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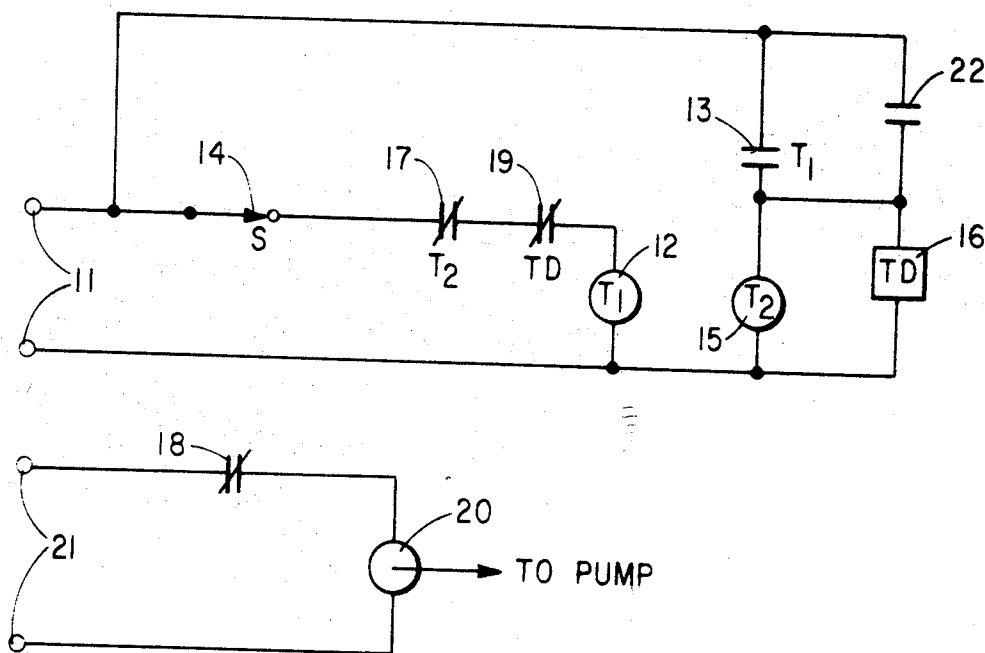
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[54] **PUMP-OFF CONTROLLER**
2 Claims, 1 Drawing Fig.

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 F04b 49/06; F04d 15/02
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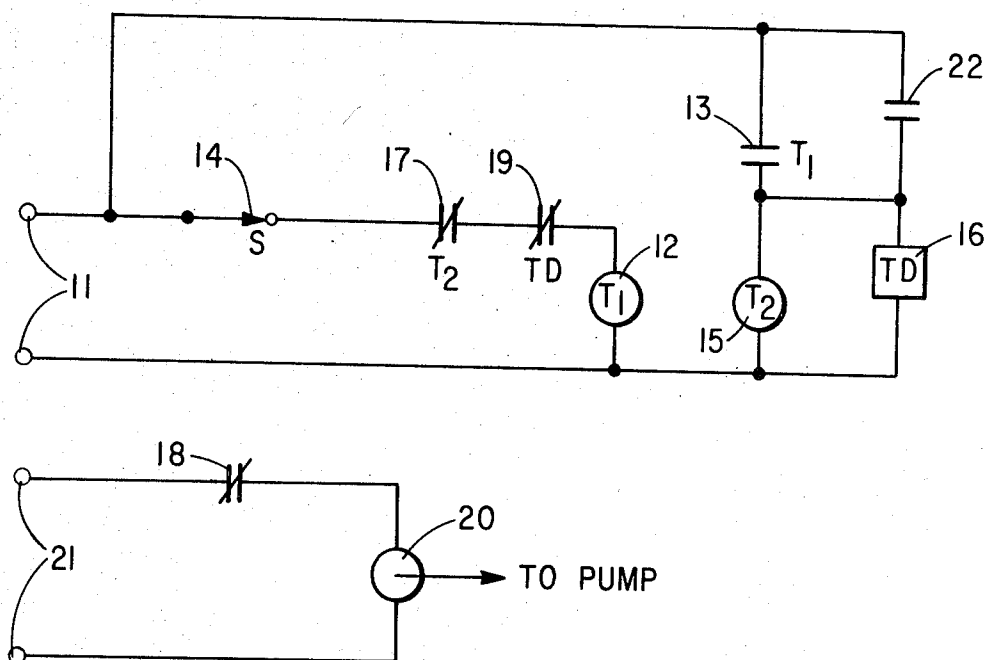
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ABSTRACT: To obtain optimum production from a producing oil well in which the pump rate exceeds flow rate of liquid into the well, it is necessary to determine the most effective producing cycle of the well. During the "on" cycle the well must be pumped enough to obtain the maximum amount of well fluid. During the "off" cycle the fluid permeating through the formation rocks refills the well bore. The controller disclosed here is designed to stop the pump, preventing rod wear and expending excessive mechanical energy, when the fluid has been pumped from the well. The well pump is restarted only after a predetermined "off" time. It is a short-cycle controller of minimum cost, simple in operation, and easy to maintain. Wide flexibility in timing permits adjustment of the off and on cycles for best results.



