

[54] **POWER FLUID CONDITIONING UNIT**
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[57] **ABSTRACT**

A one, well, self contained, wide producing range, hydraulic pumping system comprising a power fluid conditioning unit to condition produced water, oil, or a mixture of oil and water, from the produced well fluids and exhausted power fluid so that it will be suitable for use as power fluid to economically pump a well which produces medium to large volumes from average to greater depths of lift.

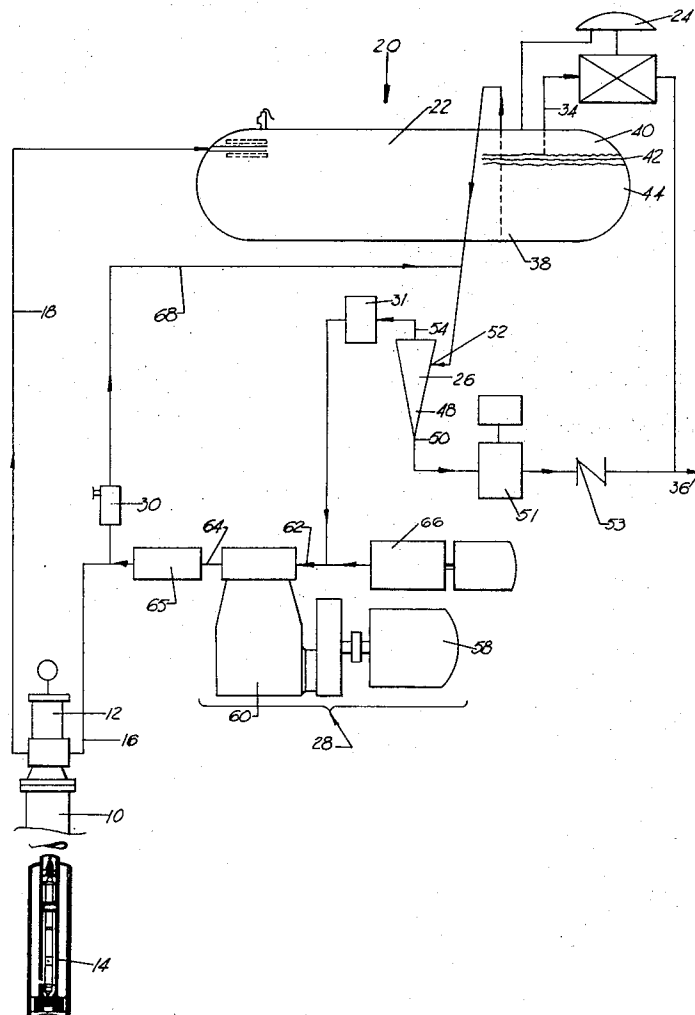
9 Claims, 6 Drawing Figures

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[58] Field of Search.....166/68, 105.4, 105.5, 105.6;
 417/77, 79-83

