

[54] OIL WELL TREATMENT

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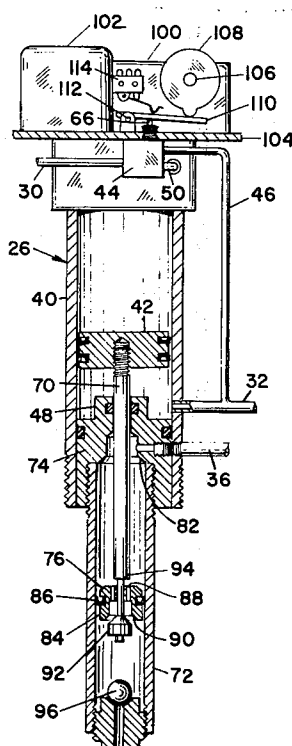
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[57] **ABSTRACT**

Chemical additives are forced into wells using the pressure above atmospheric pressure, at which the well's product issues from the well. The additive is forced into the casing of the well and product from the inner tubing string is used to flush the additive down. Apparatus for practicing that method includes a pump connected to pump the additive from a supply container into the well casing. The motor or prime mover for the pump is driven by the pressurized product of the well whereby no external power source is required. The pump delivers additive at higher pressure than the pressure at which product drives the pump motor but it delivers a smaller volume of additive than the volume of product that drives the motor. The structure includes a timing device which results in operation of the pump through a number of cycles at each well treatment and spacing of treatments as desired. It provides for flushing with product during the course of each treatment.

