Oct. 12, 1965 L. B. THIESSEN ETAL 3,211,225

WELL TREATING APPARATUS

Filed May 28, 1963

3 Sheets-Sheet 1

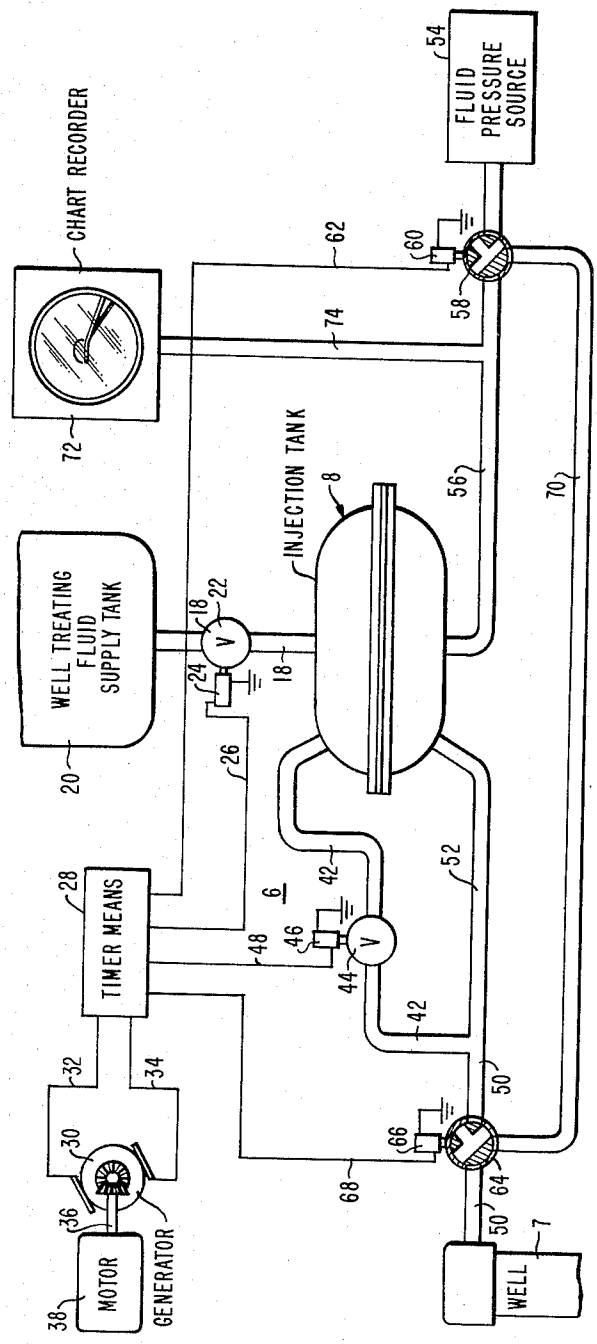


FIG.—1

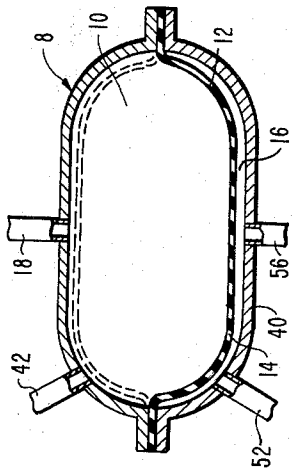


FIG.—3

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3 Sheets-Sheet 2

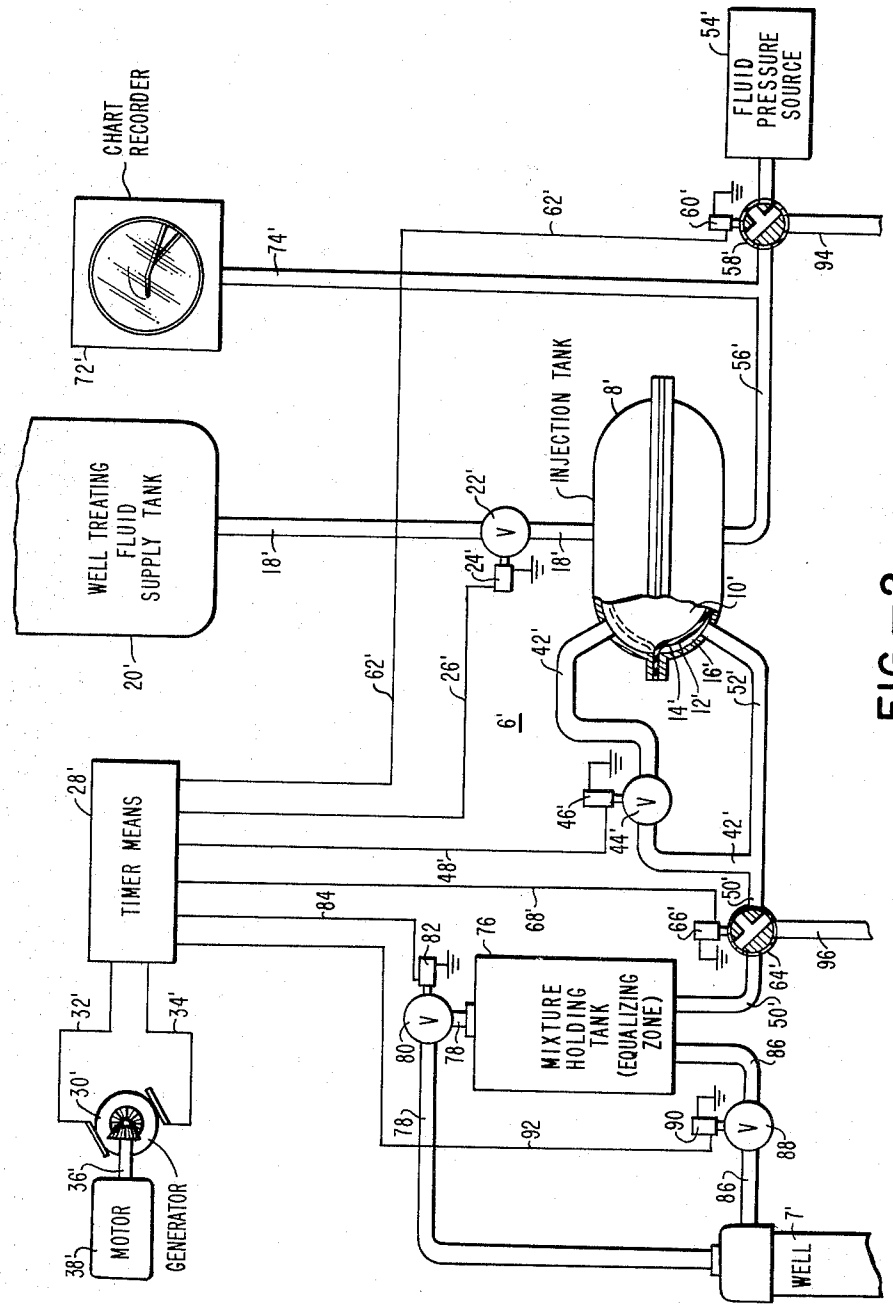


FIG.-2

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WELL TREATING APPARATUS

