Jan. 2, 1968 A. L. WALDRON 3,361,205

METHOD AND SYSTEM FOR DISSOLVING PARAFFIN

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FIG. 1.

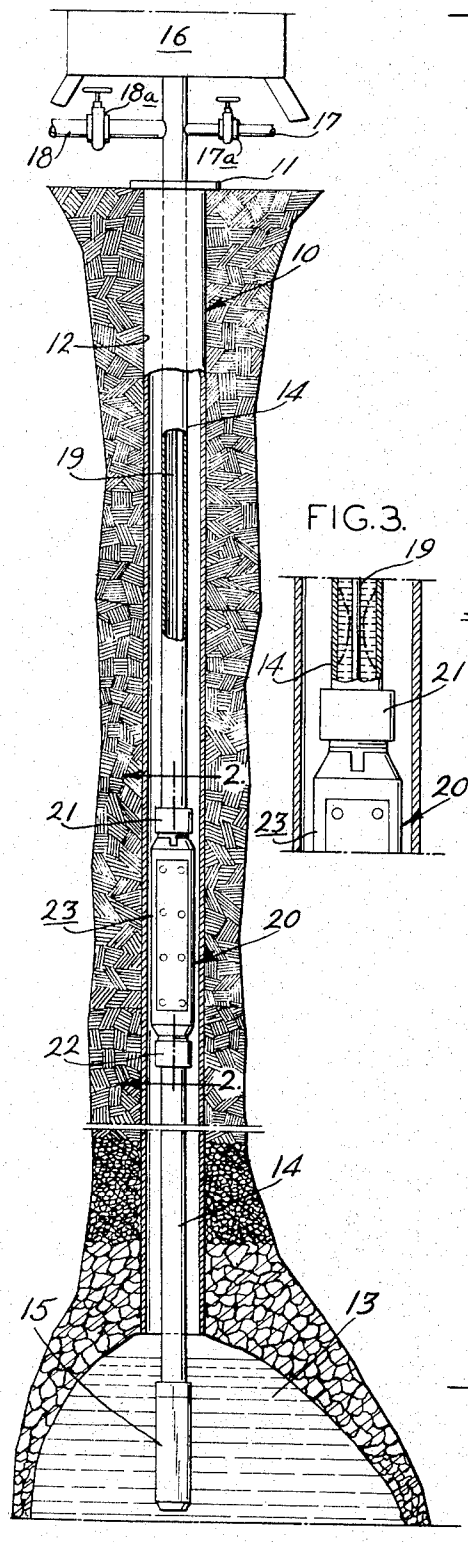

FIG. 3.

FIG. 2.