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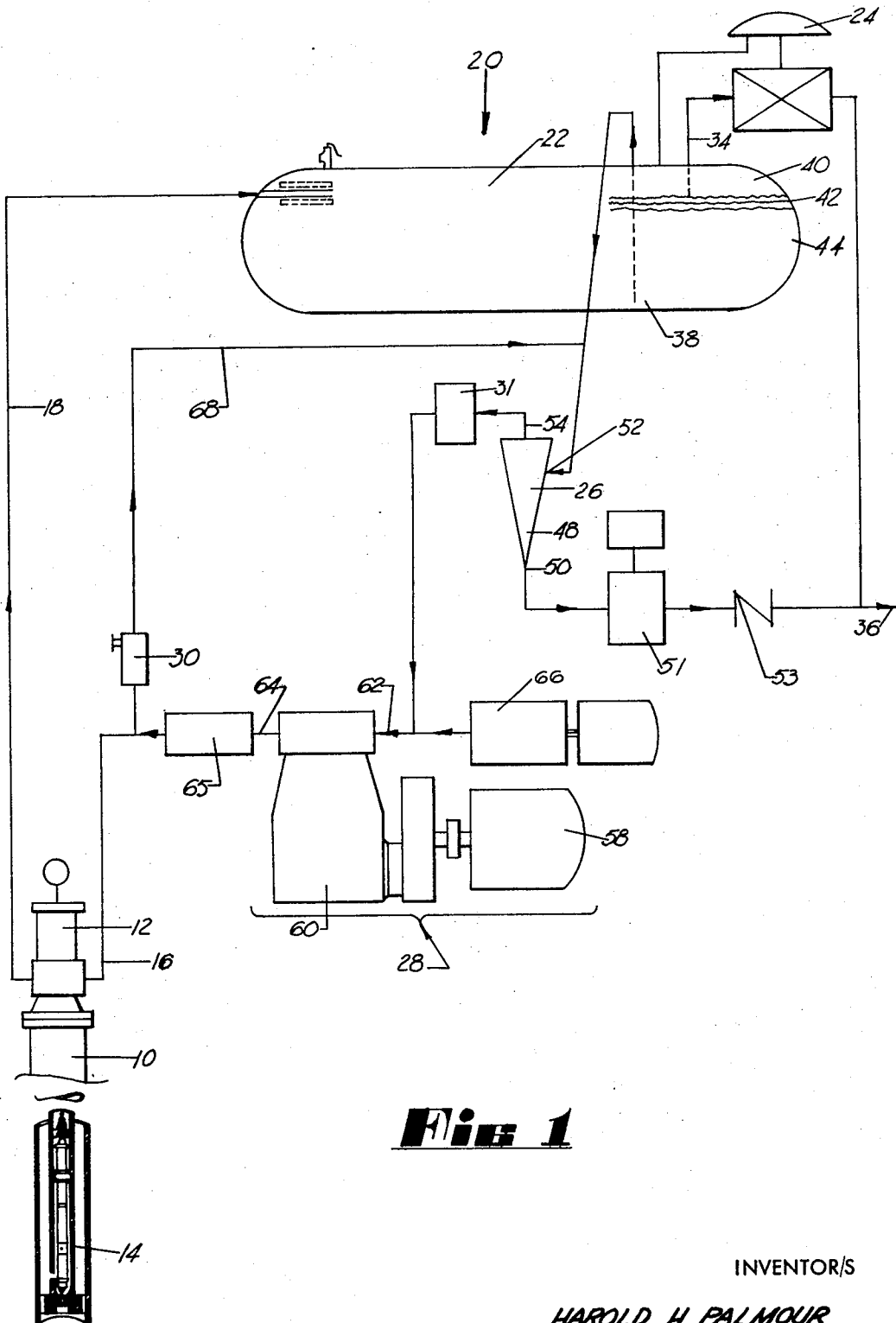