Filed May 28, 1963 3 Sheets-Sheet 3

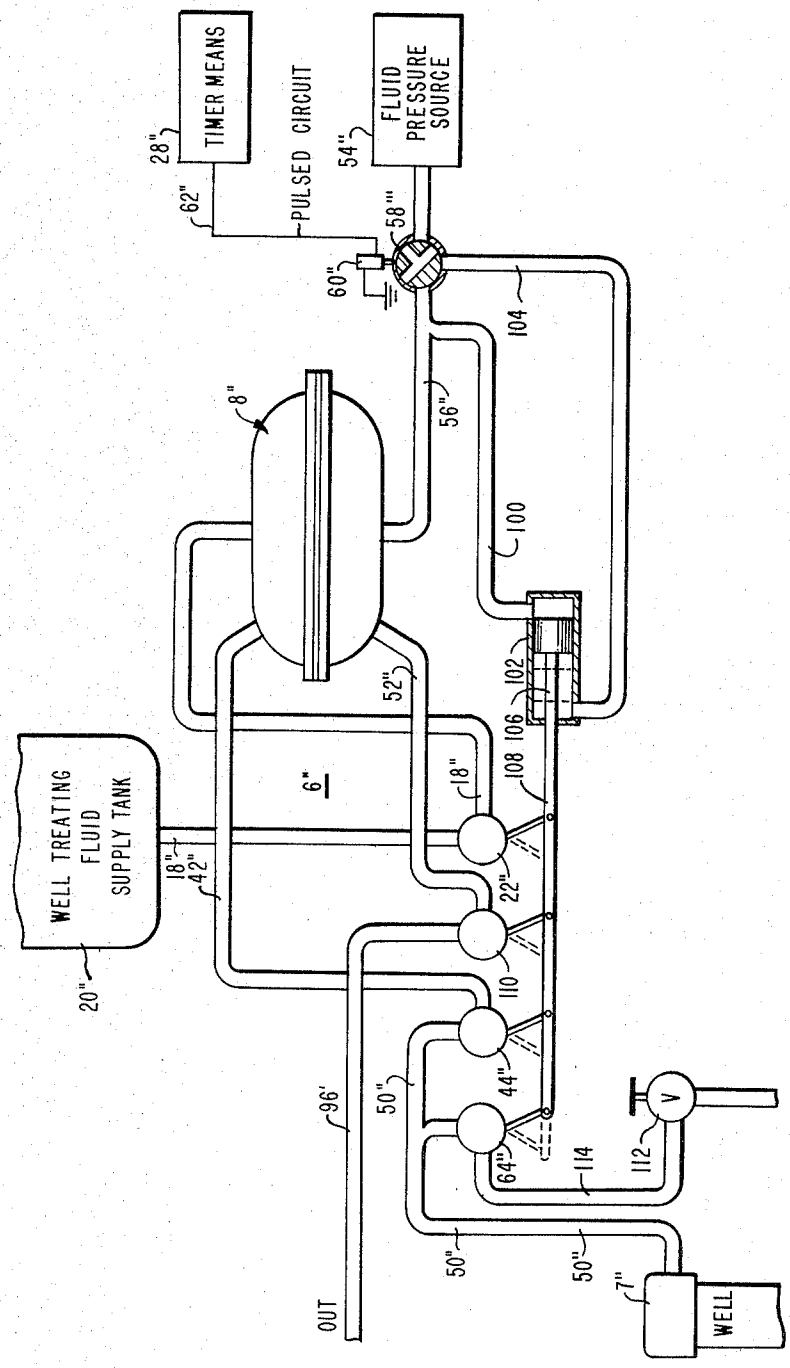


FIG.—4

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WELL TREATING APPARATUS

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Filed May 28, 1963, Ser. No. 283,817
6 Claims. (Cl. 166—75)

The present invention generally relates to well treating and more particularly relates to improved apparatus for carrying out the treating operation.