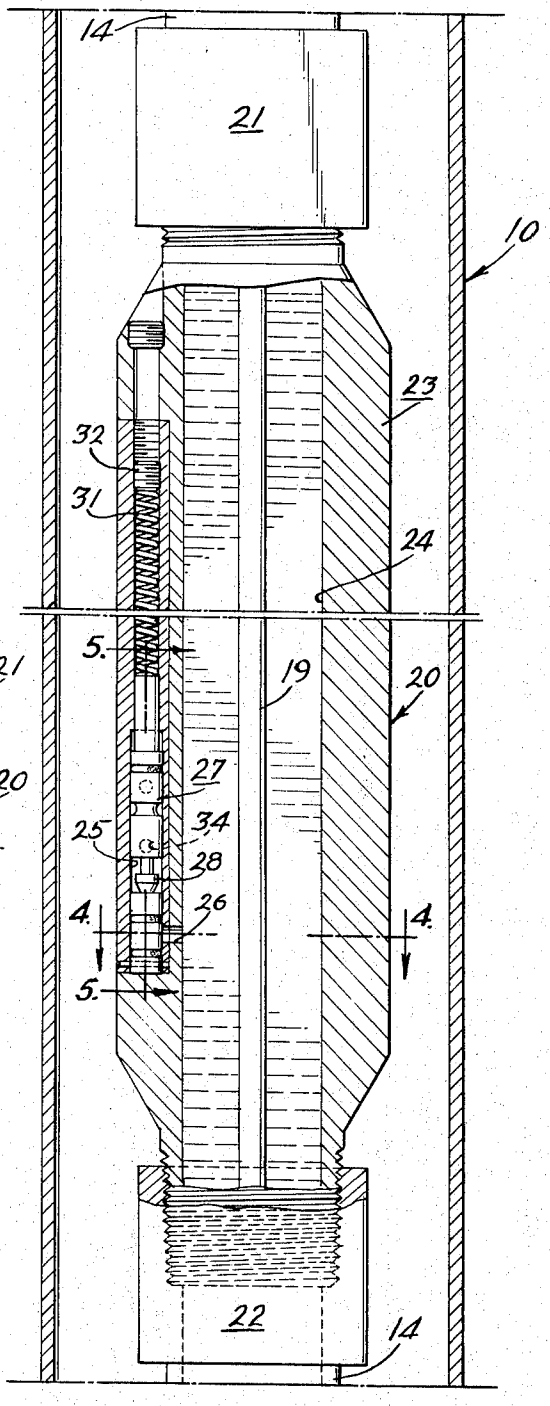

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FIG. 4.

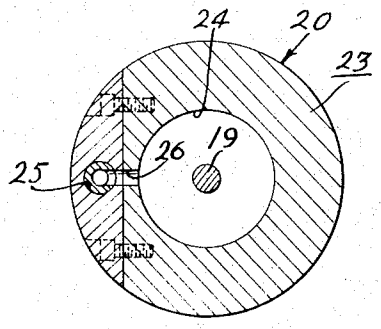


FIG. 5.

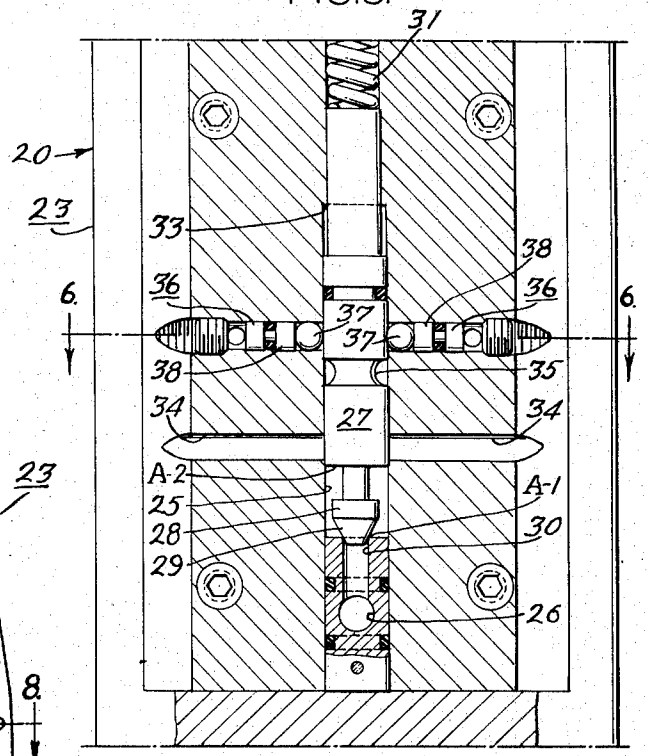


FIG. 7.

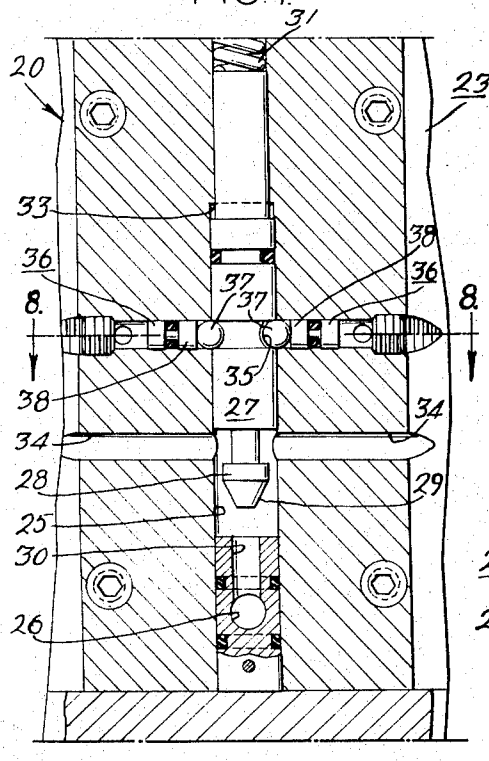


FIG. 6.