1 Claim, 4 Drawing Figures



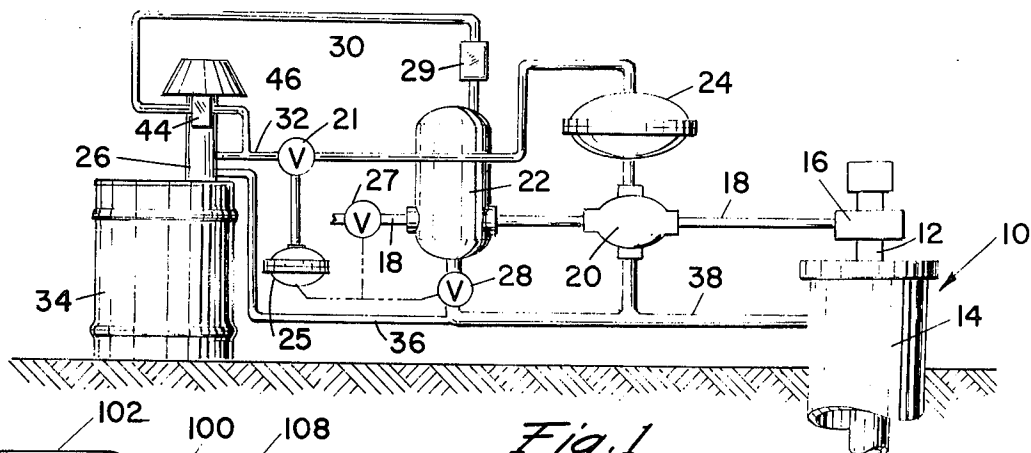


Fig. 1

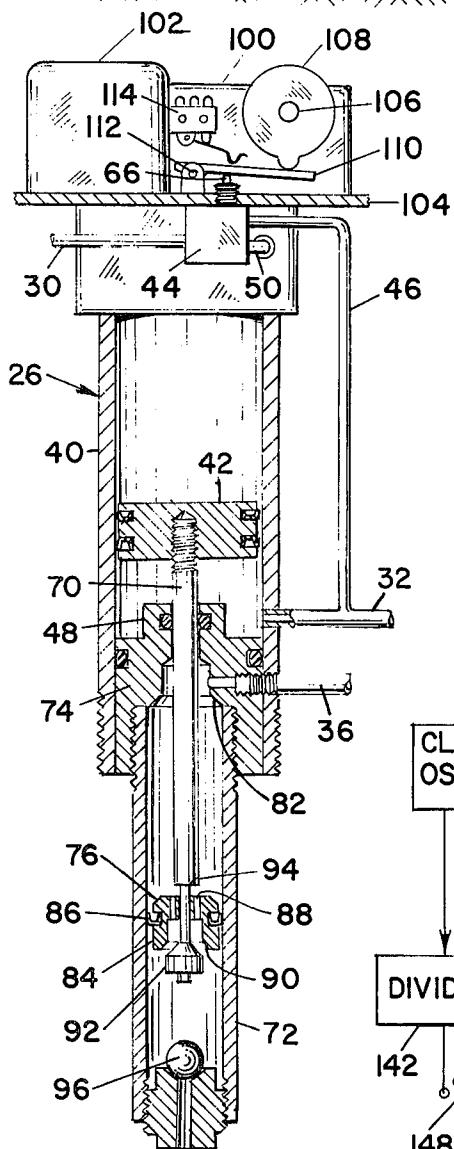
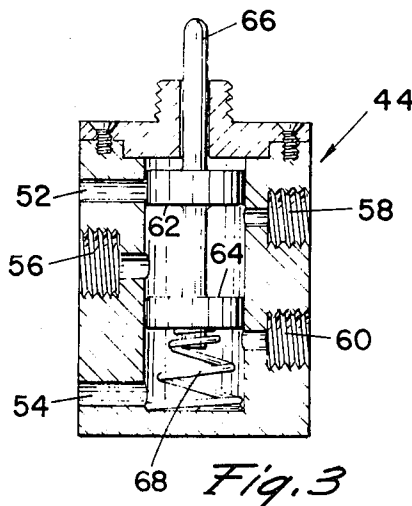


Fig. 2



OIL WELL TREATMENT

This invention relates to improvements in methods and means for transferring quantities of chemical into oil wells and other kinds of wells.

The invention is particularly useful for introducing corrosion inhibiting chemicals into the casing of wells of the kinds that employ an outer casing which houses a tubing string through which the well's product flows at positive pressure. The preferred embodiment includes the step of, and the means for, employing the well's product (oil and water or water alone) in flushing the chemical additive down into the casing. In some instances other fluids are available for flushing and the use of such fluids is also envisioned within the invention.

Not only is the oil well an important application for the invention, it is often a difficult application and for that reason the embodiment selected for illustration in the drawings is one intended for treating oil wells. The quantity of corrosion inhibitor that is added to a well and the frequency of that treatment in an optimum treatment program varies greatly from well to well, and for a given well, can vary greatly from time to time. In some cases the well is treated only once a week. In other cases it may be desirable to treat the well every several days or every day. In the past, a service man equipped with a service truck visited each well periodically. The casing was opened and a quantity of chemical was added. That chemical was usually flushed down the casing using water or a petroleum product from a flushing liquid container carried on the truck.

A preferred arrangement would be to leave a supply of chemical at the well together with an automatic apparatus for injecting that chemical periodically. Doing that is relatively simple if an electric power line or other adequate supply of power is available. However, many wells are not located near a power line and in those cases the well treater has continued to make his rounds. The product of most wells issues from the well at positive pressure so that power source is available at the well. However, that pressure is often not very great. In many cases the casing itself is pressurized and on occasion its pressure may actually exceed the pressure at which the product is delivered. That circumstance prevents effective and reliable use of the pressure differences between well tubing and well casing to force the additive into the well casing. In the invention some of the product is released to do the work of pumping chemical into the casing. The product is made to operate a prime mover which is coupled to a pump. The pump and the prime mover are arranged so that there is a multiplication of mechanical force from prime mover to pump whereby chemical is forced into the well casing at a pressure exceeding the pressure of the product. The price paid for that increased pressure is reduced volumetric capacity. To overcome that difficulty the invention provides an apparatus which recycles until the requisite amount of chemical has been supplied to the well casing.

To provide such a solution to the problem and such an apparatus are objects of the invention. Another object is to provide an apparatus which is so dependable and so reliable that it will operate to inject chemical into a well periodically over a period of many months automatically and without the need of visitation by an attendant. A related object is to provide that result not-

withstanding that the pressure of the product may vary during that time and notwithstanding that the pressure difference between well casing and well tubing may change and may even be reversed at times.