Many wells such as oil wells require the frequent application thereto of various treating solutions in order to keep the wells clear and to maximize production of fluids therefrom, e.g. oil and the like. In this regard, various chemical solutions are utilized to control oil well corrosion, minimize deposition of paraffins, carbonates, gypsum scale, etc. and to prevent the agglomeration of asphaltenes. Chemical solutions are also frequently added to oil wells for various other generally similar purposes.

Such chemicals are usually added to the wells on a regular schedule, in most instances through the use of suitable portable pumping equipment and the like moved from well to well according to the treating schedule. Thus, an operator is required to periodically visit and service each well in turn, carrying along with him the necessary portable well treating equipment. Such a procedure is necessarily relatively expensive.

Various types of apparatus have been devised to eliminate the necessity of having an operator travel from well to well to carry out the well treating procedure. In this regard, where a number of wells are closely grouped together, it becomes economically feasible to employ a relatively complicated automatic well treating system which periodically pumps well treating solutions to each of the closely grouped wells. However, such systems are initially relatively expensive, of the order of $10,000 or more, and cannot be economically employed where the wells are dispersed over a considerable area, or where only one or a few wells are involved. Furthermore, much of such multiple well treating apparatus, due to its complicated nature, is subject to maintenance problems, including corrosion and the like. Pumps are usually incorporated in such apparatus and are especially subject to corrosion and also leakage of well treating fluids.

A further problem sometimes encountered in multiple treating systems is a variation in the pressure between individual wells of the group to be treated. Certain wells may be at about atmospheric or at superatmospheric pressure while others may be at subatmospheric pressure. This tends to complicate and diversify the equipment needed for multiple well treatment.

Accordingly, it would be desirable to provide improved well treating apparatus capable of economical automatic operation on individual wells, such as oil wells. Such equipment should be simple and inexpensive to install and to maintain. Moreover, it should preferably have a high safety factor, i.e. be essentially explosion proof, so that it can be installed in close proximity to the well. In addition, it should be capable of repeatedly delivering predetermined volumes of well treating fluid over long periods of time and without leakage or malfunction.

Accordingly, it is a primary object of the present invention to provide improvements in well treating.

It is also an object of the present invention to provide improved apparatus for automatically treating an individual oil well.

It is also an object of the present invention to provide improved apparatus capable of automatically intermittently treating an oil well with fluid, which apparatus

is simple, inexpensive, corrosion resistant, and essentially leak-proof and explosion-proof.

It is a still further object of the present invention to provide improved apparatus for automatically delivering predetermined volumes of well treating solution to wells, such as oil wells, which wells may be at atmospheric, superatmospheric or subatmospheric pressure.

The foregoing objects are accomplished by providing the present well treating apparatus for the treating operation. The operation includes automatically passing a predetermined volume of well treating fluid into a pressure responsive injection zone and then exerting controlled pressure on said zone to reduce the volume of the zone and to force the well treating fluid from said zone into the annulus of an oil well, in response to such volume reduction of the injection zone. Further in accordance with the present operation, pressure is then relieved on the injection zone so as to allow the zone to return to its initial volume, whereupon a further charge of well treating fluid is passed to the injection zone for passage to the well annulus at a predetermined time.

In the present operation, a well treating fluid injection zone or chamber is disposed within container means. A pressure responsive means adapted to vary the volume of the injection chamber or zone forms a part of said zone within the container means. Suitable conduits interconnect components of the system, and fluid passage therethrough is controlled by valve means which may be actuated by timer means providing timed electrical circuit operating pulses. Periodic collapsing or volume reduction of the injection zone or chamber is effected by pressure exerted on the pressure responsive means through a pressure-imparting fluid, such as water or gases, passed into contact therewith. Moreover, pressure-imparting fluid may mix with the well treating fluid external of the container means so as to sweep the well treating fluid toward the well annulus. The pressure-imparting fluid may be a single fluid or multiple fluids introduced into the system at selected locations.

In the event that the well has a higher pressure than that of the water or other pressure-imparting fluid, a pressure equalizing zone is provided between the injection zone and the well annulus. Pressure on well treating fluid disposed in the pressure equalizing zone is adjusted to that of the well in order to allow the easy passage of the well treating fluid into the well.

With such an apparatus, predetermined volumes of a well treating fluid, such as a thioether solution adapted to minimize agglomeration of asphaltenes, can be automatically passed at predetermined timed intervals into the well to treat the same without human intervention. As an example, 500 cc. amounts of a thioether solution can be automatically delivered to a well annulus by the described apparatus every six hours for a period of several weeks without leakage of the equipment and without human manipulation or intervention.

The apparatus is relatively simple and inexpensive to initially provide and to maintain and yet provide effective automatic control of a well over long periods of time by the delivery of predetermined volumes of chemical well treating fluid to the well on a regular schedule of spaced injections.

Further advantages of the present invention will be apparent from a study of the following detailed description and the accompanying drawings of which:

FIG. 1 is a schematic flow diagram of a first embodiment of apparatus adapted to carry out the present method for the fluid treatment of a well having a pressure less than that provided by pressure-imparting fluid utilized in the appaaratus;

FIG. 2 is a schematic flow diagram of a second embodiment of apparatus adapted to carry out the present

method for fluid treatment of a well having a pressure greater than that of the pressure-imparting fluid utilized in the apparatus;

FIG. 3 is an enlarged schematic illustration of one embodiment of the injection tank utilized in the apparatus of FIGS. 1 and 2, a portion being broken away to illustrate the internal construction thereof; and

FIG. 4 is a schematic flow diagram of a third embodiment of simplified apparatus adapted for the fluid treatment of a well.

