

[54] CLEANING APPARATUS FOR OIL WELL PRODUCTION

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[73] Assignee: Kobe, Inc., Huntington Park, Calif.
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Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 256,871, May 25, 1972, Pat. No. 4,917,655.
[52] U.S. Cl. 166/75
[51] Int. Cl. E21b 33/03, E21b 43/00
[58] Field of Search 166/75, 267; 210/73, 512

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Primary Examiner—James A. Leppink
Attorney, Agent, or Firm—Harris, Kern, Wallen & Tinsley

[57] ABSTRACT

An apparatus for processing production fluid from an oil well in the field to obtain clean power oil for a fluid operated pump in the well. The apparatus is intended to service a single well, or at most a few wells, and includes components, including a tank-type separator, for removing solids, gas and water from the production fluid to obtain the clean power oil, which is pressurized by a triplex pump and delivered to the fluid operated pump in the well. The apparatus also includes a tank, either a separate storage tank, or a large separator tank, containing a sufficient reserve of power oil for running the fluid operated pump into and out of the well. A circulating pump having a capacity at least about twice that of the triplex pump continuously circulates the oil to be cleaned through one or more cyclones which continuously remove any solids. If desired, this apparatus can be used to furnish clean power water to the triplex, instead of oil.

7 Claims, 5 Drawing Figures.

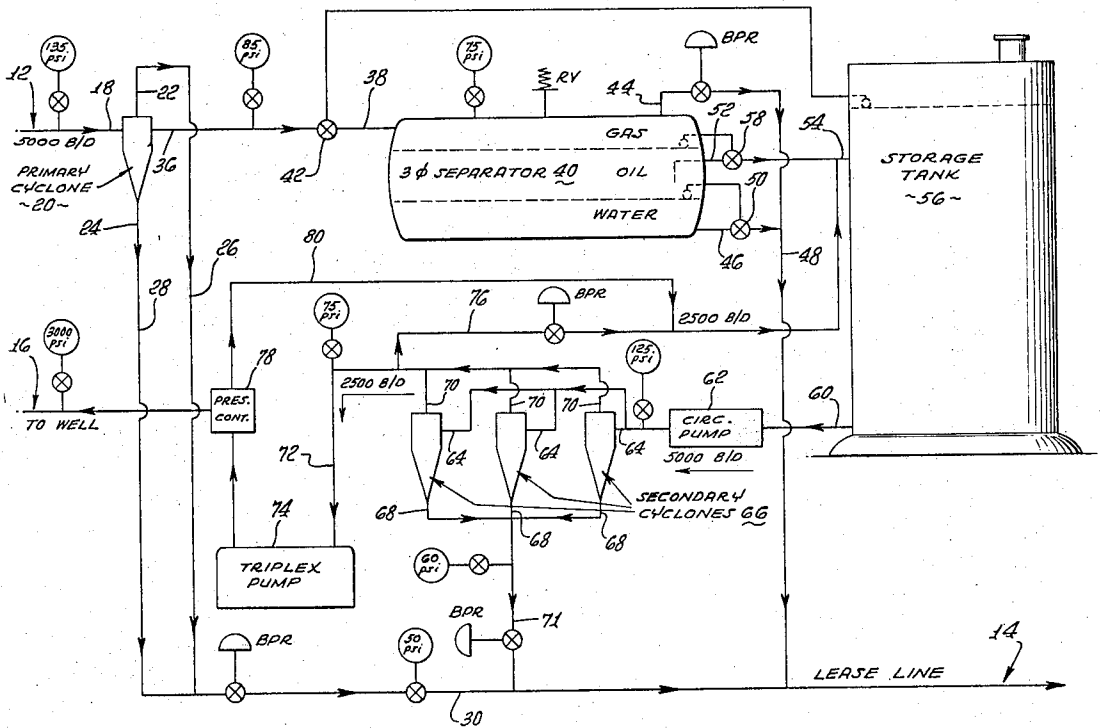


Fig. 1.