Fig 1

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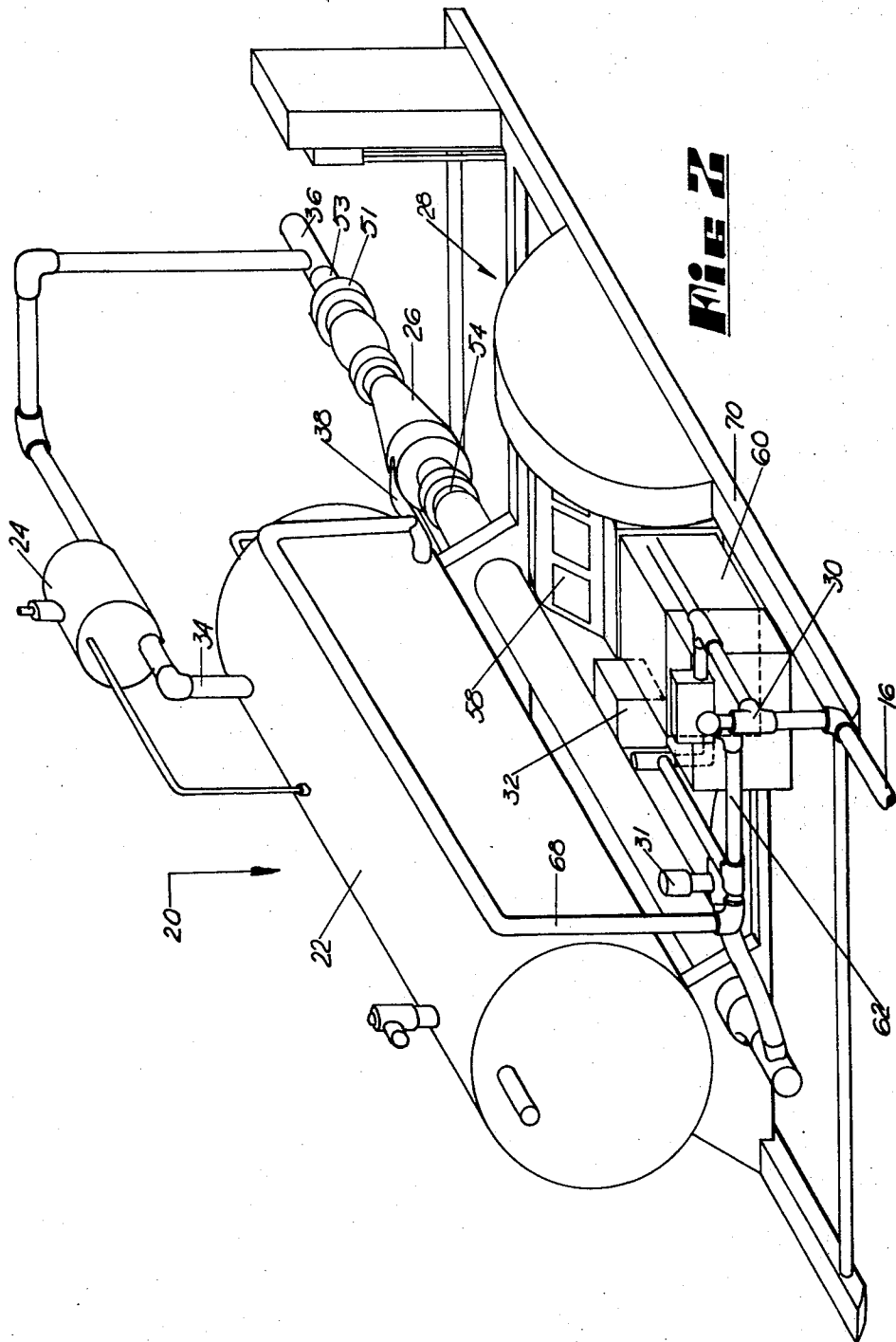
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