Now referring more particularly to FIG. 1 of the accompanying drawings, a schematic flow diagram is illustrated, which diagram depicts apparatus 6 adapted for use in carrying out the method of the present invention. The apparatus 6 is particularly suitable for the fluid treatment of individual oil wells wherein the pressure of such wells is less than the pressure of a pressure-imparting fluid utilized in the apparatus.

Referring particularly to FIG. 3 of the drawings, a container means or injection tank 8 is illustrated, which includes a variable-volume well treating fluid injection zone 10, in part defined by a pressure responsive means 12 also disposed within the container 8. The means 12 comprises a resilient flexible diaphragm separating the zone 10 from the remainder of the container 8. The diaphragm is adapted to vary the volume of the injection zone 10 in response to fluid pressure. Other forms of pressure responsive means comparable in function to means 12 can be utilized in place thereof, for example a transverse rigid wall or plate (not shown) slidable within the container 8 and sealed against by-passing of fluid around the periphery thereof. Such a plate could be fitted with means, such as a spring, etc. (not shown) adapted to return the plate to an initial position, e.g. to a position maximizing the volume of the injection zone 10. In other words, such spring could bias such plate against an injection zone 10 volume reduction i.e. by exerting pressure in a direction opposite to that of the pressure-imparting fluid.

The container 8 can be any suitable size and shape, and can be constructed of any suitable material, for example steel, which is non-reactive with the well treating fluid. For example, the container may be two steel shells releasably secured together, with the diaphragm 14 disposed therebetween. As shown in FIG. 3, the diaphragm 14 divides the container 8 into the variable volume injection zone 10 and a fluid pressure-imparting zone 16. The diaphragm 14 is resilient and flexible and can move, for example, between the large volume injection zone position shown in solid outline in FIG. 3, representing zone 10 in a well treating fluid-filled condition, to the small volume injection zone position shown in dotted outline in FIG. 3, representing zone 10 after the well treating fluid has been expelled thereform. Movement between the two positions depends on the direction and degree of pressure exerted against the diaphragm 14. The diaphragm 14 can be fabricated of any suitable material such as natural rubber, or synthetic rubber, such as neoprene, styrene-butadiene, butyl rubber, Teflon, vinyl, polyethylene, polypropylene or the like resilient stretchable material.

A well treating fluid supply line 18 runs into the container 8, specifically into the injection zone 10 as shown in FIG. 3, from a suitable source of well treating fluid, for example, the vessel 20 shown in fragmentary elevation in FIG. 1 disposed above the container 8 so as to provide a hydrostatic head of a well treating fluid for easy passage thereof into the zone 10. A valve 22 may be provided in the line 18 to control the flow of well treating fluid to the zone 10. The valve 22 is preferably operated by a solenoid 24 connected, as by electrical line 26, to a timer means 28, for automatically controlling the opening and closing of the valve 22. The timer means 28 may be of any conventional construction capable of simultaneously controlling the passage of electrical current to one or a plurality of solenoids for a predetermined interval of time and at predetermined spaced intervals. Thus, the timer means 28 may be provided with a suitable electrically operated settable clock (not shown) or the like. The time means 28 is connected to a source of electrical current, such as a generator 30, as by lines 32 and 34, which in turn can be powered through a drive shaft 36 running from a source of mechanical power, as, for example, the motor 38, as shown in FIG. 1. Thus, for example, the motor 38 can be the usual gasoline or kerosene powered small motor adapted to operate well pumping or drilling equipment or the like. Other arrangements of equipment for providing electrical current, either alternating or direct, for the timer means 28 will be obvious to those skilled in the art. Moreover, the timer means may be disposed at a distance from the apparatus and comprise means for sending a series of timed electrical impulses to the solenoids, as from a central control station adapted to electrically control the operation of a plurality of the described individual well treating devices. The timer means 28 or equivalent timer means can be constructed so that the solenoid operated valves of the apparatus 6 move to a preselected position at a preselected time when current is passed to the solenoids connected to the valves, after which they move to a different position (upon cutting off of current to the solenoid connected to each valve). Accordingly, timed automatic control of the flow of materials through the fluid lines to which such valves are connected is provided.

As well treating fluid passes, by gravity, through the line 18 from the tank 20 to the zone 10 with the valve 22 open, the diaphragm 14 is forced down towards the bottom wall 40 of the tank 8, as shown in FIG. 3, maximizing the volume of zone 10 in the tank 8. Thereafter, the valve 22 is then solenoid operated so as to close, sealing the tank 8 from the tank 20. As explained hereinafter, closing of the valve 22 can be delayed until ejection of the well treating fluid from the zone 10 is desired.

As shown in FIG. 1, a well treating fluid outlet line 42 interconnects the zone 10 with the well 7. The line 42 is provided with a valve 44 which is operated by a solenoid 46 and is connected to the timer 28 by an electrical line 48. The valve 44 is kept shut until it is desired to inject the well treating fluid in the zone 10 into the well 7. Preferably, the line 42 runs into a common line 50 into which a pressure-imparting fluid outlet line 52 also merges, so that the pressure-imparting fluid can mix with the well treating fluid and propel the same toward the well 7. The line 52 is connected at the opposite end thereof to the zone 16 of the tank 8, as shown in FIG. 3.

