 and 4 are cross-sectional views, taken along the line 3—3 of Figure 2, showing alternative arrangements of shut off switches actuated by the flow-responsive device.

Figure 5 is a cross-sectional view taken along the line 5—5 of Figure 2.

As shown in Figure 1, a pump located in well 10 is actuated in a well known manner by means of a sucker rod string 11, the well fluid lifted to the surface being directed to storage through a pipe 12. The sucker rod string 11 is reciprocated in the well by the oscillating motion of a walking beam 13, which is driven, through a pitman 14, crank 15 and speed reducing mechanism 16, by a prime-mover 17 such as an electric motor receiving its power through leads 18 and 19. It is understood that any suitable type of motor or engine may be used as the prime mover 17, such, for example as a gasoline engine having its energizing ignition current supplied through leads 18 and 19.

The control circuit of the pump motor 17 comprises three control switches 20, 21 and 22 that are connected in parallel between the motor 17 and a power source 23. Switch 20 is a normally open hand-operated switch which, when closed, places the pump 17 in continuous operation. Control switch 21 is normally open being adapted to be closed by a time-responsive device such as an electric or spring driven clock mechanism 24 of any desired type. For simplicity, this mechanism is shown in Figure 1 as comprising a rotating wheel or disc 25 provided with a segment 26 adapted to close the switch 21 by contact therewith. It will be seen that the time at which the switch 21 is closed and opened can be accurately pre-set or controlled by suitably adjusting the speed of rotation of the disc 25 and/or the size of the segment 26.

Control switch 22 is normally closed all the time that fluid is being pumped from the well borehole and through the delivery line 21. Preferably, switch 22 is small in size, such as a micro-switch, or a sealed-mercury type switch. The switch 22 is mounted on, and adapted to be actuated by, a flow-responsive controller device 27 which is in turn connected through suitable linkage means to the gate or flapper of a check valve 29 in line 12.

As shown in Figure 2, the flow-responsive controller device comprises a check valve 29, the body 30 of said valve being equipped with flanges 31 and 32 which may be secured by means of bolts 33 to flanges 34 and 35 in the pipe line 12. The check valve 29 is of the globe type having a

vertical-lift gate or disc 36 with a beveled edge 37 adapted to be seated in a beveled edge horizontal valve seat 38 surrounding the valve opening 39. Preferably, a plate 40 of suitable thickness is fixedly secured to or integrally formed on the bottom of the disc 36, said plate 40 having a diameter substantially equal to that of the valve opening 39 and adapted to close said opening 39. A plurality of downwardly-extending guide bars 41 may be secured to the lower side of the plate 40 and disc 36 for guiding said disc into its proper seating position on closing, and for maintaining the disc 36 in a fixed position with regard to the valve opening 39 when the valve is open.

A valve bonnet 42 having a lower flange 43 is secured by bolts 44 to a flange 45 of the valve body 30. A valve stem 46 is secured in either a fixed or hinged manner to the top of the valve disc 36, said stem 46 extending upwardly into the bonnet 42. The disc 36 of the check valve is normally maintained in a closed position by a compression spring 47 that surrounds the valve stem 46 and bears against the top of the disc 36. Compression of the spring 47 may be adjusted, without dismantling the valve, by an adjustment screw 48 through the top 49 of the bonnet 42, said screw being adapted to be fixedly held in place by a lock nut 50. Interposed between said compression spring 47 and screw 48 is a suitable yoke means comprising either a slotted tubular member, or a ring 51 and a plate 52 maintained in fixed space relationship to each other by at least two, and preferably four, spacing bars 63, said yoke means being positioned in said valve bonnet 42 so that said spring 47 and screw 48 bear against the ring 51 and disc 36, respectively.

A hole, 53, drilled through the side wall of the bonnet 42 and fitted with a bushing or bearing 54, serves as bearing means for a horizontal shaft 55 which extends into said bonnet above and to one side of 43, as seen from Figure 5. A recess 56 may be drilled in the inner wall of the bonnet 42 diametrically opposite hole 53, said recess 56 serving as bearing means for the end of the shaft 55 positioned within the bonnet 42. The shaft 55 and the tapered and drilled upper end 57 of the valve stem 46 are operatively connected together by a flat link member 58 having a hole 59 (Figure 5) through one end, whereby said shaft 55 may pass through said hole 59. The other end of the link 58 is slotted and drilled to fit around the tapered and drilled end 57 of the valve stem 46, the drilled ends of said link 58 and said stem 46 being secured together in hinged relationship by a pin 60 as shown in Figure 2. The link 58 is locked in a predetermined fixed position on the shaft 55, and between the spacing bars 63 of the yoke means, by a set screw 61. The shaft 55 is suitably packed in a fluidtight manner around its bearing 54, said packing being held in place by a packing nut 62 or any other suitable means.