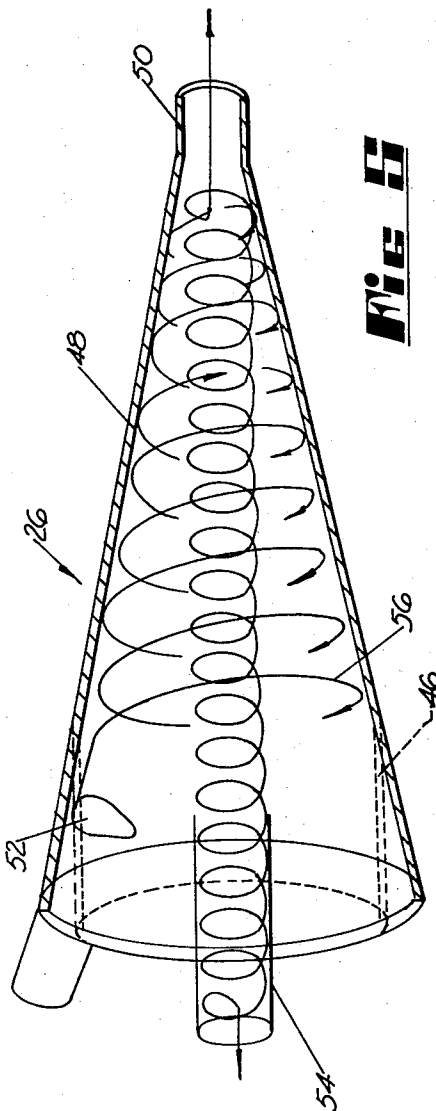
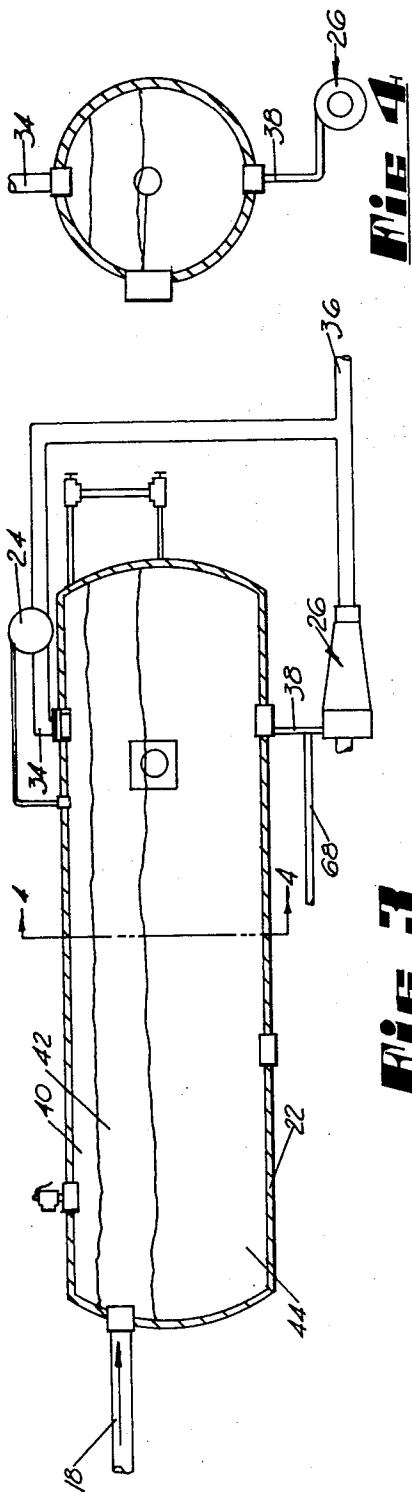
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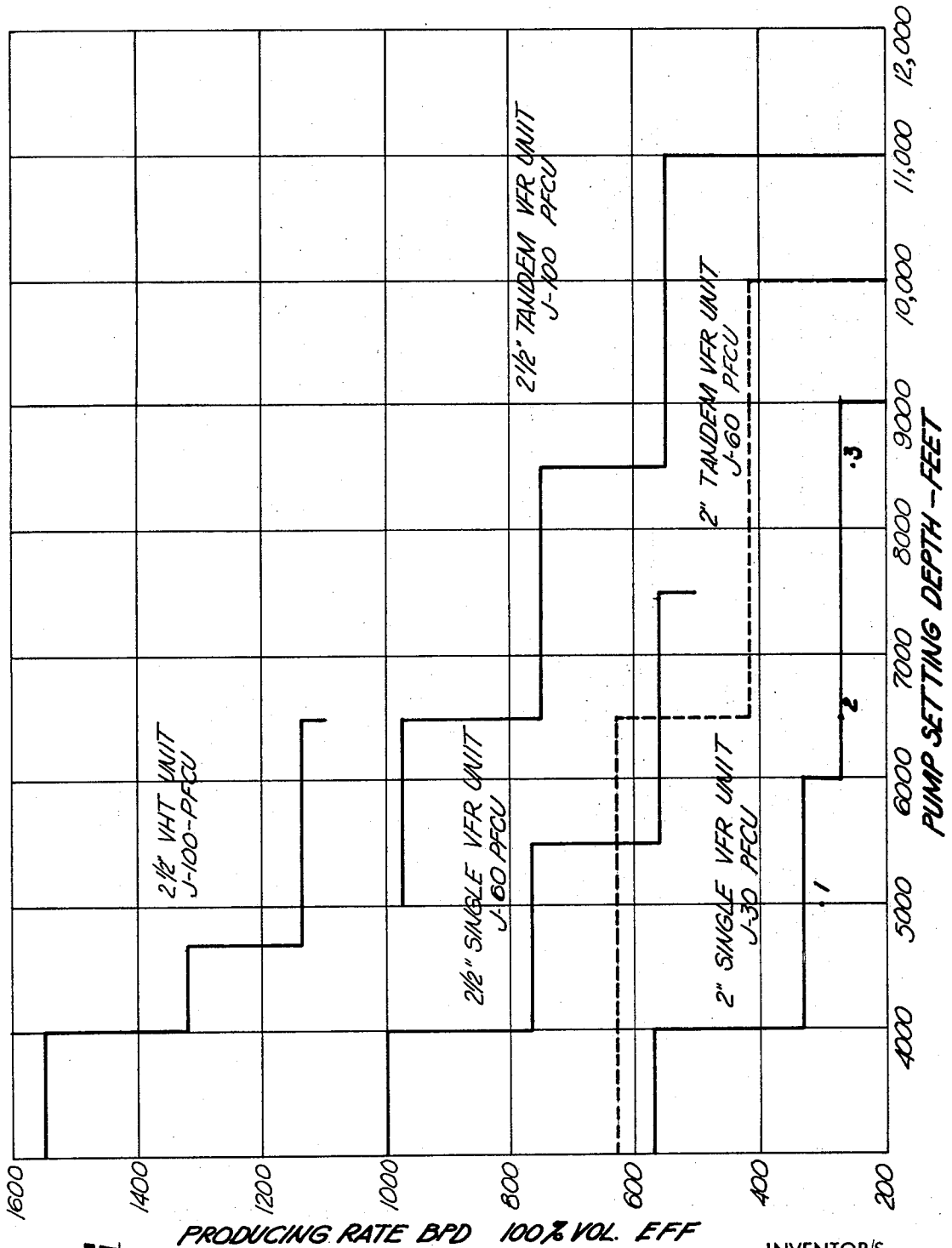