Pressure-imparting fluid, for example water under the usual water main pressure or force imparted by municipal water pumping systems, passes from a fluid pressure source 54 such as a water main or the like, through a pressure-imparting fluid inlet line 56 connected at one end to the source 54 and at the opposite end to the zone 16 of the tank 8. Accordingly, at a preselected time, the pressure-imparting fluid such as water is brought into contact in the zone 16 with the diaphragm 14 and exerts collapsing pressure on zone 10 so as to cause the well treating fluid in the zone 10 to be expelled therefrom and be passed through the line 42 into the line 50. The pressure-imparting fluid enters the zone 16 through the line 56 and exits the zone 16 through the line 52, mixing with the well treating fluid in the common line 50. The line 56 is provided with a valve 58 operated by a solenoid 60 connected to the timer by an electrical line 62. During ejection of well treating fluids from the zone 10, the valve 58 is kept open. So also is the valve 44, while the valve 22 is kept closed. The line 50 is preferably provided with a valve 64 operated by a solenoid 66 connected to the timer 28 by an electrical line 68. The valve 64 is kept open during ejection of well treating fluid from the zone 10, so as to allow injection of such fluid into the well 7, with which the line 50 is connected, as shown in FIG. 1.

The valves 58 and 64 are preferably so-called three way valves and are preferably connected to a line 70 extending therebetween and interconnecting lines 56 and 50. With such an arrangement, when the well treating fluid has been injected into the well from the zone 10, as determined by a suitable interval of time since movement of the valve 44 to the open position, and valves 64 and 54 move to positions opening the lines 50 and 56, respectively, and closing the line 70, then the current supply to the respective solenoids is cut off. As a result, the valve 44 closes and the valves 64 and 58 adjust (e.g. as by internal springs biasing said valves toward a predetermined position) so as to allow communication therebetween i.e. communication between the line 56 and the line 70 is established at the valve 58 while the passage of fluid from the source 54 through the line 56 is blocked. Moreover, communication between the line 50 and the line 70 is established at the valve 64, while passage of fluid from the line 42 into the well 7 is blocked. The pressure-imparting fluid in the zone 16 is thereby exposed to the lower pressure of the well 7 annulus and is allowed to drain thereinto, as through the line 56 into the line 70 at the valve 58, then through the line 70 into the line 50 at the valve 64, and through the line 50 into the well 7. If desired, the valves 58 and 64 can be solenoid operated so as to automatically adjust, after a suitable period of time dictated by the timer means 28, that is, after drainage of the pressure-imparting fluid from the zone 16, to a third position blocking both line 70 and lines 56 and 50, as shown in FIG. 1. Conventional valve-operating means can be provided for such purposes.

Drainage of the pressure-imparting fluid from the zone 16 into the well 7 allows the pressure responsive means 12, that is, the diaphragm 14 to move from the position shown in dotted outline to that shown in solid outline under the influence of a new charge of well treating fluid passed to the zone 10 from the tank 20 through the line 18. When the valve 44 closes, and the valves 58 and 64 change in position in response to cessation of electrical current flow to the associated solenoids, the valve 22 opens to allow the passage of the new charge of well treating fluid to the zone 10.

At a preselected time in response to the timer means and when the new charge in the zone 10 is to be expelled therefrom and injected into the well 7, the "on" portion of the cycle begins and the valve 22 closes, the valve 44 opens and the valves 58 and 64 move to positions blocking the line 70 but allowing the free passage of the pressure-imparting fluid to and from the zone 16 and into the well. The well treating fluid passes into the well 7 through the line 42, the valve 44 and the line 50, and valve 66, as previously described.

As shown in FIG. 1, means such as a chart recorder 72 which can be pneumatically operated or the like can be connected to the apparatus 6, as by line 74, so as to automatically record the successive injections of well treating fluid into the well 7. Thus, when the pneumatically responsive recorder 72 is connected to the line 56, as by the line 74, the variations in fluid pressure in the line 56 are recordable. In this regard, during the "on" portion of each cycle, the pressure in the line 56 is at a maximum, due to passage of the pressure-imparting fluid therethrough. During the "off" part of the cycle, such fluid drains into the lower pressure well and the pressure in the line 56 drops. Accordingly, the pressure variations in the line 56 accurately portray each injection cycle in the apparatus 6.

Accordingly, an improved method is provided for automatically injecting on a predetermined schedule preselected volumes of well treating fluid into the annulus of a well. Apparatus for carrying out the method is also provided. That of FIG. 1 is adapted for repeated and continual use with a well having a pressure lower than that of the drive fluid or pressure-imparting fluid, such as water, used in the apparatus.

A modification of the apparatus illustrated in the schematic drawing of FIG. 1 is set forth in FIG. 2. The apparatus 6' of FIG. 2 is adapted for carrying out the present method on a well having a high pressure, that is, a pressure higher than that of the pressure-imparting fluid, e.g., water, used in the apparatus. Components of apparatus 6' illustrated in FIG. 2 which are similar to those of apparatus 6 bear the same numerals as those of apparatus 6, but also bear a prime (') designation.