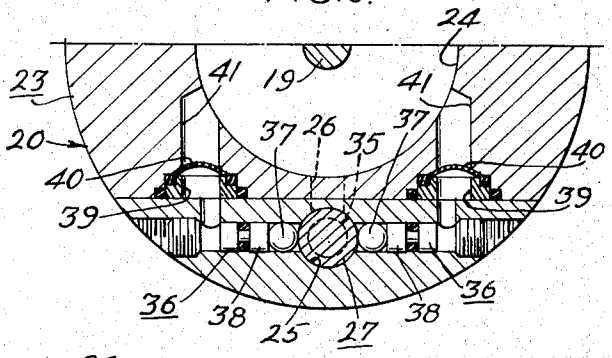
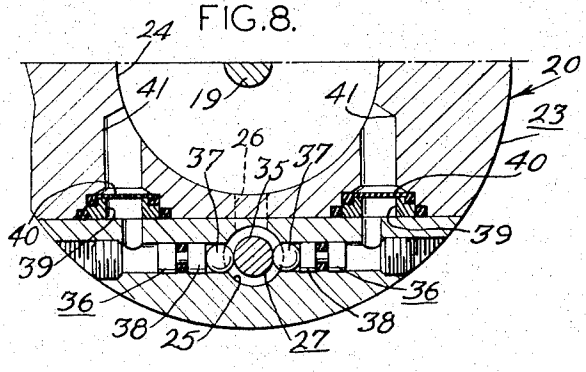


FIG. 8.



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METHOD AND SYSTEM FOR DISSOLVING PARAFFIN

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5 Claims. (Cl. 166—41)

ABSTRACT OF THE DISCLOSURE

A method and apparatus for permitting the cleaning of paraffin deposits accumulated in the tubing string of an oil well, without removing the tubing string. The apparatus includes a valve positioned in the tubing string beneath the expected point of accumulation of paraffin and includes means in the valve responsive to an overpressure in the tubing string to permit communication between the tubing string and its exterior for dumping the oil above the valve into the well casing. The valve also includes positive acting detent means which maintains fluid communication between the tubing string and the well casing until a predetermined lower pressure has been reached, the predetermined lower pressure corresponding to the desired quantity of oil superimposed of the valve in the tubing string. The method includes closing off the tubing string and pumping an overpressure into the string to cause the valve to open. Thereafter pressure is reduced by stopping the pump and a predetermined portion of the oil above the valve is permitted to drain into the well casing until the valve shuts off. Thereafter a solvent is introduced into the tubing string to dissolve the paraffin so that normal operation may once again be resumed.

The present invention relates to apparatus and a method for using the same in oil wells and more particularly to a valve assembly and the method of using the same which permits the treating of a well bore at predetermined regions for removing paraffin deposits accumulated therein.

When an oil well has been in operation for a period of time, the subterranean or reservoir pressure causing a flow of petroleum to the surface gradually decreases, to the point that it becomes necessary to recover the remainder of the oil in the subterranean cavern by a pumping operation. When recovering the petroleum by pumping, paraffin deposits in the tubing string of the pumping line, usually at a predetermined and calculable level, which deleteriously affects, curtails and even halts the pumping action. When this condition occurs, and in some wells which pump petroleum having a high paraffin content the condition occurs repeatedly at relatively short intervals, it is normally necessary to pull the tubing string for the purpose of cleaning, or to resort to laborious operations for cleaning the paraffin deposits while the tubing string is in position. In either case the cleaning of the tubing string by the methods above-described results in lengthy shut-downs with, of course, a concurrent financial loss.

The prior art has exhibited various means, including valve assemblies placed in the tubing string, for permitting the placement in the so-called "paraffin region" (i.e. the depth at which paraffin accumulations occur) of a solvent which will dissolve the paraffin deposits and permit further use of the well without removing the tubing string or the sucker rod interiorly mounted therein. For example, in the Abbott Patent No. 3,016,094, which issued on Jan. 9, 1962, this valve assembly requires above-surface extensions reaching down to the

valve assembly in order to effectuate a closing off of the tubing below the paraffin region. Because of the risk of corrosion by small quantities of water and sulphur in the petroleum, valves of this type have proved unacceptable over long periods of unattended service.

In view of the above, it is a principal object of the present invention to provide a valve assembly for placement in the tubing string whereby paraffin deposits thus occurring may be quickly and easily removed without the necessity for pulling the tubing string or sucker rod, and with a minimum delay in the operation of the well.