Fig 6

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POWER FLUID CONDITIONING UNIT**BACKGROUND OF THE INVENTION****1. Field of the Invention**

This invention relates to hydraulic pumping systems, and more particularly, to a hydraulic pumping system which is economically applicable for the average to greater depth wells which are producing only moderate to large volumes of well fluids.

2. Description of the Prior Art

It is becoming increasingly rare when the plans for the producing phase of oil fields do not include a water flood. Often water injection is begun immediately as a means of maintaining bottom hole pressures and thereby extending the flowing life of the field. In any case, as a well of this type goes on the pump, it can be assumed that large quantities of water will have to be produced with the oil and that the total volumes to be pumped will gradually increase as the percentage of water increases.

Hydraulic downwell pumps disposed at the lower ends of wells are especially suited to these installations, as their capacity may be controlled by varying their speed, and this being affected by simply adjusting power fluid flow. An additional advantage of hydraulic pumps is being able to retrieve a free type hydraulic pump by circulating it out of the well. Such retrieval becomes even more important when inspection or repair is necessary due to the adverse environment which is often encountered.

The oil industry today is also concerned with deeper drilling, off shore development and continued activity in the formation of large secondary recovery projects. With each of these trends, when artificial lift is required, it will be desirable to have a lift system capable of lifting greater volumes, and in many instances from greater depths of lift, requiring subsurface production units which develop more downhole horsepower within the confines of dimensional limitations of the tubing or casing string to provide the required energy to lift the well fluids to the surface. Accordingly, the development of sub-surface production units which have increased producing capabilities also requires larger volumes of power fluid to be directed to these units in order to provide the additional energy required.

While water has heretofore been utilized as a power fluid, its use has been in multiple well installations where central power plants, treating facilities, tankage and controls are at one location, requiring high pressure power fluid lines out to each well to conduct the power fluid to that well. Its use has also been in "closed power fluid systems", wherein the power fluid is kept separated from the well fluids and thereby requires a separate string of pipe to return the exhaust or spent power fluid back to the surface and a return line from the well back to the central station. In addition to the power fluid, high pressure distribution lines to the wells and the return power fluid lines back to the central station, another string of pipe or production tubing is necessary from the surface to the bottom of the well. A flow line from the well to the tank battery or central station is, of course, necessary for all methods of artificial lift. The power water used in these multi-well installations is supplied from a source other than the producing well and is stored for use in a tank at atmospheric pressure near the surface power pump.

While the prior art has successfully used both power water and power oil as hydraulic fluid to operate sub-surface hydraulic pumps, such use has been with multi-well installations or in closed power fluid systems where the power fluid is kept separated from the well fluids, and not with a one-well, self contained unit that has universal application to produce solid free power fluid.

SUMMARY OF THE INVENTION

The present invention provides a one well, self contained, hydraulic pumping installation for a pumping system of the type having a downwell pump which utilizes produced water, oil, or a mixture of oil and water, as the power fluid for pumping well fluids. The pumping installation comprises a power fluid conditioning unit to condition produced water, oil, or a mixture of oil and water, which is always under pressure above atmosphere, from the produced well fluids and exhausted power fluid so that it will be suitable for use as power fluid. Briefly, the produced well fluids and exhausted power fluid from the well, which include oil, gas and water, enters a pressurized, separator-accumulator tank where water is separated from the oil and gas by gravity separation. Water, oil, or a mixture of oil and water, from the pressurized tank is then forced into the inlet of at least one cyclone separator, wherein solids are separated therefrom. The conditioned fluid discharged from the cyclone separator then proceeds into the suction manifold of a pressure pump, wherein, if necessary, appropriate chemicals are injected into the suction of the pressure pump by a chemical pump and high pressure conditioned fluid is discharged from the power fluid outlet of the pressure pump and down the well to operate a sub-surface production unit, such as a downwell hydraulic pump.