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3,559,731



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PUMP-OFF CONTROLLER

BACKGROUND OF THE INVENTION

After the flush period of a flowing well is over, it is necessary to use a pump to produce the well. One major type of pumping arrangement uses an electric motor actuating a reciprocating pump jack which raises and lowers a string of pump rods extending down through the well to the reciprocating pump. Depending upon the reservoir energy still present, the pump may be actuated continuously, or it may be possible to operate it only intermittently, stopping pumping after the liquid level in the well reaches the pump intake. If the pump is not stopped at this point, there is excessive rod wear and fluid pounding. Fluid pounding generally causes excessive rod breakage. There is also likelihood that the polish rod (which extends through the stuffing box and is located at the top of the rod string) may be damaged or the stuffing box burned out, etc.

By now it has been well established through field experience that short-cycle pumping is the most effective and economic means of producing wells which are pumped on time cycles. In order to minimize need for pumps it is desirable to have flexible means to start the electric pump motor at a specified point in time after the well has pumped off which permits optimum well fillup, but does not thereafter allow extra time in which further fillup is either small or zero. The pump-off controller provided herein accomplishes these functions effectively. On the other hand, the time the pump operates should depend on the volume of liquid which flowed into the well while the pump was off.

DESCRIPTION OF THE PRIOR ART

A number of pump-off controllers have been developed and patented. Probably the closest to the system discussed herein is U.S. Pat. No. 3,276,380 Stevenson which incorporates a time-delay relay acting on a flow-sensitive switch to shut down the electric motor actuating the pump when the flow decreases beyond that sufficient for pump operation without damage. It is a shutoff control only. It also requires use of a double throw switch, both contacts of which must be in precisely controlled positions, and operates on both over and under flow of the pumped liquid, an undesirable arrangement. A similar arrangement is shown in Pat. No. 3,297,843 Hoss which involves a shutoff for an electric pumping motor for an oil well. This apparatus interrupts the motor at a suitable time delay when the well flow decreases beyond a desired minimum.

Earlier patents have considered the problem of pump off. Generally these arrangements operate on simply turning off of the motor at a low flow condition. Thus U.S. 2,550,093 discloses a control switch constantly urged towards the open position by a motor means, and towards a closed position by a flow-sensitive check valve. When the flow decreases to a certain value, the motor switch opens.