The arrangement of apparatus 6' is essentially the same as that of apparatus 6, except for the addition of a mixture holding tank 76 which serves as a pressure equalizing zone. Thus, the line 50' does not pass directly to the well 7', but instead runs to the tank 76. The top of the tank 76 is connected to a line 78 which runs to the well 7'. The line 78 is provided with a valve 80 which is operated by a solenoid 82 connected to the timer means 28' by an electrical line 84. Once the tank 76 is filled with a mixture of well treating fluid and pressure-imparting fluid, the valve 80 opens to equalize the pressure between the well 7' and the tank 76. After the pressure is equalized, the fluid mixture passes by gravity out of the tank 76 through a line 86 and valve 88 into the well 7'. The valve 88 is operated by a solenoid 90 connected to the timer means 28' by an electrical line 92. Since the well 7' is at a higher pressure than the pressure-imparting fluid in the zone 15, during the "off" part of the cycle in the apparatus 6' the pressure-imparting fluid in the zone 15 is removed therefrom not by drainage into the well 7', but by drainage to a point external of the system, as through line 56', valve 58 and line 94 exposed to the atmosphere. Such fluid can also exit the apparatus 7' through line 52', valve 50' and line 96 connected thereto and exposed to the atmosphere.

During the "on" part of the cycle, the valve 58' is adjusted so that the line 94 is blocked and the line 56' is open from the pressure source 54'. The pressure-imparting fluid flows from the source 54' through the valve 58' and through the line 56' into the zone 16', expending that zone by forcing the diaphragm 14' up, thereby reducing the volume of zone 10 and forcing the well treating fluid therein out of the line 42', through the valve 44' (which during this portion of the cycle is open while the valve 22' is closed) and into the line 50'. In the line 50', the well treating fluid mixes with pressure-imparting fluid passed thereto through the line 52' from the zone 16', the mixture passing through the valve 64' and the line 50' into the tank 76, the line 96 being closed.

After the tank 76 is filled or after a suitable interval of time, as controlled by the timer means 28', the valve 44' closes and the valve 22' opens, while the valve 58' moves to a position blocking fluid from the source 54' and opening the line 94 into communication with the line 56'. Simultaneously, the valve 64' moves to a position such that the line 96 opens into communication with the line 50' and the lines 42' and 52' but passage of fluid through the line 50' into and out of the tank 76 is blocked.

Thus, the pressure-imparting fluid drains from lines 96 and 94 while the well treating fluid passes to the zone 10, filling and expanding the same. Simultaneously, the valve 80 opens and pressure between the well 7' and the tank 86 is equalized through the line 78, whereupon the mixture in the tank 76 passes into the well 7' through the line 86, valve 83 being opened simultaneously with the valve 80. After a suitable timed interval, the valve 88 closes, and the valve 80 also closes. Alternatively, the valve 80 can be adapted to move to a position closing access of fluid to the well 7' through line 78 but opening the tank 76 to the atmosphere to facilitate subsequent filling of the same in the next cycle. The chart recorder 72' and line 74' are connected to the apparatus 6' so as to record each such injection cycle as it occurs.

It will be understood that the apparatus 6' can be operated to provide an "on" cycle portion in which the well

treating fluid in the zone 10' is moved to the tank 76 after mixing with the water or pressure-imparting fluid, and an "off" portion, in which the mixture in tank 76 is passed to the well 6', in which the zone 10' is refilled with well treating fluid and in which the pressure-imparting fluid is drained from the zone 16' and out of the apparatus.

It will be further understood that other arrangements of equipment can be utilized for carrying out the present method. Thus, additional valves, lines and the like can be disposed in the apparatus 6 and/or 6', as desired. Moreover, components equivalent in function to those described can be employed in the apparatus 6 and/or 6' or in a similar apparatus. For example, the present method can be effectively carried out utilizing a plurality of pneumatic-mechanical operated valves controlled by a single solenoid operated valve actuator. Gas can be used to actuate the actuator and to force the well treating fluid from the chemical proportioning chamber. Such an arrangement is illustrated in FIG. 3 of the accompanying drawings.

As shown in FIG. 3, a simplified well treating device 6'' is provided. Components of the device 6'' which are similar to those of device 6 (FIG. 1) bear the same numerals but also a double prime ('') designation. The device 6'' includes a supply tank 20'' and supply line 18'' running to a chemical fluid injection tank 8'', the line 18'' being provided with a mechanically operated valve 22''. The tank 8'' is constructed internally substantially identically to that of the tank 8. A fluid pressure source such as a pressurized gas line 54'' runs to a solenoid operated three way valve 58'' and fluid passes therethrough to the tank 8'' by way of a line 56''. The line 56'' is connected, as by a line 100, with one side of a cylinder or piston valve 102, as shown in FIG. 4. The opposite side of the valve 102 is connected to the solenoid valve 58'' as by a line 104. The valve 102 includes a piston 106, a stem 108 of which extends from one end of the valve 102 and mechanically connects with the lever arms of the two-way mechanical valves 22'', 110, 44'' and 64'' to operate all four of such valves simultaneously.

The "on" portion of the treatment cycle, during which well treating fluid in the tank 8'' passes to a well annulus 7'', is initiated by pulsing a signal from a timer means 28'' through an electrical line 62'' to a solenoid 60'' connected to the valve 58'' to allow fluid from the source 54'' to pass through the line 100 into the cylinder valve 102, driving the piston to the position illustrated in FIG. 4 and thereby simultaneously closing the valves 22'' and 110 and opening the valves 44'' and 64''. The fluid from source 54'' passes through the line 56'' into the bottom of the tank 8'' and causes expulsion of well treating fluid therefrom in the manner described for the operation of devices 6 and 6', the well treating fluid passing from the tank 8'' through a line 42'', the valve 44'' and a line 50'' running to the well annulus 7''. In line 50'' the well treating fluid merges with a second pressure-imparting fluid, for example water, passing thereinto from a water main 112, a line 114 and the valve 64''. It will be understood that another pressure-imparting fluid instead of water can be used to mix with and sweep the well treating fluid into the well annulus 7'' from the line 50''.