Supporting means for related control equipment may be positioned adjacent the valve 29. In this embodiment, a platform 64 is shown in Figure 2 as being bolted to the flange 43 of the bonnet 42 beneath the extending shaft 55. Carried on said platform 64 are motor means, such as a clock mechanism, spring motor or small electric motor 65 having its shaft 66 coupled, if desired, to the high speed shaft of suitable speed reducing means 67. Fixedly secured to the low-speed shaft 68 of the speed reducer 67, by a set screw 69, is a ratchet wheel 70 which may be slowly rotated at any predetermined speed, say, one revolution per hour. Freely mounted for

swinging on said shaft 68 adjacent the ratchet wheel 70 is an actuator or cam 71 formed with a small lever arm 72 (Figure 3). Due to its shape and loose eccentric mounting on the shaft 68, the cam 71 has a tendency to swing downward so that its longer and heavier end depends below said shaft. However, as will be explained below, the cam 71 is normally maintained in a substantially horizontal position by a pawl 73 (Figure 3) carried by said cam and actuated by a spring 74 to engage the teeth of the ratchet wheel 70. Thus, the ratchet wheel 70 and pawl 73 form overriding clutch means or adjustable coupling means between the drive shaft 68 and the actuator 71. A nut 75 at the end of shaft 68 prevents any horizontal movement of the cam 71 on said shaft 68.

Affixed to the end of shaft 55 at a predetermined angle, by a set screw 76, is a rocker arm 77 having an extending pin 78 secured to one end. Preferably, the low-speed shaft 68 of the speed reducer is mounted coaxially with shaft 55 extending from the bonnet 42 of the valve, whereby the rocker arm 77 may be positioned so that its pin 78 extends beneath the cam 71 to establish contact therewith, as shown in Figure 2. Thus, any upward motion of the rocker arm 77 and pin 78 is transferred to the cam 71.

The pump cut-off switch 22 is shown in Figures 2 and 3 as consisting of a switch housing 79, a switch button 80 extending to the switch inside said housing, and a contact spring arm 81 adapted to be contacted by the lever arm 72 of the cam 71, whereby the spring arm 81 presses the switch button 80 and opens the switch 22. Current passes switch 22, when it is closed, through leads 82 and 83. It is realized that any other suitable type of switch may be used and mounted with regard to the above described equipment so that it will be opened by a predetermined movement of the cam 71. Thus, as shown in Figure 4, a switch 84 of the mercury-sealed type having leads 85 and 86 secured thereto may be mounted on the arm 87 of a cam 88 whereby any movement of said cam 88 beyond a predetermined point will tilt the switch 88 so that the mercury contained therein flows to one end of the switch housing thus opening said switch.

The present pumping system may be put into operation by closing the hand-operated switch 20 (Figure 1) to start the motor 17 which causes the pump in the well 10 to be reciprocated. The fluid delivered by the pump surges or flows through the delivery line 12 with every stroke of the pump. Each surge of fluid through the line, in the direction indicated by the arrow in Figure 2, causes the disc 36 of the check valve to be raised vertically in the valve opening 39. Since there is a plate 40 secured to the bottom of the disc 36, this plate 40 acts as a piston and no fluid starts to flow through the opening valve until the gate has been raised a distance equal to the thickness of the plate 40. This serves to compensate for "play" or lost motion in the linkage of the present device.

As the disc 36 is raised against the compression of the spring 47, the link member 58 is moved upward causing the horizontal shaft 55 to rotate, for example, in a clockwise direction, when viewing the valve housing from the side of the motor 65. The rocker arm 77, being fixedly attached to shaft 55 is also moved in a clockwise direction, that is, the arm 77 is moved upwardly so that its pin 78 contacts the cam 71 and raises it so that

its lever arm 72 is out of contact with the switch spring 81 thus allowing spring-loaded switch 22 to automatically close.

With the switch 22 closed the hand-operated switch 20 may be opened and the motor 17 will continue to operate the pump as long as lever 72 does not contact and open switch 22, the operation being as follows: The cam 71 is mounted loosely on shaft 68 and its center of gravity is disposed so that it tends to swing counter-clockwise on said shaft. However, the spring-loaded pawl 73 engages the cam 71 with the ratchet wheel 70, so that the cam can move counter-clockwise only together with said wheel, which is adjusted to rotate continuously at some suitable low speed, such as one revolution per hour. As the slow rotation of the wheel 70 tends to bring the lever 72 of the cam 71 into contact with switch 22 to open said switch, this tendency is counteracted by the action of the pump, which forces a surge of fluid through the check valve 29, raising stem 46 and actuating rocker arm 77 and pin 78 to rotate the cam 71 clockwise about its shaft whereby the pawl 73 is caused to disengage one tooth on the ratchet wheel and to engage another tooth further up. The cam is thus maintained in a substantially horizontal or any other desired predetermined position by two opposing actions: the continuous slow rotation of the ratchet wheel in one direction, and the intermittent rotation in the reverse direction due to the lifting effect applied by rocker arm 77 and pin 78 every time that the valve 29 operates. However, when the well is dry, and fluid is no longer being pumped through the check valve 29, the valve disc 36 remains closed, and the link 58 and rocker arm 77 no longer operate to counteract the steady rotation of wheel 70. With the rocker arm 77 and pin 78 at their lowermost position, the cam 71 slowly rotates with the ratchet wheel 70 in a counter-clockwise direction until the lever arm 72 of the cam 71 contacts the spring 81 on the switch 22 and causes it to open shutting off the pump motor 17.