U.S. 2,707,440 employs a temperature-responsive device in the flow line to open the power circuit to the pump motor when fluid flow stops. A time delay in the control circuit prevents momentary temperature drops from stopping the motor. After a selected time period, a timer restarts the motor. The electric control system requires a power supply, balanced bridge circuit, and amplifier. This arrangement is expensive and may require considerable maintenance and repair. Rather similar to this arrangement is that taught in Pat. 2,947,931 in which the current demand of the pump motor is the indication used to stop the motor. This also uses a time-delay relay to average out fluctuations in pumping. The motor is restarted by a timer.

U.S. 3,075,466 utilizes a stepping switch which in effect counts the pump strokes. The power circuit is opened after a determinable series of pump strokes, through a micro switch. A timer restarts the motor.

A different arrangement was proposed in U.S. 3,269,320. When the vibration at the pump base becomes excessive due

to pump off, a vibration sensor produces a sufficient signal to open the motor power circuit. The motor is restarted by a timer.

SUMMARY OF THE INVENTION

The arrangement taught in this specification is an improvement over those previously disclosed in that it involves timed adjustment of the off cycle with flow control of the on cycle of the pump motor, but also incorporates a time-delay means which insures that the well pump will operate a few strokes before the flow-sensitive device operates. Such an arrangement is not shown in the prior art. It permits both greater optimization of the pump cycle on wells difficult to control, and lower cost than the commercial devices built in accordance with the prior art. This present system is particularly adapted for operations on wells of low fluid volume with small to moderate gas production as well as larger volume producing wells with high volume gas production. Additionally it is found that the installation of this controller is less expensive than most types because very little conduit and wire and no ditching are required to mount the flow-sensitive unit. Furthermore, the flow sensing device (frequently a pressure switch) can be operated at a point removed from the wellhead which protects this switch from damage resulting from dismantling wellhead piping during workover operations at the well.

BRIEF DESCRIPTION OF THE DRAWING

The FIG. shows a wiring diagram of the pump-off controller system.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The pump-off controller described herein essentially consists of four parts. One is a switch sensitive to liquid flow, or if desired, to flowline pressure, which is related to liquid flow. The second is a resetting, adjustable timer used to operate when the well pumps off. The third unit is a second adjustable resetting timer used to shut in the well for a predetermined (adjustable) time. Finally, there is a time-delay relay, the function of which is to permit the well pump to operate a few strokes before sampling to see whether there is a flow of fluid.

These units are shown in the FIG. A source of alternating current power (for example, 110 60 Hertz), available at the pump site, is present across terminals 11. Resettable timer T₁ (12) is in reality a synchronous motor clock mechanism containing a set of normally open insulated contacts 13 which close after a time interval adjustable by the operator. Such adjustable timers are very well known in electric motor control and can be purchased with any desired period of maximum time actuation. I prefer to use one in which the maximum time until actuation is around 30 seconds. (It is understood that this may vary, depending upon the flow conditions in the well.) This timer is connected to the alternating current source 11 through switch S (14) which is flow sensitive, or pressure sensitive. Both pressure switches and flow switches have been used for switch S (14). When a pressure switch is employed it is of the type where the electric contacts are closed at low pressure and the contacts open under pressure produced by fluid flowing through the flowline from the well. A particularly advantageous type is that known as the "Static-O-ring" switch, but other pressure switches can be employed. I have also employed for this unit a device actuated by the actual flow (rather than pressure) of liquid through the flowline, for example one actuated by what is essentially a check valve which, as it swings open in response to liquid flow, opens the electric contacts. The flow sensor which has been used effectively is one known as the "Liquid Level Lectronics" flow indicator.

In series with switch S (14) are the normally closed contacts from two additional units. One of these is the second adjustable resettable timer T₂ (15); the other is the time-delay mechanism TD (16). The second timer 15 is identical in operation to timer 12, except that it has both a set of normally

closed contacts 17 and a set of separate, normally open contacts 18. I prefer to use a unit with maximum time setting of 150 minutes. The time-delay relay 16 can be any of the well known types of electric time delay which open a set of normally closed contacts 19 at a fixed time after energy is applied across the unit 16. As shown in the FIG., the actuating mechanisms of the second timer 15 and of the time-delay relay 16 are connected in parallel. These two units in turn are connected in series through the normally open contacts 13 of the first timer 12 across the input power source 11.