After suitable intervals of time, as controlled by timer means electrical pulses, the solenoid 60'' is shut off, and the valve 58'' moves to a position (as by a spring, etc.) which closes off the line 56'' and allows the pressure-imparting fluid to pass through the line 104 to the valve 102, driving the piston 106 to the position shown in dotted outline in FIG. 4, so as to simultaneously close the valves 44'' and 64'' and open the valves 22'' and 110. Accordingly, well treating fluid now passes from the supply tank 20'' through the line 18'' and open valve 22'' into the tank 8'', filling the same. The pressure-imparting fluid exits the bottom part of the tank 8'' through an outlet line 52'', the open valve 110 and a line 96' communicating with the atmosphere. The system is now ready for a further injection of a predetermined volume of well treating fluid into the well annulus 7''.

The simplified system 6'' functions with only a single solenoid operated three-way valve. The mechanical two-way valves and the cylinder valve are relatively inexpensive. Moreover, if the timer means 28'' comprises a control remote electrical signal sending station capable of operating a plurality of the systems 6'' simultaneously, a further reduction in cost of the system 6'' occurs.

It will be understood that the present method and apparatus are capable of delivering all types of well treating fluids, both gases and liquids, the latter including dispersions, solutions and the like, in predetermined volumes into wells which are at superatmospheric, atmospheric or subatmospheric pressure. The following example further illustrates certain features of the present invention.

Example

An oil well treating apparatus, constructed substantially as set forth in FIGS. 1 and 3 and employing water at normal water main pressure as the pressure-imparting fluid, was used to deliver automatically successive charges of about 600 cc. each of a corrosion and scale inhibitor comprising a mixture of amines and polyphosphates as a well treating fluid to an oil well operating at a pressure lower than that of the water. The apparatus employed a steel cylinder having a neoprene rubber diaphragm 14 dividing the interior thereof to provide an injection zone 10. Polyethylene tubing was used for the water and well treating fluids lines. The electrical lines were sealed in explosion-proof condulets (conduits), as was the electrically operated clock timer 28. A sealed generator was connected by explosion-proof condulets to the timer and to sealed solenoid valves. A key-wound (weekly) pneumatic pressure chart recorder was connected to the water inlet line 56 upstream of the zone 16. A 53 gallon well treating fluid supply tank was used to supply the zone 10 with the well treating fluid. With such apparatus, a total of two charges of about 600 cc. each of corrosion and scale inhibitor well treating fluid were delivered automatically to the well daily for a period of ten months. The chart recorder was examined and rewound weekly.

The recorder clearly indicated that all 14 charges of well treating fluid were delivered on schedule to the well each week without human intervention. Due to the sealed nature of the electrical system, the apparatus 6 was considered essentially explosion-proof and was installed within 15 feet of the oil well. Maintenance costs of the apparatus during the test period were essentially nil. The apparatus continued to operate satisfactorily without leaking or malfunction throughout the test period.

Later tests indicated that the apparatus was equally well adapted for use in the treatment of oil wells with other types of well treating fluids, including corrosion inhibitors such as selected amines, scale preventatives and removers, such as selected chromates, polyphosphates and the like, and dehydration chemicals.

The preceding example clearly illustrates various advantages of the method and apparatus of the invention. The method is simply and effective. The apparatus specified in the example is relatively inexpensive compared to other automatic well treating equipment. Moreover, maintenance and labor costs are very low in contrast to those when each well is conventionally periodically treated by manually operated portable apparatus.

The present apparatus is light weight, simple and effective. It can be made essentially leak-proof and explosion-proof at low cost and is easy to repair. The apparatus is adapted to incorporate an optional recording means which automatically keeps an accurate record of the efficiency of operation of the apparatus and the number of injections taking place in a given period of time. The timing means for operating the solenoid controlled valve

or valves of the apparatus can be simple, efficient and durable, and either integral with or interconnected with the apparatus. The apparatus is also adapted for the delivery of any suitable well treating fluid in any desired amounts and in accordance with any desired schedule. The pressure-imparting fluid can be any suitable gas or liquid. Moreover, the present method is equally applicable, with minor modifications of apparatus, to individual wells operating at superatmospheric, atmospheric or subatmospheric pressure. Further advantages are as set forth in the foregoing.

Although particular arrangements of well treating apparatus and particular manners of practicing the method of the present invention have been set forth, it will be understood that various modifications, changes, additions and substitutions can be made in the apparatus and the steps of the method. All such modifications, changes additions and substitutions in the method and apparatus are within the scope of the appended claims and are a part of the present invention.