The volume of oil, gas and water a well is producing is discharged from the separator-accumulator tank into a flow line which leads to further processing units. Solids separated by the cyclone separator are discharged with some fluid directly into the flow line and join the production of the well.

The power fluid conditioning unit of the present invention provides a one-well synergetic lift system which is safe, flexible and an economical method of producing an oil well. Since the power fluid conditioning unit of the present invention combines the spent power fluid with the fluid at the bottom of the hole and then separates conditioned power fluid in the power fluid conditioning unit, it saves the surface piping as well as a string of tubing from the bottom of a hole, which are required, for example, with existing closed central systems serving many wells. The power fluid conditioning unit of the present invention keeps the power fluid under pressure at all times and thus it is not exposed to air where it can pick up oxygen and be more corrosive, as is the case with other closed water power systems. It eliminates the cost associated with a sucker rod pumping system. In addition, it eliminates (1) the inventory of power oil, (2) the power oil tank, (3) high pressure power oil lines, (4) fire hazards, and (5) additional treating facilities necessary at the central battery of the usual closed central system. The power fluid conditioning unit of the present invention may be tailored to fit the requirements of a well with a maximum flexibility for producing rates or well changes and it may be

quickly installed because it does not entail a major construction job at the lease.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic flow diagram showing a one well, self contained, hydraulic pumping system according to the present invention.

FIG. 2 is a perspective view showing the skid mounted power fluid conditioning unit of the present invention.

FIG. 3 is a cross sectional view through an exemplary separator-accumulator tank which forms a part of the power fluid conditioning unit of the present invention.

FIG. 4 is a cross sectional view taken on the lines 4 — 4 of FIG. 3.

FIG. 5 is a perspective cross sectional view showing an exemplary cyclone separator which forms a part of the power fluid conditioning unit of the present invention.

FIG. 6 is a graphical summary (maximum pump displacement vs. pump setting depth) of the results of a testing program on the power fluid conditioning unit of the present invention as utilized with a variety of downwell hydraulic pumps at differing pump setting depths.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Turning first to the schematic view of FIG. 1, it will be seen that a typical well 10 is provided with a standard wellhead control 12 communicating with a sub-surface production unit, such as the downwell pump 14, which utilizes water, oil, or a mixture of oil and water, as the power fluid, for pumping the well. The power fluid intake is illustrated at 16 and the produced well fluids and exhausted power fluid are illustrated at 18.

The present invention provides a one well, self contained, hydraulic pumping installation comprising a power fluid conditioning unit 20 to condition produced fluid from the produced well fluids and exhausted power fluid so that it will be suitable for use as power fluid. The conditioning unit 20 includes a pressurized separator-accumulator tank 22, including a back pressure valve 24 for controlling the pressure therein, a cyclone centrifugal separator 26, power driven pump means 28, and means for controlling the speed of the downwell pump 14 in the well 10, by controlling the power fluid flow, such as the valve means 30 which bypasses a quantity of clean power fluid back to the intake of the cyclone separator 26. Additionally, means 66, such as a chemical pump, may be provided for discharging chemicals into the suction of the pump means 28, such as an electric motor driven multi-plex plunger pump 60, so that the clean power fluid passing therethrough acquires lubricating, non-corrosive and other desired power fluid qualities. If necessary, a gas eliminator 31 may also be provided between the cyclone separator 26 and the pump means 28.

The produced well fluids and the exhausted power fluid 18 are pumped from the well 10 into the pressurized separator-accumulator tank 22, which is designed basically as a free-water knockout, wherein the gravity separation of water from oil and gas takes place. The separator-accumulator tank, as best seen in

FIGS. 3 and 4, is provided with at least two main outlets therein, a first outlet 34 communicating with the flow line 36, which leads to the lease treating facilities and tank battery (not shown), the volume of oil, gas and water produced by the well 10 being discharged therethrough, and a second outlet 38 in the lower section of the tank 22 for release of desired quantities of gravity separator water, oil, or mixture of oil and water, to be conditioned for use as power fluid. In FIGS. 3 and 4, the separation of the produced well fluids and the exhausted power fluid in the tank 22 into gas, oil and water is indicated by the numerals 40, 42 and 44, respectively.

A back pressure valve 24 is positioned between the flow line 36 and the tank 22 for controlling the pressure in the tank 22.