Since chemical is added periodically, some means must be provided in the invention for keeping track of time. Power to operate the timer may be derived from the well's pressurized product or, because the amount of power required is very small, it can be conveniently supplied by a small inexpensive battery capable of operating a timer for many months.

It is desirable to flush the chemical additive down the well if possible. Since the product is ordinarily pressurized above the casing pressure it is feasible to use the well's product as the flushing fluid and the preferred form of the invention includes utilization of the pressure differential between the tubing and atmosphere to divert some of the product back down into the casing. That product may be a gas, or oil, or water, or a combination of them.

One of the objects of the invention is to provide an apparatus that is easily and reliably installed. The preferred embodiment includes a prime mover and pump arrangement that is adapted for use with a conventional 55 gallon steel drum. A drum full of chemical is delivered to the well site where the prime mover and pump are installed in the bung hole at the top of the drum. The pump can also be installed in the bung hole at the side of a horizontally positioned drum. One advantage of the invention resides in the fact that the drum can be refilled whereby the apparatus need not be moved or disturbed to replenish the supply.

These and other objects and advantages of the invention will be apparent from an examination of the drawings in which:

FIG. 1 is a schematic diagram of the apparatus of the invention associated with an oil well head;

FIG. 2 is a view partly in elevation and partly in section of the control structure and pump and prime mover mechanism employed in the apparatus in FIG. 1;

FIG. 3 is a schematic diagram of the control valve employed in the apparatus of FIG. 2; and

FIG. 4 is a block diagram of the timing circuitry and control elements that are incorporated in the control structure of FIG. 2.

In FIG. 1 the numeral 10 designates a well head. This is an oil well. Its tubing string 12 is contained in the casing 14. The product of the oil well is a mixture of gas, oil and water. It is delivered to the fitting 16 where it is transferred to a line 18 which leads to a storage facility not shown. A three-way valve 20, which may comprise two two-way valves, is included in that line. The valve is normally positioned so that the product flows through the valve to the gas separator-accumulator 22. Gas accumulates in the upper portion of the unit 22. It is used to operate the gas motor 24 that operates three-way valve 20, or to operate gas motor 25 that operates two-way valves 27 and 28. A manually operated three-way valve 21 applies the gas to a selected one or the other of motors 24 and 25. Ordinarily only one of those motors is used. The valve 21, one of the motors 24 or 25 and the valve it operates would be omitted. The gas also is used to power the controller and pump and prime mover unit 26. Gas from the separator-accumulator 22 flows through a filter 29 and line 30 to unit 26 where a control valve 44 controls its application

to line 32 and motor 24 or motor 25. That same control valve applies gas to the prime mover of a pump. The latter pumps chemical down from drum 34 to a line 36 from which it flows into flushing line 38. Line 38 extends from the normally closed outlet of three-way valve 20, and from the normally closed outlet of two-way valve 28, to the interior of casing 14. When pressure is applied to line 32, the motor 24 operates to divert product from line 18 to line 38 to flush the chemical additive from that line and down the casing. On the other hand if the three-way valve 21 is adjusted so that the flow of gas is from line 32 to motor 25 rather than motor 24, valve 27 will be closed and valve 28 will open to permit a flow of flushing water from the lower outlet of the separator to the flushing line 38. Other flushing fluid is sometimes available and might be used instead.

In this embodiment a small quantity of chemical is pumped into line 38 during a few seconds of successive 1 to 2-minute intervals. During the interval the valve 20 is operated, or valves 27 and 28 are operated, to divert product to the flushing task. The number of cycles is selected so that some predetermined quantity of chemical is added. In one practical embodiment the pump cycles five times and delivers just over a pint of chemical to the well. This alternate pumping and flushing in cycles is preferred. It permits injection of chemical at relatively high pressure and it interrupts the steady state pressure relationships in the system for only short periods.