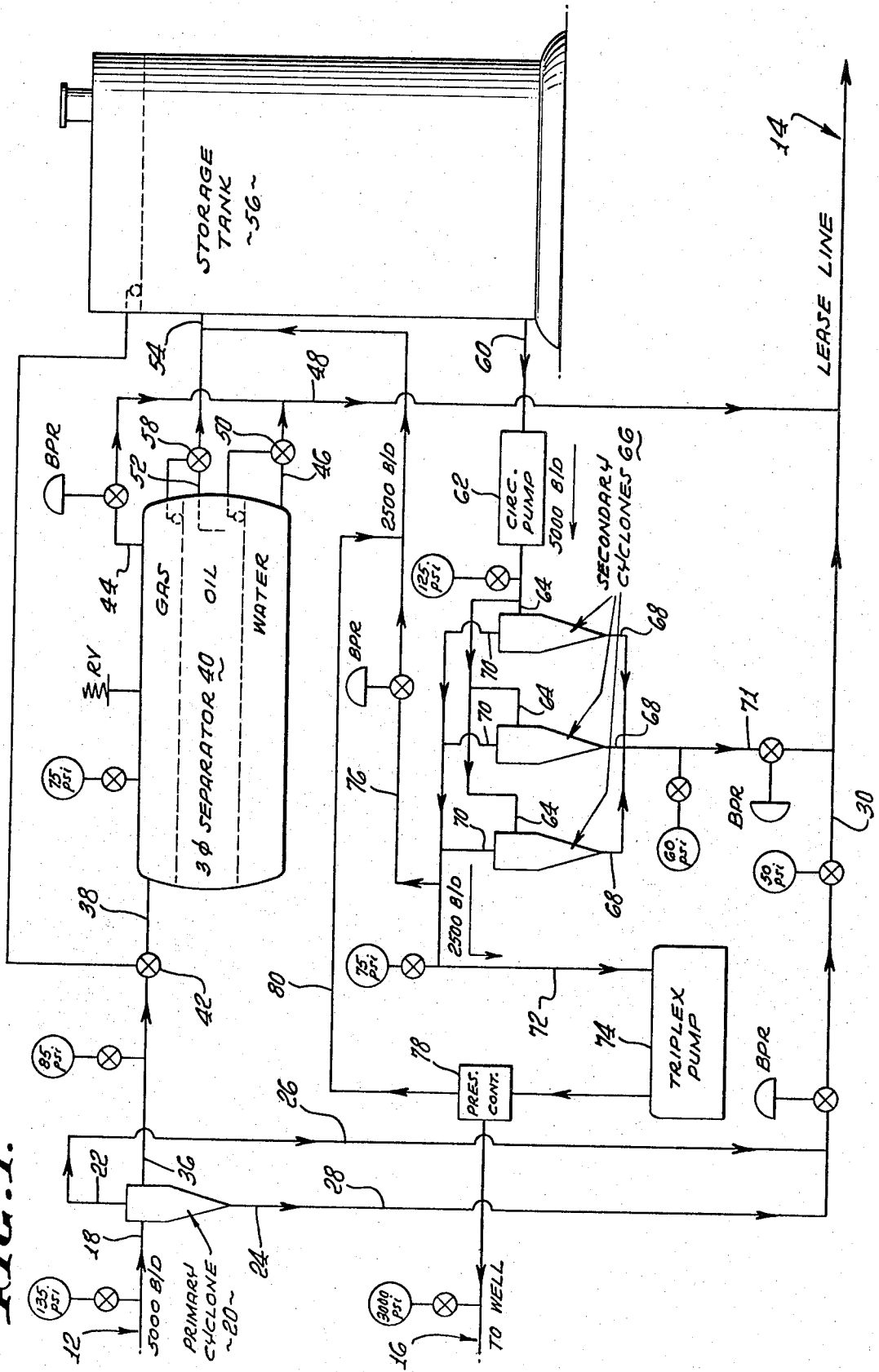


FIG. 2.