At least one cyclone, centrifugal separator 26 communicates with the second outlet 38 in the lower section of the tank 22 so that the cyclone separator 26 will receive fluid from the lower section of the tank 22 at an optimum pressure (controlled by the back pressure valve 24) to give a desired pressure drop there across for the requirements of a particular well.

As can best be seen from FIG. 5, the cyclone separator 26 is provided with an inverted conical section 48, which may, as desired, include an upper vertical side wall 46 of circular cross section. The apex 50 of the conical section 48 is connected with the flow line 36 for passage of liquids and solids from the cyclone separator 26. An inlet 52 on the side wall of the cyclone separator 26 communicates with the second outlet 38 of the tank 22. The inlet 52 is adapted to direct the inlet flow of fluid to be conditioned from the tank 22 substantially tangentially to the inner surface of the cyclone separator 26. An outlet 54 for conditioned fluid from the cyclone separator 26 is provided in the upper end thereof. In operation, pressurized fluid to be cleaned enters the inlet 52 and rotation thereof, as indicated by the arrows 56, develops high centrifugal forces in the cyclone separator 26, drawing suspended solids outward toward the wall of the conical section 48 and downward in an accelerating spiral along the wall to the solids discharge point at the apex 50 and moving conditioned water inward and upward to the outlet 54 as a spiraling vortex. The collected solids separated by the cyclone separator 26 are discharged with some fluid through the hydromotor valve 51 and the check valve 53 into the flow line 36, and join the production of the well 10 leading to the tank battery (not shown). As more fluid goes with the collected solids, finer size separation is possible.

It should be noted that the check valve 53 prevents a back flow of collected solids from the flow line 36 into the cyclone separator 26 when the conditioning unit 20 is not in operation. Additionally, it should also be noted that the hydromotor valve 51, which is open when the electricity is on and closes automatically when the electricity is off, prevents the cyclone separator 26 from losing its fluid if the well 10 continues to produce gas when an electric failure occurs and stops the pump means 28. The hydromotor 51 is, of course, an optional piece of equipment and unnecessary when the conditioning unit 20 is utilized on certain wells.

Clean fluid which is discharged from the outlet 54 of the cyclone separator 26 proceeds through the gas

eliminator 31 into the suction manifold 62 of the power driven pump means 28, such as the electric motor 58 and the multi-plex plunger pump 60. The outlet 64 of the pump 60 communicates through the desurger 65, which reduces the flow during the peak flow and adds to the minimum flow, with the power fluid intake 16 of the downwell pump 14 in the well 10, and, as long as the average pressure remains the same and the pump cycles remain constant over a period of time, provides substantially a constant volume of clean, high pressure fluid to be delivered to the downwell engine of the downwell pump 14.

At this point it should be noted that the downwell pump 14 discharging into the pressurized separator-accumulator tank 22 as the result of the horsepower created by the surface pump means 28 supplies the pressure that is used to make all of the components of the power fluid conditioning unit 20 of this invention function. Accordingly, it is unnecessary to use an auxiliary power source such as a centrifugal pump to charge the cyclone separator 26 and the pump 28.

It should also be noted that it is extremely desirable to treat the clean, high pressure power fluid so that it will acquire lubricating, non-corrosive and other desired power fluid qualities. Accordingly, means 66, such as a chemical pump, may be provided for discharging desired chemicals into the suction manifold 62 of the pump 60.

The capacity of the downwell pump 14 may be controlled by varying its speed, and this may be affected by any suitable means for controlling the power fluid flow to the intake 16 from the outlet 64 of the pump 60. For example, the power fluid flow may be varied by varying the speed of the pump 60 which can be done in a controlled manner; for instance when using an internal combustion engine, or it can be accomplished by a constant speed prime mover with a variable speed drive.

Exemplary means for controlling the power fluid flow to the downwell pump 14 from the pump 60 is shown in FIGS. 1 and 2. Suitable by-pass means 68 communicate between valve means 30 and the inlet 52 of the cyclone separator 26. The valve means 30 controls the speed of the downwell pump 14 by passing back to the inlet 52 of the cyclone separator 26 a quantity of clean fluid, the amount of the fluid being by-passed controlling the amount of fluid sent to the well 10 so as to maintain the desired strokes per minute on the downwell pump 14.

As shown in FIG. 2, the power fluid conditioning unit 20 is preferably mounted upon a suitable skid 70 so that it is compact and may be positioned as desired with respect to a well.