The pump and pump motor, or prime mover, are shown in FIG. 2 in a preferred form suitable for use with steel drums of the kind that have a bung hole opening at their upper ends or at their sides. Cylinder 40 and piston 42 are part of the driver. When pressurized gas entering control valve 44 by line 30 is permitted to flow by line 50 to the space above piston 42, the piston is forced downwardly toward shoulder 48. Subsequently, valve 44 diverts the pressurized product gas from line 50 to lines 46 and 32. Line 46 communicates with the lower end of cylinder 40 where the gas it brings to the cylinder forces the piston back up.

The valve 44 is shown schematically in FIG. 3. Ports 52 and 54 are exhaust ports. Line 30 connects to inlet port 56. The two cylinder ports 58 and 60 connect to lines 46 and 50, respectively. Two spools 62 and 64 are carried on an operating shaft 66 which is biased by spring 68 to the upper position shown in FIG. 3. In that position spool 62 closes exhaust port 52 and opens port 58 to permit flow of gas from inlet port 56. Gas cannot flow from the inlet port 56 to the other cylinder port 60. Instead, port 60 is vented through exhaust port 54. When valve stem 66 is up, piston 42 is up or is going up. When the valve stem 66 is depressed, port 58 is opened to exhaust port 52. Exhaust port 54 is closed by spool 64 and cylinder port 60 is connected to inlet port 56. In this valve position, drive piston 42 is down or is going down.

Since line 32 is pressurized whenever line 46 is pressurized, the motor 24 and valve 20 are operated, or the motor 25 and valves 27 and 28 are operated, and flushing fluid flows when piston 42 is up or is going up.

The piston 42 is carried on an axle shaft. The shaft 70 extends downwardly from the piston, through shoulder 48 into the second pump cylinder 72. The shoulder 48 is formed as part of the upper end of a cylindrical coupler 74. An O-ring fitted into a groove in the wall of the shaft opening cooperates with the shaft to seal

the volume below piston 42 from the volume above piston 84.

The upper end of the lower cylinder is fitted and sealed within cylindrical coupler 74. The upper outer end of the coupler is fitted and sealed into the inner lower end of cylinder 40. The lower end of cylinder 40 is threaded to fit the bung hole threads of the drum 34. When the unit is to be assembled on the drum, the bung closure is removed and the cylinder 40 is screwed into the opening.

Air is admitted into the drum to equalize pressure as chemical is removed. Air enters through the unsealed space between cylindrical coupler 74 and cylinder 40 below line 36.

The lower interior of cylindrical coupler 74 has reduced diameter to form an inside shoulder 82. The shoulder limits upward movement of the pump piston 84. A cup seal 86, carried by piston 84, prevents flow around the piston. But flow is permitted through piston 84 on its down stroke by way of passages 88 which extend through its opening. At the bottom inside of the piston 84, an annular valve seat is formed by an inwardly and upwardly extending, conical wall 90. The head 92 for that seat is carried at the end of shaft 70. The lower portion of the shaft 70 has reduced diameter to form a shoulder 94. The pump piston 84 is slidably mounted on the lower portion of the shaft. When the shaft moves down, the piston 84 is free to slide up against shoulder 94 whereby head 92 is removed from seat 90 and fluid chemical from the space below the piston is free to flow through the check valve 90, 92 to the space above the head. A ball check 96 at the bottom of cylinder 72 prevents chemical from flowing out the bottom of the cylinder.

Downward movement of motor drive piston 42 forces shaft 70 down whereby pump piston 84 is forced through the liquid in the pump cylinder until head 92 comes to a rest on ball check 96 thus preventing further fluid flow. On the return stroke piston 42 and shaft 70 move upwardly. Head 92 is drawn into engagement with seat 90 and piston 84 is pushed up. As the piston 84 moves up it creates a suction which draws a new supply of chemical through check valve 96. Acting like a pump piston on its up stroke, piston 84 forces the liquid above it into outlet conduit 36 until shoulder 76 on the upper end of piston 84 seats against shoulder 82 thus preventing further fluid flow.