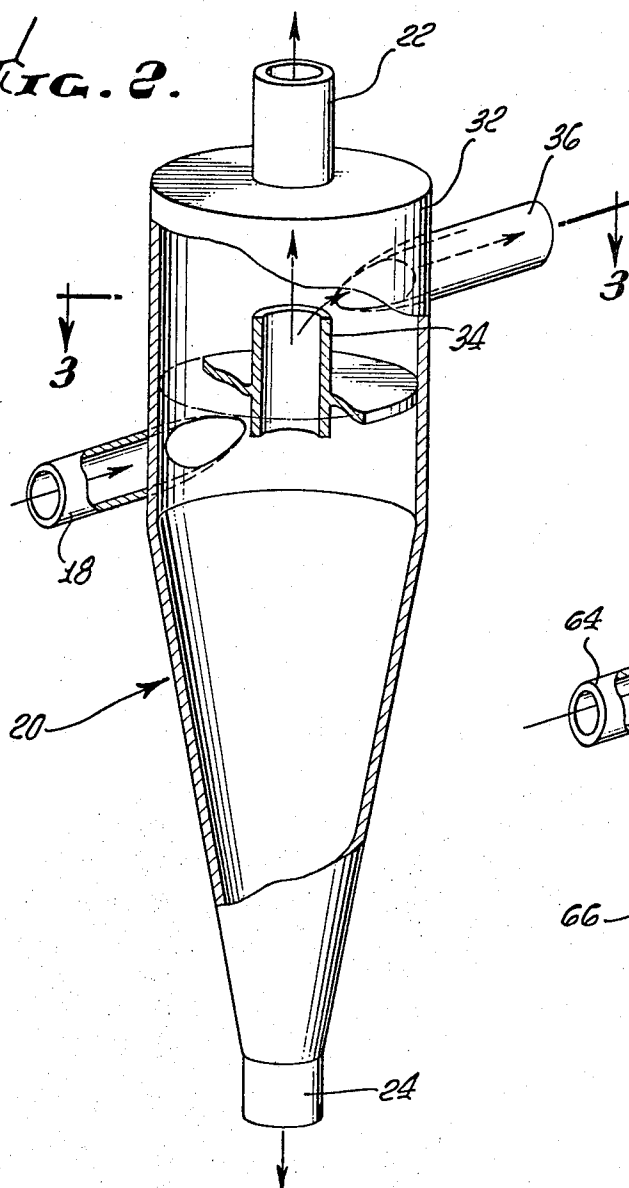


FIG. 4.

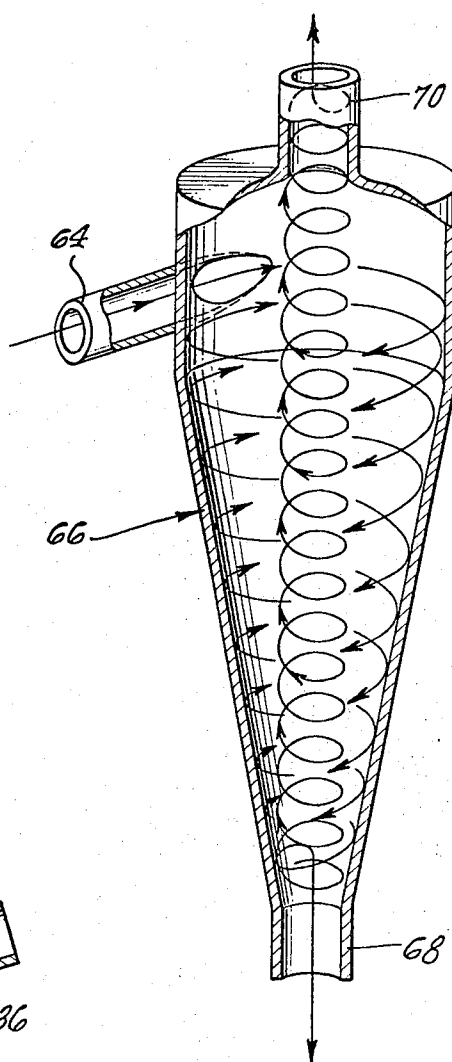


FIG. 3.