FIG. 6 is a graphical summary of the results of a testing program on the power fluid conditioning unit 20 of the present invention as utilized with a variety of downwell hydraulic pumps at differing pump setting depths. As can be seen, maximum pump displacement vs. pump setting depth is shown. Such data is based upon 50 percent water-cut production, 5 1/2 inches casing, and a maximum well head operating pressure of 2500 p.s.i.

While certain preferred embodiments of the invention have been specifically illustrated and described, it is understood that the invention is not limited thereto, as many variations will be apparent to those skilled in

the art, and the invention is to be given its broadest interpretation within the terms of the following claims.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. In a downwell engine and pump unit which utilizes power fluid for pumping well fluid, such as oil, gas and water, from a well to a flow line, a one well, self contained, hydraulic pumping system comprising a power fluid conditioning unit to condition produced fluid from the produced well fluid and well exhausted power fluid so that it will be suitable for use as power fluid, which comprises:

- a. a pressurized separator-accumulator tank which communicates with said well for receiving the exhausted power fluid and produced well fluid, the gravity separation of water from oil and gas taking place in said tank, said tank having at least two main outlets therein, a first outlet communicating with said flow line, the volume of oil, gas and water produced by said well being substantially discharged therethrough, and a second outlet in the lower section of said tank for release of gravity separated water, oil, or mixture of oil and water;
- b. a back pressure valve disposed between said flow line and said tank for controlling the pressure in said tank;
- c. at least one cyclone, centrifugal separator for conditioning fluid from said separator-accumulator tank by removing suspended solids therefrom, said cyclone separator having an inlet which communicates with said second outlet of said tank for receiving fluid from the lower section of said tank at an optimum pressure so as to give a desired pressure drop across said cyclone separator for the requirements of a particular well, a first outlet connected with said flow line for passage of suspended solids separated by said cyclone separator with some fluid into said flow line, and a second outlet for the discharge of conditioned fluid;
- d. power driven pump means, the inlet thereof communicating with said second outlet of said cyclone separator and the outlet thereof communicating with said downwell pump in said well and providing condition, high pressure fluid to be used as power fluid; and
- e. means to control the speed of said downwell pump by adjusting power fluid flow thereto from said power driven pump means so as to maintain the desired strokes permitted on said downwell pump.

2. The downwell engine and pump according to claim 1, wherein said means to control the speed of said downwell pump comprise by-pass means communicating between said inlet of said cyclone separator and the outlet of said power driven pump means, and valve means associated with said by-pass means which controls the speed of said downwell pump by passing back to said cyclone separator a quantity of clean fluid, the amount of said fluid being by-passed controlling the amount of fluid sent to said well.

3. The downwell engine and pump according to claim 1, wherein said cyclone, centrifugal separator comprises an inverted conical section, said first outlet being located at the apex thereof, said inlet being positioned in the side wall in the upper region of said

cyclone separator and being adapted to direct the inlet flow of fluid to be conditioned substantially tangentially to the inner surface of said side wall, and said second outlet being located in the upper end of said cyclone separator, whereby pressurized fluid to be conditioned enters said inlet and rotation thereof develops high centrifugal forces in said cyclone separator, drawing suspended solids outward toward the side wall and downward in an accelerating spiral along the side wall to said apex and moving conditioned fluid inward and upward to said second outlet as a spiraling vortex, and the underflow of suspended solids separated by said cyclone separator are discharged with some fluid through said first outlet into said flow line.

4. The downwell engine and pump according to claim 1, wherein means are provided for discharging chemicals into the suction of said pump means so that the clean fluid passing therethrough acquires lubricating, non-corrosive and other desired qualities.

5. The downwell engine and pump according to claim 4, wherein said chemical discharge means comprises a chemical pump.

6. The downwell engine and pump according to claim 1, wherein said power fluid conditioning unit is mounted upon a skid.

7. The downwell engine and pump according to claim 1, wherein a check valve is positioned between the apex of said cyclone separator and said flow line to preclude a back flow of solids from said flow line to said cyclone separator when said power fluid conditioning unit is shut down.

8. The downwell engine and pump according to claim 7, wherein said pump means comprises an electric motor driven pump.

9. The downwell engine and pump according to claim 8, wherein a hydramotor valve, which is open when the electricity is on and which closes automatically when the electricity is off, is positioned between said check valve and the apex of said cyclone separator so as to prevent said cyclone separator from losing fluid if an electrical failure occurs and stops said pump means and said well continues to produce gas.

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