To initiate that cycle of operation of chemical flushing and pumping, the control valve shaft 66 is released. Spring 68 returns it to up position. Gas pressure is then applied to the bottom of piston 42 and both pistons move up. They move up until piston 84 reaches stop 82. Meanwhile the chemical above the piston is forced out of the pump cylinder and more is drawn in below the piston.

While the valve shaft 66 is up and the pistons are up, or are moving up, pressure is being applied by line 32 to one of the flushing valve motors 24 or 25. Since the pumping stroke is only a few seconds long and flushing is desired for one or more minutes, the apparatus for depressing shaft 66 is arranged to provide that timing. After a short time, long enough for the piston 42 to have reached bottom position, control valve shaft 66 is depressed, pistons 42 and 84 move down and chemical fills the space above piston 84.

In the embodiment shown in the drawings, the timer 100 and a battery 102 are mounted on a plate 104

which is fixed to the top of cylinder 40. The timer controls a motor 105 whose shaft 106 is visible in FIG. 2. A cam 108 is carried on that shaft. When the motor is energized, the cam rotates slowly. In one example it revolves once in 2 minutes. The cam 108 has a projection on its periphery which, over about 10° of cam rotation, acts to depress a lever 110 about its pivot 112. That lever engages shaft 66 of control valve 44 and depresses shaft 66 for 4 or 5 seconds of each 2-minute interval. That ratio of flushing time to pumping time can be changed by changing cams.

In this embodiment the lever 110 is spring biased to its upper position by the spring 68 that is seen in FIG. 3 to be contained within the valve 44. In an alternative arrangement the cam is provided with a continuous track. A follower that moves in that track is fixed to the valve operator 66. Whatever the construction, motion of the valve stem 66 or the cam 108 or the lever 110 also controls the actuator of a switch 114. That switch is normally closed and is opened only when, as illustrated schematically in FIG. 4, the projection on cam 108 acts to depress the lever 110 and the operator 66 of control valve 44.

Switch 114 forms part of the timer 100. A preferred form of that timer is shown in FIG. 4, it being understood that the battery 102 is connected across the terminals marked + and - of FIG. 4. A clock oscillator 140, which may comprise a unijunction oscillator, furnishes pulses at a given pulse rate to a divider 142. The divider may have conventional form and may in fact comprise an integrated circuit-type CD4020E. Division is accomplished by stages and output signals at different frequencies are available at each of those stages. In the embodiment shown in FIG. 4, 10 output signals are available. Those signals have the form of pulses that are separated by different intervals. The five terminals that extend to the right in FIG. 4 furnish pulses after long intervals. The intervals in this case are representative and are one half-day, 1 day, 2 days, 4 days, and 8 days, respectively. Pulses separated by very much shorter intervals are available at the five terminals that extend downwardly from the divider in FIG. 4. In this case intervals of 11 minutes, 23 minutes, 45 minutes, 90 minutes and 180 minutes are available. One of the five terminals at the right is connected by a switch 144 to the base of a transistor 146 through capacitor 145. One of the five terminals at the bottom of the divider is connected by a switch 148 to the base of a transistor 150. The emitter of transistor 146 is connected to the positive line 152. The collector of that transistor is connected through a resistor 154 to the negative line 156. The DC motor 105 is connected from line 152 to line 156 in series with a silicon controlled rectifier 160 whose control electrode is connected to the junction between resistor 154 and the collector of transistor 146. Switch 114 and the emitter-collector circuit of transistor 150 are connected in series in parallel with the silicon control rectifier 160.

The silicon controlled rectifier SCR160 is turned on by a signal applied to its control electrode as a result of the application of a signal to the base of transistor 146 from one of the long interval output terminals of the divider. The rectifier continues conducting until the voltage drop across it is lowered to near zero. The voltage drop will be lowered and conduction will stop when the parallel circuit through switch 114 and transistor 150 is complete to short circuit the SCR160. The motor

105 will rotate when the SCR is conducting. It will continue to rotate through a small angle after the SCR is shorted because a current path is maintained through switch 114 and transistor 150. The short circuit is completed only when switch 114 is closed. The short is terminated when the motor rotates the cam enough to permit opening of the switch. In view of that the "at rest" condition is one in which the motor has moved lever 110 to a position in which switch 114 is open and the valve operator 66 is depressed. Thus the condition that valve 44 is shown to have in FIG. 2 is the "at rest" condition.