Another object of the present invention is to provide a valve assembly whereby a paraffin-removing agent such as a solvent may be effectively introduced into the tubing string at the region of paraffin deposits for effectively and economically removing the latter and restoring the production of the well.

Still another object of the present invention is to provide a valve which is automatically operated and needs no connecting apparatus extending from the "paraffin region" to the surface.

Still another object of the present invention is to provide a valve assembly which may be placed in any part of the tubing string wherein the predetermined "paraffin region" occurs, and which valve may be adjusted to operate at the desired depth in the tubing string.

Another object of the present invention is to provide a method of automatically dumping oil in the tubing string, above a novel valve assembly located therein, which method and apparatus permits the placement of a solvent in the tubing string for dissolving the paraffin in the "paraffin region."

Other objects and a fuller understanding of the invention may be had by referring to the following description and claims taken in conjunction with the accompanying drawings in which:

FIG. 1 is a fragmentary side elevation view partially in section illustrating an oil well having a valve constructed in accordance with the present invention, positioned therein;

FIG. 2 is an enlarged fragmentary sectional view taken along line 2—2 of FIG. 1;

FIG. 3 is a fragmentary sectional view of a portion of the exterior casing of the valve constructed in accordance with the present invention and illustrating paraffin deposits above the valve;

FIG. 4 is a sectional view taken along line 4—4 of FIG. 2 and as if FIG. 2 were not in section;

FIG. 5 is a sectional view taken along line 5—5 of FIG. 2 and as if FIG. 2 were not in section;

FIG. 6 is a sectional view taken along line 6—6 of FIG. 5;

FIG. 7 is a fragmentary sectional view similar to that illustrated in FIG. 5 with the valve of the present invention in another position than that shown in FIG. 5; and

FIG. 8 is a fragmentary sectional view taken along line 8—8 of FIG. 7.

Referring now to the drawings, and especially FIG. 1 thereof, a casing 10 having having an upper casing head or flange 11 is shown inserted in a well bore 12 and having a lower terminus in a subterranean oil reservoir 13. Interiorly of the casing 10 is a tubing string 14, the lower end of which is connected to a conventional reciprocating pump 15 which, in the present instance, is positioned in the oil reservoir 13. At the upper end of the tubing stiring 14 is a tubing head 16, an oil discharge pipe 17, and a solvent and air bleeder pipe 18 with valves 17a and 18a respectively therein. Interiorly of the tubing string 14 and extending substantially coaxially therewith is a sucker rod 19 which sucker rod connects the tubing head 16 with the reciprocating pump 15 and permits operation of the pump in a conventional manner.

In accordance with the invention, a valve assembly 20 is positioned in the tubing string 14 below the predetermined and calculable area of accumulation of the paraffin interiorly of the tubing string 14, whereby upon closing off of the oil outlet pipe 17 by the valve 17*a* and operating of the reciprocatory pump 15 with the valve 18*a* closed, a sufficient pressure is built up interiorly of the valve which automatically dumps the oil, or a certain set portion thereof, in the tubing string above the valve into the space intermediate the tubing string 14 and the casing 10. The pump 15 is then shut down. Upon the release of the oil in the tubing string superimposed above the valve 20, or any predetermined portion as preset, the valve 20 automatically closes, trapping a certain amout of oil above the valve in the tubing string. At this point the valve 18*a*, which has associated therewith an air bleeder check valve (not shown) to admit atmospheric pressure into the tubing string above the oil as it is dumped, is opened and a solvent or the like placed into the tubing string 14. In a short period of time the solvent causes dissolving of the paraffin, tars or basic sediments which have been deposited and built up interiorly of the tubing and above the valve 20.

To this end, and as best illustrated in FIGS. 2, 4, 5, and 6, the valve 20 is provided with tubing coupling means 21 and 22 for mounting a tubular body 23 in the tubing string while permitting fluid communication therethrough as by the bore 24 interiorly of the body 23.