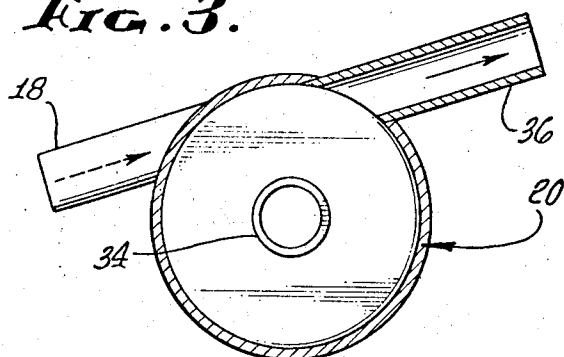
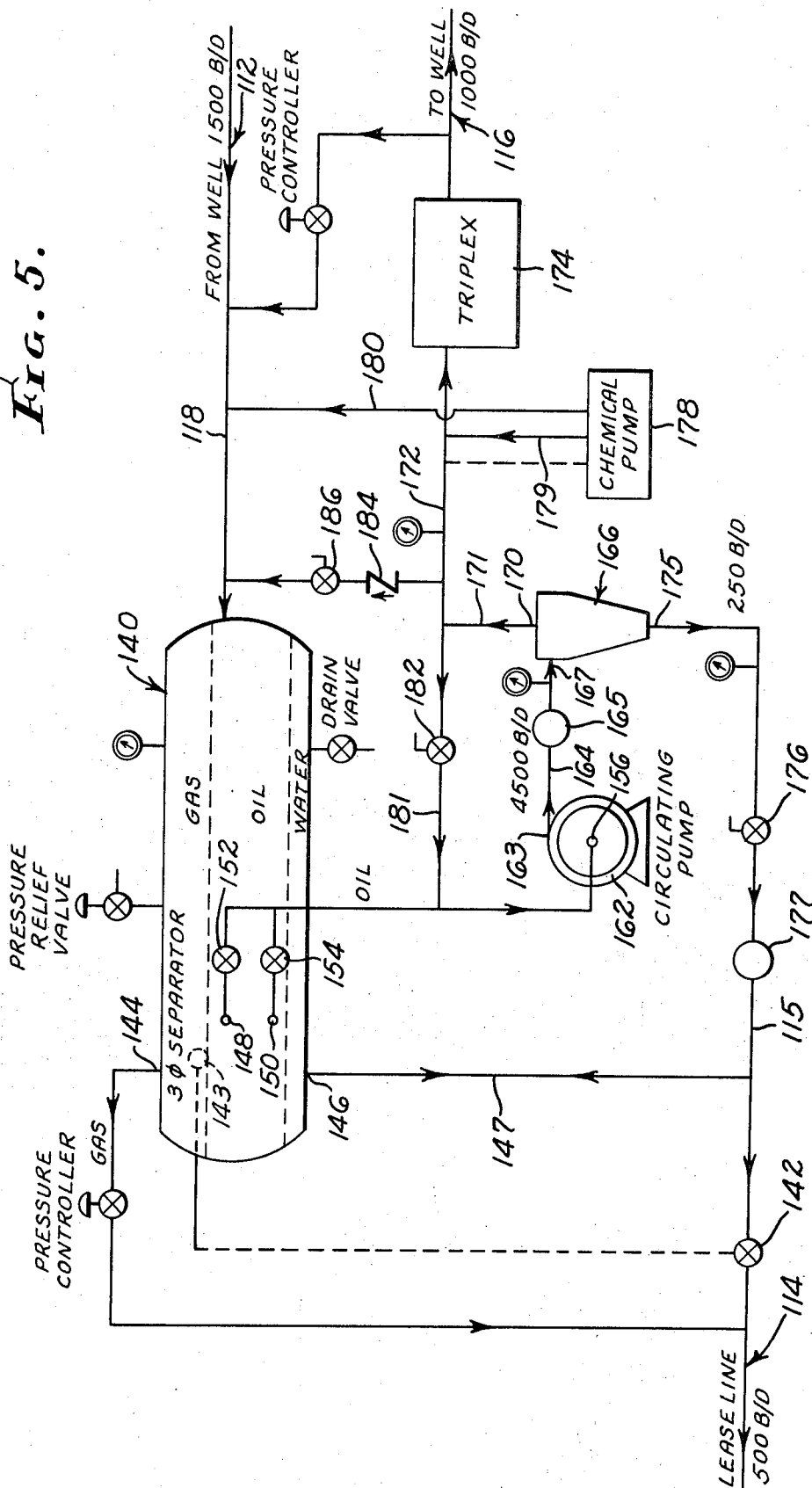


Fig. 5.



CLEANING APPARATUS FOR OIL WELL PRODUCTION

CROSS REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part of my co-pending application Ser. No. 256,871, filed May 25, 1972, now U.S. Pat. No. 4,917,655, issued Sept. 18, 1973.

BACKGROUND OF INVENTION

The present invention relates in general to an apparatus for cleaning oil well production fluid and, more particularly, to an apparatus for processing production fluid from an oil well in the field to obtain clean power liquid for a fluid operated pump in the well. The clean power liquid may be either oil or water, and oil will be considered hereinafter for convenience.

The prior art known to me includes the references of record in Ser. No. 256,871, and including U.S. Pat. No. 3,709,292, issued Jan. 9, 1973 to Harold H. Palmour.

SUMMARY AND OBJECTS OF INVENTION

The primary object of the present invention is to provide a self contained apparatus which may be installed at or adjacent the well head to obtain the necessary clean power liquid from the production fluid as the latter is produced.

Another object of the invention is to provide an apparatus having components for removing at least solids and gas from the production fluid to obtain clean power liquid for the fluid operated pump in the well, the clean power liquid being pressurized for delivery to the fluid operated pump by a triplex pump forming part of the unit.

Another object is to provide an apparatus having a storage capacity sufficient for such related operations as circulating the fluid operated pump into and out of the well.

A further object is to continuously circulate previously cleaned power liquid through a cyclone or cyclones to remove solids.

The invention may be summarized as including, and an important object is to provide an apparatus which includes: a production fluid inlet for production fluid from the well; a production fluid outlet connectible to a point of production fluid disposal; a power liquid outlet connectible to the liquid operated pump in the well; a separator connected to the production fluid inlet, the separator having at the top and bottom thereof upper and lower outlets connected to the production fluid outlet and having an intermediate outlet; a cyclone having a liquid inlet and a liquid outlet and having a solids outlet, the latter being connected to the production fluid outlet; a circulating pump having an inlet connected to the intermediate outlet of the separator, and having an outlet connected to the liquid inlet of the cyclone; a triplex pump, or equivalent, having an inlet connected to the liquid outlet of the cyclone, and having an outlet connected to the power liquid outlet; the circulating pump having a capacity in excess of that of the triplex pump; and a bypass from the liquid outlet of the cyclone back to the inlet of the circulating pump.