Instead of being started manually by means of switch 20 the pump motor may be automatically started again, after a predetermined time interval, by the rotating segment 26 of the time-responsive device which closes the switch 21 and holds it close for the length of time that it takes for said segment 26 to rotate past the switch, say, 10 minutes, whereafter the system is maintained in further operation by the switch 22 in the manner described above.

I claim as my invention:

1. A control system for a well installation comprising a reciprocating well pump, a prime mover for said pump, an energizing electric circuit for said prime mover, and conduit means for the fluid delivered by said pump, said control system comprising a normally closed switch in said electric circuit, adjustable actuator means for opening said switch upon movement to a predetermined position, motor means for continuously moving said actuator means toward said position, check valve means in said conduit means, and transmission means between said check valve means and said actuator means responsive to the periodic opening at each pump stroke of said check valve means by the pump fluid for periodically moving said actuator means in a direction opposite to that of the motion of said motor means, whereby said actuator means are prevented from opening said switch during the delivery of the pump fluid to said conduit means.

2. A control system for a well installation comprising a reciprocating well pump, a prime mover for said pump, an energizing electric circuit for said prime mover, and a conduit for the fluid delivered by said pump, said control system comprising a normally closed switch in said electric circuit, adjustable actuator means for opening said switch upon movement to a predetermined position, slow-speed motor means for continuously moving said actuator means toward said position, a check valve in said conduit, a vertical-lift disc in said check valve, a valve stem secured to the top of said disc, and linkage means between said valve stem and said actuator means responsive to the periodic opening of said check valve by the pump fluid for periodically moving said actuator means in a direction opposite to that of the motion of said motor means, whereby said actuator means are prevented from opening said switch during the delivery of the pump fluid to said conduit means.

3. A control system for a well installation comprising a reciprocating well pump, a prime mover for said pump, an energizing electric circuit for said prime mover, and a conduit for the fluid delivered by said pump, said control system comprising a switch in said electric circuit, said switch being in a closed position while a fluid is being pumped through said conduit, actuator means for opening said switch upon movement to a predetermined position, slow-speed motor means, overriding clutch means coupling said motor means to said actuator means for continuously moving said actuator means toward said position, a check valve in said conduit, a vertical-lift disc in said check valve and transmission means between said disc and said actuator means responsive to the periodic opening of said check valve means by the pump fluid for periodically moving said actuator means in a direction opposite to that of the motion of said motor means, whereby said actuator means are prevented from opening said switch during the delivery of the pump fluid to said conduit means.

4. A control system for a well installation comprising a reciprocating well pump, a prime mover for said pump, an energizing electric circuit for said prime mover, and conduit means for the fluid delivered by said pump, said control system comprising a normally closed switch in said electric circuit, a check valve in said conduit means, a vertical-lift disc in said valve, a valve stem secured to the top of said disc and movable therewith, a first shaft extending into said valve above said valve stem, linkage means connecting said valve stem and said shaft whereby a vertical motion of the valve stem is translated into an intermittent rotation of said shaft, motor means mounted adjacent said valve, a second shaft continuously rotated by said motor means, a ratchet wheel fixedly mounted on said second shaft, an actuator freely mounted on said second shaft, said actuator being adapted to open the switch in the electric circuit upon movement to a predetermined position, a spring-loaded pawl mounted on said actuator for engaging said ratchet wheel whereby said actuator is continuously moved toward said position by said ratchet wheel and lever means mounted on said first shaft, said lever means being responsive to the periodic opening of said check valve by the pump fluid for periodically moving said actuator in a direction opposite to that of said ratchet wheel, whereby said actuator is prevented from opening said

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switch during the delivery of the pump fluid to said conduit means.

5. A control system for a well installation comprising a reciprocating well pump, a primer mover for said pump, an energizing electric circuit for said prime mover, and conduit means for the fluid delivered by said pump, said control system comprising first and second switches connected in parallel in said electric circuit, said first switch being normally closed, said second switch being normally open, adjustable actuator means for opening said first switch upon movement to a predetermined position, motor means for continuously moving said actuator means toward said position, check valve means in said conduit, transmission means between said check valve means and said actuator means responsive to the periodic opening of said check valve means by the pump fluid for periodically moving said

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actuator means in a direction opposite to that of the motion of said motor means, whereby said actuator means are prevented from opening said switch during the delivery of the pump fluid to said conduit means, and time responsive control means for closing said second switch at predetermined time intervals.

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