The operating portion of the valve which permits dumping of the oil in the tubing string upon a predetermined overpressure being reached therein, and which permits closing off of the valve upon dumping of the fluid into the casing and at a predetermined pressure, is best shown in FIGS. 2 and 5. As shown in FIG. 2, the body 23 is provided with a bore 25 having an oil inlet 26 at one end therefiof which permits communication of the bore with the interior of the tubing via the bore 25 of the valve body 23. Mounted interiorly of the bore 25 is a piston 27 and at the lower end thereof a valve plug or disc 28 with, in the present instance, a conical seating portion 29 for seating in an extension 30 of the inlet 26. As shown in FIG. 5, the seating cross sectional area of the valve plug or disc 28, designated A–1 for purposes of identification, is less than the cross sectional area of the piston 27, which area is designated A–2. Aligned with the piston 27 and normally biasing the disc 28 into the closed position is biasing means, in the present instance a main piston spring 31, the upper portion of which abuts an adjusting screw 32 (see FIG. 2). As illustrated in FIG. 5, the main piston 27 is provided with a shoulder stop 33 which prevents, upon the piston being displaced vertically in the bore 25, vertical overriding of the piston. Upon sufficient pressure being applied to the inlet 26 and thus the area A–1 of the plug 29, the plug moves off its seat and the pressure at the inlet reaches the larger area A–2, thus causing the piston to raise against the spring.

In order to dump the oil contained in the tubing string 11 above the valve 20 and to hold the piston open against the spring 31, outlet means for dumping the oil in the tubing string is provided to dump the oil into the casing while piston engaging means are provided to engage and hold the piston 27 until a predetermined low pressure is reached at which time the piston is permitted to move downwardly and the plug 29 to reseat in the seat of the inlet extension 30. To this end, and as best illustrated in FIGS. 6, 7, and 8, at least one outlet means, in the present instance two outlets 34 are provided which permit communication, when the piston 27 is in its raised or elevated position, with the bore 25 and thus the inlet 26, the outlets connecting and permitting the dumping of the oil in the tubing string above the valve into the space between the tubing 14 and the casing 10.

To permit the piston to be held in the elevated position to allow communication between the inlet 26 and the outlets 34 until a preset low pressure corresponding to a fixed amount of oil remaining in the tubing string is left, the piston 27 is provided with engagement means, in the present instance an annular groove 35 which permits engagement of pressure responsive detent means 36, located on either side of the piston and which engage the engagement means and hold the piston in an elevated position. As illustrated in FIG. 6, each of the detent means 36 comprises a ball 37 lying in rubbing engagement with the piston 27, a ball piston 38 and a grease-filled conduit 39 fitted with a diaphragm 40. The opposite side of the diaphragm communicates with the bore 24 of the valve 20 thus causing the movement of the ball pistons to be responsive to changes in internal pressure in the tubular valve body 23. The purpose in filling the conduit 39 with grease instead of allowing direct communication of the oil with the base of the ball pistons 38 is to avoid, as much as possible, corrosive contact with the oil, which may contain sulphur and water and other impurities. Such impurities, because of their corrosive effect, may deleteriously affect the operation of the valve. As illustrated in FIGS. 7 and 8, as the piston 27 raises against the spring pressure 31, the outlets 34 permit dumping of the oil into the casing 10, while the pressure existing at the inlets 41, causes inward deflection of the diaphragm and thus of the ball pistons. This causes placement of the balls into the annular groove 35, when the piston 27 raises to a position wherein the groove aligns with the balls. At a predetermined pressure, depending upon the setting of the detent means 36, the spring pressure of the spring 31 will overcome the piston 27 and the detent means 36 and permit the piston 27 to reseat in the inlet extension 30.

It should be kept in mind that each oil well is different and that the valve as heretofore described may be placed in the tubing string anywhere from 500 to 5,000 feet below the earth's surface. In addition, it has been found that the valve spring pressures should be designed so that an overpressure of from 200 to 350 p.s.i. imposed on the static head in the tubing string 14 will cause the valve to operate while a low pressure of approximately 50 to 200 p.s.i. will cause the valve to reseat. In any event, the valve may be set to close with from 80 to 600 feet of oil remaining in the tubing string as the low pressure setting is proportional to the depth at which the valve is placed and inversely as the weight of the pumped oil.

As will be known to those skilled in the art, the areas and spring pressures of the various components of the valve 20 as heretofore described may vary from well to well and the depth at which the valve 20 is placed. Generally, it has been found that a ratio between the areas A–1 and A–2 of approximately 1:6 or a value of A–1 equal to 16 to 20% of A–2 achieves the desired result, above described, and which provides parameters for spring compression design. Obviously, the adjustment of the spring compression by the adjusting screw 32 is dependent primarily upon the location of the lower portion or bottom of the paraffin zone and the specific gravity of the oil being pumped.