A further object is to provide an apparatus of the foregoing nature wherein the circulating pump has a capacity considerably in excess of that of the triplex, and preferably at least twice the triplex capacity, and wherein there is a bypass from the clean liquid outlet of the cyclone back to the circulating pump inlet. With this construction, the power liquid being cleaned is continuously circulated through the cyclone for further solids removal.

Other objects in connection with various embodiments are to provide an apparatus wherein the bypass conveys the liquid from the liquid outlet of the cyclone directly back to the inlet of the circulating pump, or by way of the separator, or by way of a separate storage tank. An object in connection with another embodiment is to connect the circulating pump inlet to the intermediate separator outlet through the storage tank mentioned.

Another object in connection with one embodiment is to provide a primary cyclone for precleaning the fluid delivered to the separator, undesirable materials discharged by this primary cyclone being delivered to the production fluid outlet of the apparatus.

The foregoing objects, advantages, features and results of the present invention, together with various other objects, advantages, features and results which will be evident to those skilled in the oil well production fluid cleaning art in the light of this disclosure, may be achieved with the exemplary embodiments of the invention illustrated in the accompanying drawings and described in detail hereinafter.

DESCRIPTION OF DRAWINGS

In the drawings:

FIG. 1 is a schematic view of an oil well production fluid cleaning apparatus which embodies the invention;

FIG. 2 is a sectional perspective view illustrating a primary cyclone incorporated in the apparatus of FIG. 1;

FIG. 3 is a horizontal sectional view taken as indicated by the arrowed line 3—3 of FIG. 2;

FIG. 4 is a sectional perspective view of a secondary cyclone incorporated in the apparatus of FIG. 1 of the drawings; and

FIG. 5 is a view similar to FIG. 1, but showing a simpler and presently preferred embodiment of the invention.

DESCRIPTION OF EXEMPLARY

EMBODIMENT OF INVENTION, FIGS. 1 TO 4

Referring initially to FIG. 1 of the drawings, the oil well production fluid cleaning apparatus of the invention is illustrated therein diagrammatically and is composed of components which, for the most part, are entirely conventional so that detailed descriptions of the components are not necessary, the invention residing in the combination of these components and the relationship between them.

Throughout FIG. 1 there are legends indicating such things as flow rates in barrels per day, pressures in pounds per square inch, and the like. These are illustrative only and serve to indicate flow rates and pressures which will provide an operative system. It will be understood, of course, that other flow rates and pressures may be substituted. Also, throughout FIG. 1 there are various conventional components which are identified

by the legends "BPR" (pressure reducing valve) and "RV" (relief valve). It is thought that the functions of these conventional components will be apparent so that descriptions thereof are not necessary.

Considering the cleaning apparatus generally, it includes a production fluid inlet 12 which receives the production fluid pumped from an oil well, not shown, by a conventional fluid operated pump, not shown. The production fluid may include native well fluid and spent power oil (or water) discharged by the pump. The cleaning apparatus also includes a production fluid outlet 14 which is shown as comprising a lease line leading to a suitable point of disposal for the production fluid, such as processing equipment, storage tanks, and the like. The apparatus also includes a power oil (or water) outlet 16 which is connectible to the fluid operated pump in the well and from which the fluid operated pump is supplied with clean power oil furnished by the apparatus.

As is well known, the production fluid from the well entering the cleaning apparatus at the production fluid inlet 12 may contain oil, water, gas, solids, and the like. The function of the apparatus is to remove substantially all of the gas, water, solids, and other contaminants, from the crude oil so as to provide the desired clean operating fluid for the pump in the well. The contaminants, i.e., the gas, water, solids, and the like, are discharged from the apparatus at the production fluid outlet 14.

The production fluid flowing into the cleaning apparatus at the inlet 12 enters the inlet 18 of a primary cyclone 20 which is illustrated diagrammatically in FIGS. 2 and 3. The primary cyclone 20 is provided with a gas outlet 22 and a solids and dirty liquid outlet 24 which are connected to the production fluid outlet 14 by lines 26 and 28 and a line 30. The primary cyclone 20 differs from the usual cyclone in that it is provided at the top with an extra cylindrical section 32 connected to the lower section by a central duct 34. Liquid is discharged from the cylindrical section 32 tangentially through a clean liquid outlet 36.

With the foregoing construction, major portions of the gas and solids are removed so that the fluid discharged through the outlet 36 of the primary cyclone 20 consists of oil and water which are relatively gas and solids free.