If it is assumed that switch 114 is connected to the 8-day divider output terminal and that the switch 148 is connected to the 90-minute divider output and that the cam 108 revolves once in 2 minutes, then the timing system will operate as follows.

At the end of an 8-day interval a signal will be applied through switch 144 and transistor 146 to trigger the SCR. That will complete the circuit from battery 102 through the motor and the SCR. The motor will rotate until the SCR is turned off. During each revolution of the cam 108, the switch 114 will close for a few seconds but that will not serve to complete the short circuit until 90 minutes have elapsed.

All outputs of the divider are derived from the same input pulse so all output signals are coherent. The 90 minute interval begins when the 8-day interval ends. Thus the transistor 150 will be turned off for 90 minutes while the cam 108 rotates 45 times. At the end of 90 minutes transistor 150 is turned on. The SCR will be shorted when cam 108 next closes switch 114. Rotation continues because of current through the short until the switch opens. A turn on signal will be applied to the base of transistor 150 every 90 minutes but the transistor does not turn on because the circuit is open at switch 114. Thus the system remains at rest until the SCR is retriggered at the end of 8 days.

When each of the 45 revolutions of cam 108 during the 90 minute on time, the operator 66 of valve 44 is released and depressed. The chemical pump operates 45 times and each of those 45 times motor 24, or motor 25, operates the valves that flush the chemical down the well.

In this embodiment there are two motors coupled to shaft 106. One is a small gas turbine 220 which is driven by gas from line 26 when valve 222 is opened by solenoid 224. The other is the electric motor 105. A single pole double throw switch 228 selects either the motor of the solenoid for connection to the D.C. power source. If gas pressure is high the gas motor would be selected to preserve battery power.

Returning to FIG. 2, the area of piston 42 is many times greater than that of piston 84. Nearly six times greater in this embodiment. The stroke of the two pistons is almost the same, differing only to the extent that piston 84 can move relative to shaft 70. Thus, chemical is delivered to the well casing, in this particular embodiment, at a pressure above atmospheric pressure approximately six times the well product pressure. An adequate quantity of chemical is introduced into the well at each treatment by adjusting timer 116 so that the pump will be operated for an adequate number of cycles.

I claim:

1. Apparatus for use in applying chemical from a storage container to the casing of a well of the kind in

which fluid product issues at positive pressure from a tubing string in the casing comprising:

a gas separator for connection to said tubing string such that pressurized gas is separated from said product and stored;

a pumping means including a pump and flow conduits for transferring chemical from said storage container to said well casing and a gas pressure powered driver for driving said pump, the driver having mechanical advantage over the pump such that delivery pressure from the pump exceeds the pressure applied to the driver;

a normally closed, pressure-opened connection from the tubing to the casing of the well;

a line connecting the separator to said driver and to said pressure-opened connection;

control means including valving in said line and a timer for actuating said valving for causing the driver to operate the pump and for opening said connection a predetermined number of times after a predetermined interval;

said pumping means comprising a driver cylinder and

piston and a pumping cylinder and piston, the two pistons being mounted on a common shaft for reciprocation together in their respective cylinders and the pump piston and cylinder having smaller cross-sectional area than the driver piston and cylinder;

said control means comprising a three-way valve having an inlet for connection to said gas separator and having two alternate outlets each connected to the driver cylinder at a respectively associated side of the driver piston, one of the outlets of said three-way valve being connected to said pressure-opened connection;

means for mounting said pumping means such that it can extend through the bung hole of a drum with its pump extending within the drum; and

said three-way valve including an operating shaft and in which said timer comprises a rotating cam position to actuate said cam in a given rotational position and means for rotating said cam for a given period during a longer period.

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