The second set of contacts of the second timer (normally closed contacts 18) are connected in the pump motor circuit. As shown in the FIG. these contacts may be simply put in series with the pump motor 20 and the source of electric power 21 for this motor. Ordinarily I prefer to have these contacts 18 in series in the motor holding circuit (starting mechanism) where they accomplish the same function but carry lower current.

The operation of this circuit is as follows: Let it be assumed that the pump motor 20 is operating from power source 21 and that switch 14 is open, either because of pressure in the flowline or because the flow itself causes this switch to be open. Accordingly, timer T_1 is not energized. As the liquid is removed from the well, the well "pumps off", that is, the flow of liquid becomes less and less. The switch 14 then will start to close whenever the pressure (if using a pressure-actuated type switch S) decreases to the point where the contacts no longer stay open, or the flow so decreases (if switch S is a flow-sensitive type). Initially the switch will open during about $\frac{1}{4}$ of the pump stroke, and, accordingly, timer T_1 will be interruptedly energized. As pump-off approaches, the timer T_1 will be energized longer and longer periods, and eventually switch 14 will be closed for a sufficient length of time so that timer T_1 "times out," i.e., goes through its cycle. When it reaches the end of the time for which it was set, the first timer 12 will close the normally open contacts 13. Closure of these contacts in turn energizes the second timer 15 which now commences its operation. As soon as it is energized, contacts 17 open, as do contacts 18. The opening of contacts 17 deenergizes the first timer 12. Simultaneously, the opening of the normally closed contacts 18 deenergizes the pump motor 20. Energization of the second timer 15 also closes a set of normally open contacts 22 which are in parallel with contacts 13, which assures that the second timer 15 will continue to operate through the time for which it is set. This insures that the pump will be shut off for the desired "off" part of the pump cycle.

During the time that the second timer 15 is actuated, there is also actuation of the time-delay relay 16 which after its normal period of delay operates to open contacts 19. Preferably this delay is greater than the time of four to five pump strokes—that is, of the order of 1.5 minutes.

When the second timer 15 reaches the end of the time for which it was set, it in turn "times out", closing contacts 17 and 18, and opening contacts 22. Since there is no flow from the well pump at this point, contacts 14 are closed but contacts 19 of the time-delay relay are still open, since the time delay has not passed for which this relay was set. Since contacts 18 have closed, the pump motor 20 starts, and assuming there is fluid in the well, it will be pumped out and into the flowline where it will actuate switch 14, opening it. Thus, when time-delay 16 finally operates to reclose contacts 19, assuming there is a liquid flow through the flowline, the contacts 14 will be open and the first timer 12 will not be actuated. If, on the other hand, at the time when time-delay relay 16 closes contacts 19 there has not been adequate flow from the well for some reason, switch 14 will be closed, contacts 17 and 19 will be closed, and timer T_1 will be energized which after its set time has passed will energize the second timer 15 and again shut down the pump motor.

To summarize the action of this unit: The unit is sensitive to the pressure or flow of liquid through the flowline and will, accordingly, pump until there is inadequate liquid in the flowline. A set time after this condition occurs (in accordance

with the setting of the first timer 12), the pump is shut off for a predetermined period of time in accordance with the setting of the second timer 15. The pump then restarts but will shut off after the time setting of the first timer 12 unless there is adequate liquid flow. If there is adequate liquid flow, the pump continues to operate until the well has been pumped off.

Obviously the maximum setting of each timer depends upon conditions in the well. I have found very satisfactory results obtained when using a first timer 12 having a maximum 30-second timing period, usually setting actuation time at around 15 seconds. The second timer, which governs the period during which the well is refilling with liquid, depends as to maximum setting on the characteristics of the permeable formations through which liquid is flowing into the well. I have used timers having maximum settings up to 150 minutes, but the usual timing period is around 15 to 30 minutes. The time-delay relay 16 employed in this controller usually has a setting of around $1\frac{1}{2}$ minutes.