The clean fluid from the outlet 36 enters the inlet 38 of a conventional three-phase separator 40. The flow into the separator 40 is controlled by a float actuated valve 42 the float of which is in a storage tank 56 to be described. The separator 40 is provided with gas and water outlets 44 and 46 connected to a line 48 leading to the production fluid outlet 14. The water level in the separator 40 is controlled by a float actuated valve 50 controlling flow through the water outlet 46, the float of the valve 50 being in the separator. The oil phase leaves the separator 40 through a clean oil outlet 52 connected to the inlet 54 of a clean oil storage tank 56, the liquid level in the storage tank being controlled by the float actuated valve 42. The oil level in the separator 40 is controlled by a float actuated valve 58 the float of which is in the separator.

The foregoing combination of the primary cyclone 20 and the three-phase separator 40 is one of the important features of this embodiment of the invention. The primary cyclone 20 disposes of most of the dirty liquid and the gas, discharging only relatively clean li-

uid into the separator 40. Also, the primary cyclone 20 achieves some degree of oil and water separation so that the water content of the oil entering the separator 40 is reduced. This results in a substantial reduction in the load on the separator 40, which means that the separator can operate much more effectively for a given capacity.

The storage tank 56 provides a reserve of clean power oil whenever the separator 40 runs out of oil due to a gas head from the well, or such well servicing operations as pumping the fluid operated pump in or out. The storage tank 56 has a power oil outlet 60 which is connected to the inlet of a circulating pump 62 having an outlet connected to the inlets 64 of three parallel connected, secondary cyclones 66. One of these is shown in some detail in FIG. 4, which also illustrates its characteristic mode of operation. The secondary cyclones 66 are provided at their lower ends with solids outlets 68 connected by a line 71 to the line 30 leading to the production fluid outlet 14.

The secondary cyclones 66 are provided at their upper ends with clean power oil outlets 70 connected to a line 72 leading to the inlet of a conventional triplex pump 74. The clean power oil outlets 70 of the secondary cyclones 66 are also connected to a bypass line 76 leading back to the storage tank inlet 54.

The outlet of the triplex 74 leads to a pressure controller 78 which determines the power oil pressure delivered to the power oil outlet 16 leading to the fluid operated pump in the well. Any excess power oil from the pressure controller 78 is returned to the storage tank 56 by a line 80 connected to the bypass line 76.

An important feature of all embodiments of the invention is that the capacity of the circulating pump 62 and the combined capacities of the secondary cyclones 66 are considerably greater than, and preferably at least about twice, the capacity of the triplex 74. Consequently, assuming, for example, a flow of 5,000 barrels per day through the secondary cyclones 66 and an output of 2,500 barrels per day by the triplex 74, 2,500 barrels of oil are returned to the storage tank 56 daily for further processing in the secondary cyclones, the storage tank comprising part of a bypass from the cyclone outlets 70 back to the inlet of the circulating pump 62. This constant recirculation of part of the clean power oil in the storage tank 56 through the secondary cyclones 66 results in the removal of further foreign matter from the power oil, thereby minimizing any residual foreign matter in the power oil delivered to the triplex 74, and ultimately to the fluid operated pump in the well. Thus, the storage tank 56 serves the additional function of permitting recirculation of the power oil through the secondary cyclones 66 for further cleaning, which is an important feature.

Another feature resides in the use of the parallel connected secondary cyclones 66, instead of a single larger cyclone. The smaller cyclones permit developing higher centrifugal forces, and thus better separation of contaminants.

DESCRIPTION OF EXEMPLARY

EMBODIMENT, FIG. 5

Turning now to FIG. 5 of the drawings, this embodiment of the oil well production fluid cleaning apparatus of the invention is illustrated therein diagrammatically and is generally similar to the embodiment of FIGS. 1

to 4. The embodiment of FIG. 5 is composed of components which are conventional so that detailed descriptions of the individual components are not necessary, the invention again, as in the previous embodiment, residing in the combination of these components and the relationship between them.

Throughout FIG. 5, there are legends indicating exemplary flow rates in barrels per day. These are illustrative only and serve to indicate flow rates which will provide an operative system. It will be understood, of course, that other flow rates may be substituted. Also, throughout FIG. 5, there are various conventional components which are identified by legends clearly indicating their functions so that further descriptions will not be necessary.

In addition, since many of the components of the cleaning apparatus of FIG. 5 correspond to components of the embodiment of FIGS. 1 to 4, the components of FIG. 5 will be identified by reference numerals higher by one hundred than those used for the corresponding components of FIGS. 1 to 4.