What is claimed is:

1. Improved oil well treating apparatus, which apparatus comprises, in combination, container means which includes a single variable volume well treating fluid injection chamber, pressure responsive means forming a part of said chamber in said container means and adapted to vary the volume of said chamber in response to pressure variations, a well treating fluid supply line interconnecting said injection chamber and a well treating fluid source, valve means controlling the passage of well treating fluid from said source to said injection chamber, a well treating fluid outlet line interconnecting said chamber and the annulus of a well to be treated with said well treating fluid, valve means disposed in said well treating fluid outlet line between said injection chamber and said well annulus, a first pressure-imparting fluid inlet line interconnecting said pressure responsive means and a pump-free source of pressure-imparting fluid external of said well, valve means disposed in said first pressure-imparting fluid inlet line between said pressure responsive means and said source of pressure-imparting fluid, a pressure-imparting fluid outlet line connected to said pressure responsive means and fluid pressure relief means connected to said pressure responsive means whereby pressure-imparting fluid in contact with said pressure responsive means can be moved out of contact therewith so as to reduce pressure imparted to said pressure responsive means, a second pressure-imparting fluid inlet line interconnecting a pump-free source of fluid pressure and said well treating fluid outlet line external of said container means, whereby said well treating fluid is contacted with pressure-imparting fluid and is thereby urged toward said well annulus, and valve means disposed in said second pressure-imparting fluid inlet line, and timer means interconnected to said valve means and to said fluid pressure relief means and adapted to intermittently activate the same, whereby the intermittent injection of a predetermined volume of said well treating fluid into said annulus is effected.

2. The apparatus of claim **1** wherein said valve means disposed in said first pressure-imparting fluid inlet line comprises a solenoid-actuated valve interconnected with said timer means, wherein a mechanical valve actuator is operably connected to said solenoid-actuated valve in turn mechanically connected to each of said fluid pressure relief means and said remaining valve means.

3. Improved oil well treating apparatus adapted to be operated at a pressure higher than that of the annulus of a well to which the apparatus is to be connected, which apparatus comprises, in combination, container means which includes a single variable volume well treating fluid injection chamber, pressure responsive means forming a part of said chamber in said container means and adapted to vary the volume of said chamber in response to pressure variations, a well treating fluid supply line interconnecting said injection chamber and a well treating fluid source, valve means controlling the passage of well treating fluid from said source to said injection chamber, a well treating fluid outlet line interconnecting said chamber and the annulus of the well to be treated with said well treating fluid, valve means disposed in said well treating fluid outlet line between said injection chamber and said well annulus, a pressure-imparting fluid inlet line interconnecting said pressure responsive means and a pump-free source of pressure-imparting fluid, valve means disposed in said pressure-imparting fluid inlet line between said pressure responsive means and said source of pressure-imparting fluid, a pressure-imparting fluid outlet line connected to said pressure response means and to said well treating fluid outlet line external of said container means, whereby said well treating fluid is contacted with a pressure-imparting fluid and is thereby urged toward said well annulus, fluid pressure relief means connected to said pressure responsive means whereby pressure-imparting fluid in contact with said pressure responsive means can be moved out of contact therewith so as to reduce pressure imparted to said pressure responsive means, and timer means interconnected to said valve means and to said fluid pressure relief means and adapted to intermittently activate the same, whereby intermittent injection of a predetermined volume of said well treating fluid into said annulus is effected, said fluid pressure relief means comprising a fluid bypass line interconnected with said pressure-imparting fluid inlet line through said valve means in said pressure-imparting fluid inlet line and interconnected with said pressure-imparting fluid outlet line by valve means in communication with said pressure-imparting fluid outlet line, whereby pressure-imparting fluid can be passed from contact with said pressure responsive means by drainage into said well.

4. The apparatus of claim **3** wherein said apparatus is adapted to operate with water as said pressure-imparting fluid, wherein said valve means in communication with said pressure-imparting fluid outlet line is disposed in a common line into which said pressure-imparting fluid outlet line and said well treating fluid outlet line merge.

5. Improved oil well treating apparatus adapted to be operated at a pressure lower than that of the annulus of a well to which said apparatus is to be connected, which apparatus comprises, in combination, container means which includes a single variable volume well treating fluid injection chamber, pressure responsive means forming a part of said chamber in said container means and adapted to vary the volume of said container in response to pressure variations, a well treating fluid supply line interconnecting said injection chamber and a well treating fluid source, valve means controlling the passage of well treating fluid from said source to said injection chamber, a well treating fluid outlet line interconnecting said chamber and the annulus of the well to be treated with said well treating fluid, valve means disposed in said well treating fluid outlet line between said injection chamber and said well annulus, a pressure-imparting fluid inlet line interconnecting said pressure responsive means and a pump-free source of pressure-imparting fluid, valve means disposed in said pressure-imparting fluid inlet line between said pressure responsive means and said source of pressure-imparting fluid, a pressure-imparting fluid outlet line connected to said pressure responsive means and to said well treating fluid outlet line external of said container means, whereby said well treating fluid is contacted with a pressure-imparting fluid and is thereby urged toward said well annulus, fluid pressure relief means connected to said pressure responsive means whereby pressure-imparting fluid in contact with said pressure responsive means can be moved out of contact therewith so as to reduce pressure imparted to said pressure responsive means, and timer means interconnected to said valve means and to said fluid pressure relief means and adapted to intermittently activate the same whereby

intermittent injection of a predetermined volume of said well treating fluid into said annulus is effected, pressure equalizing container means connected to a common line merged to said pressure-imparting fluid outlet line and said well treating fluid outlet line, an exit line disposed between said pressure equalizing container means and said annulus of said well valve means disposed in said exit line, whereby pressure between said well annulus and said pressure equalizing container means can be equalized and whereby passage of a mixture of said well treating fluid and said pressure-imparting fluid into said well annulus is facilitated.

6. The improved apparatus of claim 5 wherein said apparatus is adapted to operate with water as pressure-imparting fluid and wherein said fluid pressure relief means comprises a relief line connected to said valve

and said pressure-imparting fluid inlet line and exposed to the atmosphere, whereby water can be drained from contact with said pressure responsive means through said pressure-imparting fluid inlet line and associated valve means and out of said apparatus through said relief line.

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