In practice, the valve is preferably placed at a depth of 400 to 500 feet below the bottom of the paraffin zone and thus the desired valve pressure setting will be the static pressure at a point 400 to 500 feet below this region and may be determined roughly from the following equation:

$$\text{Valve pressure setting in p.s.i.} = (D+400) \times S.G. \times .433$$

where

D=valve installation depth from ground level

$S.G.$=specific gravity of the petroleum.

Thus for example if the lowest point at which paraffin accumulates is 1500 feet below the surface, and assuming the valve is positioned in the tubing string 2000 feet below the surface level, the valve should be set to open at approximately 1000 to 1200 p.s.i. If the valve is set to close at between 100 and 150 p.s.i., approximately 200 to

280 feet of oil would be located in the tubing string above the valve. Thereafter of course the solvent would be applied and allowed to remain for a sufficient period to dissolve the paraffin and then pump it out.

Thus a novel valve assembly is provided by the present invention for placement in the tubing string which valve permits the removing of paraffin deposits accumulated in the string without the necessity for pulling the tubing string or sucker rod for cleaning, thus providing the economic gain of minimum downtime. In addition, a novel method of dissolving the paraffin in the paraffin region is provided wherein a predetermined amount of oil above the valve may be dumped into the casing for placement in the tubing string of paraffin dissolving solvents.

Although the invention has been described with a certain degree of particularity, it is understood that the present disclosure has been made only by way of example and that numerous changes in the details of construction, method of operation, and the combination and arrangement of parts may be made without departing from the spirit and the scope of the invention as hereinafter claimed.

What is claimed is:

1. A method of dissolving paraffin from paraffin deposits accumulated in a tubing string mounted interiorly of a well casing, said tubing having means connected thereto for moving oil up said tubing out of a subterranean oil reservoir, said method comprising the steps of: providing a valve in said tubing string, said valve being responsive to pressure and having a first position opening said tubing string to said well casing and a second position closing said valve to said well casing; closing off said tubing string above said valve; pumping an overpressure into said tubing string, below the point of closure, until said valve reaches its first or open position; reducing the overpressure in said tubing and permitting at least a portion of the oil in said string above said valve to flow into said casing until said valve closes off; and thereafter injecting a parffin solvent into said tubing string thereby dissolving the paraffin accumulated therein.

2. A method in accordance with claim **1** including the step of, at the time of insertion of said tubing string into said well casing, positioning said valve below the predetermined region wherein paraffin deposits accumulate.

3. A method in accordance with claim **1** wherein said step of reducing the overpressure in said tubing includes the step of shutting down said means for moving oil up said tubing after said valve reaches its open or first position.

4. A method of dissolving paraffin deposits in a tubing string mounted substantially coaxially with a well casing, said tubing string having a pump connected at the lower end thereof and a sucker rod connected to said pump and connected above ground to a tubing head for moving oil up said tubing out of a subterranean oil reservoir; said method comprising the steps of: positioning a valve in said tubing string below the predetermined region wherein paraffin deposits accumulate; said valve providing an opening between the interior of said tubing and said well casing upon a predetermined overpressure occurring in said tubing string; and closing said opening upon a preset and determined lower pressure occurring in said tubing string; closing off the upper portion of said tubing string above said predetermined region while continuing to operate said pump to create an overpressure in said tubing string until said valve opens, and thereafter shutting down said pump; permitting at least a portion of the oil in said string above said valve to flow into said casing until said valve closes off; and injecting a paraffin solvent into said tubing string and keeping said solvent therein until said paraffin dissolves.

5. A system for dissolving paraffin from paraffin deposits accumulated in a pressure assisted oil well; said oil well comprising a well casing having mounted therein and substantially coaxially therewith a tubing string; an oil reservoir adjacent the lower terminal end of said well casing and a pump connected to said tubing string at the lower end thereof in said oil reservoir; means operable from the surface for actuating said pump; a pressure actuated valve in said tubing string; and means to restrict the flow of oil up said tubing string; said valve having means responsive to an increase in pressure in said tubing string to permit dumping of oil from said string through said valve and into said casing, and responsive to a decrease in pressure to close said valve off to stop said dumping at a predetermined pressure substantially below the pressure required to open said valve, whereby a solvent may be injected into said tubing string to clean said string of accumulated paraffin or other deposits therein.

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