The apparatus of FIG. 5, considered generally, includes a production fluid inlet 112 which receives the production fluid pumped from an oil well, not shown, by a conventional bottom hole, fluid operated pump, not shown, in the well. The production fluid may include native well fluid and spent power oil (or water) discharged by the pump.

The apparatus of FIG. 5 also includes a production fluid outlet 114 which is shown as comprising a lease line 115 leading to a suitable point of disposal for the production fluid, such as processing equipment, storage tanks, and the like. The apparatus also includes a power oil (or water) outlet 116 which is connectible to the fluid operated pump in the well and from which the fluid operated pump is supplied with clean power liquid furnished by the apparatus.

As is well known, the production fluid from the well entering the cleaning apparatus at the production fluid inlet 112 may contain oil, water, gas, solids, and the like. The function of the apparatus is to remove substantially all of the gas, solids, and other contaminants, so as to provide the desired clean operating fluid, preferably oil, but water as an alternative, for the pump in the well. The contaminants are discharged from the apparatus at the production fluid outlet 114.

The production fluid flowing into the cleaning apparatus at the inlet 112 flows through a line 118 into a three phase separator or separator tank 140. The liquid level in the separator 140 is controlled by a float actuated valve 142 in the lease line 115, the float for actuating this valve being identified by the numeral 143 and being located in the separator.

The separator 140 is provided with upper and lower gas and water outlets 144 and 146 both connected to the lease line 115, the former through a pressure controller and the latter through a line 147.

The separator 140 is provided with upper and lower power fluid outlets 148 and 150 which are intermediate outlets, i.e., which are below the upper outlet 144 and above the lower outlet 146. The upper and lower power fluid outlets 148 and 150 are connected to parallel valves 152 and 154 both connected to the inlet 156 of a circulating pump 162. The valve 152 connected to the upper intermediate outlet 148 is normally open, and normally connects the oil zone of the separator 140 to the circulating pump 162. The valve 154 associated

with the lower intermediate outlet 150 is normally closed, and may be opened, in any suitable manner, to provide additional liquid to the circulating pump 162, if necessary, for performing such functions as circulating the bottom hole, fluid operated pump into or out of the well. (While the power fluid outlets 148 and 150 are shown as normally communicating with the oil zone of the separator 140, it will be understood that they may communicate with the water zone thereof. For example, in a well having a very high water cut, it may be necessary to use water as the power fluid, or as the fluid for circulating the bottom hole pump into or out of the well, or both.)

The outlet 163 of the circulating pump 162 is connected through a line 164 and a meter 165 to the inlet 167 of a cyclone 166 similar to one of the cyclones 66. If desired, there may be two or more of the cyclones 166 connected in parallel in the same manner as the cyclones 66.

The cyclone 166 is provided at its upper end with a clean power fluid outlet 170 leading through a line 171 and a line 172 to the inlet of a triplex, or equivalent, 174, the outlet of the latter being connected to the power fluid outlet 116. The cyclone 166 is also provided with a lower outlet 175, for solids-contaminated liquid, connected through a manual valve 176 and a meter 177 to the lease line 115, i.e., the production fluid outlet 114.

A chemical pump 178 may, if desired, be provided to inject suitable conditioning chemicals into the line 172 through a line 179 and into the line from the well to the separator 140 through a line 180.

The outlet 170 of the cyclone 166, in addition to being connected to the inlet of the triplex 174, is connected back to the inlet of the circulating pump 162 through a line 181 containing a manual valve 182, which valve may be adjusted to control the relative amounts of power fluid which are delivered to the triplex 174 and returned back to the inlet of the circulating pump 162. Any excess power fluid discharged by the triplex 174 is returned from the power fluid outlet 116 back to the production fluid inlet 112 through a pressure controller, which governs the power fluid pressure delivered to the bottom hole pump.

The outlet 170 of the cyclone 166 is also connected through a check valve 184 and a manual valve 186 to the production fluid inlet of the separator 140. Thus, that portion of the clean power fluid discharged by the cyclone 166 which is not delivered to the triplex 174, can be returned to the circulating pump inlet 156, or the separator 140, or both depending upon the settings of the manual valves 182 and 186. The capacity of the circulating pump 162 is considerably greater than that of the triplex 174, preferably by a factor of two or more. With the particular illustrative legends applied to FIG. 5, the capacity of the circulating pump is 4,500 barrels per day while the capacity of the triplex 174 is 1,000 barrels per day, which means that, with this illustrative example, 3,500 barrels per day are recirculated from the cyclone outlet 170 to the circulating pump inlet 156, either directly by the line 181, or indirectly through the separator 140, or both, depending upon the settings of the manual valves 182 and 186.