As an example of the use of this controller, the following examples are of interest. A well in the Smyer Field in Texas was producing from the Clearfork zone with a pumping schedule of 15 minutes on and 45 minutes off with an average oil production of 13.4 bbl/day and average water production of 1.7 bbl/day. The well was accordingly under pumping conditions 6 hours per day. Then this controller was put on the well. The first set of runs was accomplished using a timer setting T_1 of about 15 seconds and 60 minutes for T_2 . The well produced 12.0 barrels of oil per day and 2.5 barrels of water per day, with the pump running 2 hours, 54 minutes per day. On a second test on the same well the preset down time was increased to 90 minutes, in which case the production was 13.9 barrels of oil per day and 0.7 barrels of water per day, with a total time that the well was being pumped of 2 hours, 43 minutes. Thus there was a considerable decrease in the time the pump was running and hence decrease in electric energy used (and in lifting costs), with a decrease in wear of moving parts. Sonic measurements on the well indicated that it was being maintained in a pumped-down condition with about 94 feet of fluid above the pump. In another well in the same field, production prior to the use of the pump-off controller was 57 barrels of oil and 4 barrels of water per day, on a cycle of 1.25 hours "on" and 1.75 hours "Off." A test of approximately one week's duration following installation of the pump-off controller gave an average production of 70.5 barrels of oil per day and 4.1 barrels of water per day. The increase in production was obviously solely due to the use of the controller. In this well the preset down time (setting of the second timer) was approximately 30 minutes. Pumping time was found to run from approximately 60 minutes to approximately 70 minutes.

The conclusions from a number of such tests were that the controller could be used to establish a more efficient producing cycle on low volume producing wells. On larger volume producing wells this controller would not establish a fixed pumping cycle, but would pump the well at various lengths of time, depending upon the influx of fluid into the well bore. One of its major advantages lay in the fact that this controller automatically adjusts the producing cycle as the producing characteristics of the well change, for example, under water-flood conditions. These tests also appeared to indicate that the controller employing a check valve-actuated type switch would be more suitable for relatively low volume producing wells with small to moderate gas production, while one in which switch 14 was pressure actuated from the flowline would be more suitable for larger volume producing wells with high volume gas production.

It should be added that this controller is considerably less expensive than other commercial controllers, and also is unusually free of maintenance problems.

I claim:

1. Apparatus for controlling the motor of a pump adapted to pump liquid from a well at a rate greater than that at which said liquid flows into said well comprising:

a source of electric power;

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a first resettable timer having a normally open set of contacts (1), which close at an adjustable time after energization of said timer;

a flow-sensitive switch mounted in the flowline from said well having a set of contacts (2) opened by flow of liquid through said line and closed when said flow is negligible;

a second resettable timer having a normally open set of contacts (3) in parallel with said contacts (1) and two sets of normally closed contacts (4) and (5), one of said two sets of contacts (4) being in series in the starting apparatus of said pump and the other of said two sets of contacts (5) being in series with said contacts (2) and said first resettable timer across said source of power, said second timer being adapted to actuate its sets of contacts at an adjusta-

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ble time after energization of said second timer, said second timer being connected through said contacts (1) and said contacts (3) across said source of power; and

A time-delay relay connected in parallel with said second timer and having a set of normally closed contacts (6) connected in series with said first timer and said contacts (2) and said contacts (5) across said source of power.

2. Apparatus in accordance with claim 1 in which the maximum time to which said first timer can be adjusted is about 30 seconds, the maximum time to which said second timer can be adjusted is about 150 minutes, and the actuation time of said time-delay relay is of the order of 1 1/2 minutes.

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