If all of the recirculated liquid is returned from the cyclone 166 directly to the circulating pump 162, it is continuously cleaned by the cyclone to insure a continuous supply of power liquid for the triplex 174 which

has been repeatedly cleaned, this being an important feature. Alternatively, the excess cleaned power liquid discharged by the cyclone 166 may be recirculated by way of the separator 140 to build up in the separator a reserve supply of at least partially cleaned power liquid which is subjected to a final cleaning in the cyclone 166 before being delivered to the triplex 174. Alternatively, a combination of these two procedures may be used by having both valves 182 and 186 at least partially open.

The flow could be in either direction in the line 147. The normal flow could be 250 B/D out of the cyclone 166, as shown in FIG. 5. However, it might be that the underflow from the cyclone 166 is 550 B/D and, thus, 50 B/D would recycle back into the tank 140 through the line 147. The underflow at 175 is regulated by the throttling valves 182 (or 186) and 176.

Thus, the cleaning apparatus of FIG. 5 is a very versatile one which can be used in a number of different ways, as hereinbefore outlined. Further, the embodiment currently under consideration is simpler than that previously described in that it eliminates the upstream cyclone 20 and the separate storage tank 56, the tank of the separator 140 being made sufficiently large to maintain an adequate reserve supply of power liquid.

Although exemplary embodiments of the invention have been disclosed for purposes of illustration, it will be understood that various changes, modifications and substitutions may be incorporated in such embodiments without departing from the spirit of the invention as defined by the claims appearing hereinafter.

I claim as my invention:

1. An apparatus for processing production fluid from an oil well in the field to obtain clean power liquid for a liquid operated pump in the well, including:
 - a. a production fluid inlet for production fluid from the well;
 - b. a production fluid outlet connectible to a point of production fluid disposal;
 - c. a power liquid outlet connectible to the liquid operated pump in the well;
 - d. a separator connected to said production fluid inlet, said separator having at the top and bottom thereof upper and lower outlets connected to said production fluid outlet and having an intermediate outlet;
 - e. a cyclone having a liquid inlet and a liquid outlet and having a solids outlet, the latter being connected to said production fluid outlet;
 - f. a circulating pump having an inlet connected to said intermediate outlet of said separator, and having an outlet connected to said liquid inlet of said cyclone;

- g. a triplex pump having an inlet connected to said liquid outlet of said cyclone, and having an outlet connected to said power liquid outlet;
 - h. said circulating pump having a capacity in excess of that of said triplex pump; and
 - i. a bypass from said liquid outlet of said cyclone back to said inlet of said circulating pump.
2. An apparatus according to claim 1 wherein said bypass includes said separator.
 3. An apparatus as defined in claim 1 wherein said bypass leads from said liquid outlet of said cyclone directly back to said inlet of said circulating pump.
 4. An apparatus as set forth in claim 1 wherein said bypass includes a storage tank.
 5. An apparatus according to claim 4 wherein said inlet of said circulating pump is connected to said intermediate outlet of said separator through said storage tank.
 6. An apparatus as defined in claim 1 wherein there are upper and lower intermediate outlets in vertically spaced relation between said upper and lower outlets and respectively connected to said circulating pump inlet through parallel, upper, normally open, and lower, normally closed, valves.
 7. An apparatus for processing production fluid from an oil well in the field to obtain clean power liquid for a liquid operated pump in the well, including:
 - a. a production fluid inlet for production fluid from the well;
 - b. a production fluid outlet connectible to a point of production fluid disposal;
 - c. a power liquid outlet connectible to the liquid operated pump in the well;
 - d. a separator connected to said production fluid inlet, said separator having vertically spaced outlets connected to said production fluid outlet and having another outlet;
 - e. a cyclone having a liquid inlet and a liquid outlet and having a solids outlet, the latter being connected to said production fluid outlet;
 - f. a circulating pump having an inlet connected to said other outlet of said separator, and having an outlet connected to said liquid inlet of said cyclone;
 - g. a triplex pump having an inlet connected to said liquid outlet of said cyclone, and having an outlet connected to said power liquid outlet;
 - h. said circulating pump having a capacity in excess of that of said triplex pump; and
 - i. a bypass from said liquid outlet of said cyclone back to said inlet of said circulating pump.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,802,501 Dated April 9, 1974

Inventor(s) Mathew R. Mecusker

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Page 1: Related U.S. Application Data, [63],
"Pat. No. 4,917,655" should be --Pat. No. 3,759,324--.

Column 1, line 9, "Pat. No. 4,917,655" should be
--Pat. No. 3,759,324--.

Column 2, line 4, "tiplex" should be --triplex--.

Column 3, line 2, "fuctions" should be --functions--;

Column 3, line 26, "wall" should be --well--.

Signed and sealed this 1st day of October 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents