

June 2, 1942.

H. C. PYLE

2,285,169

WELL PUMP

Filed June 27, 1938

Fig. 1.

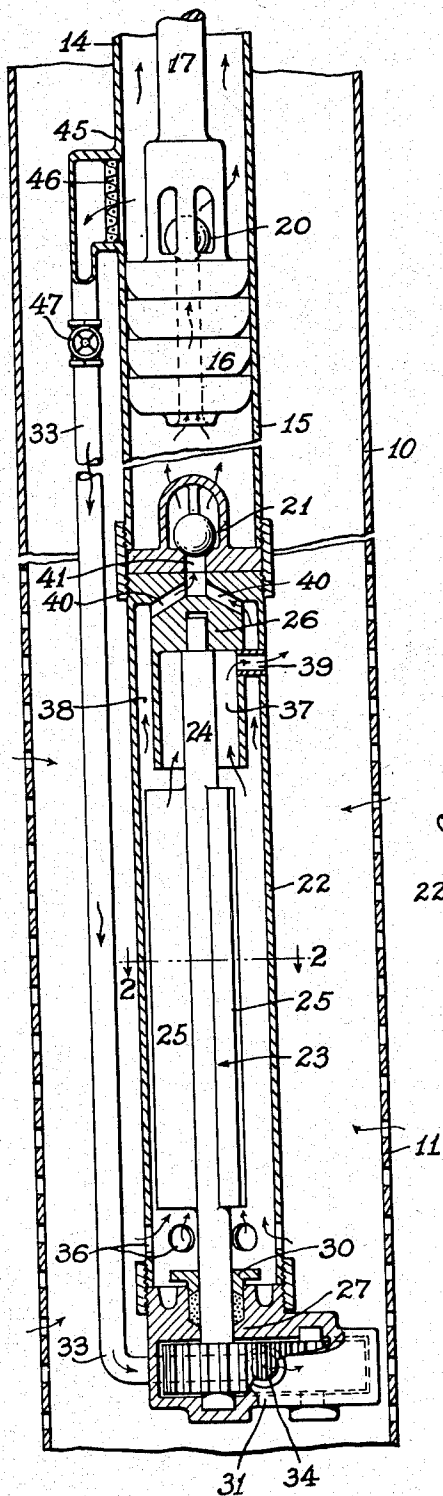


Fig. 3.

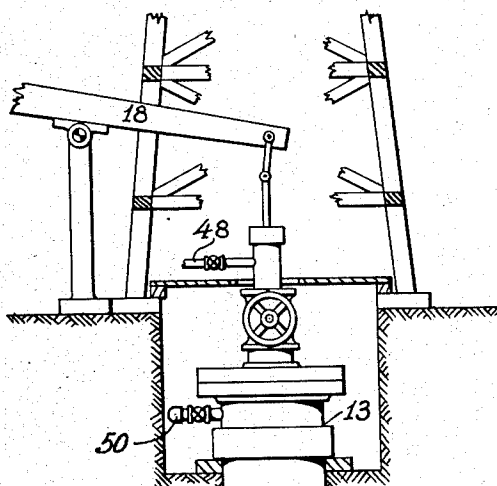
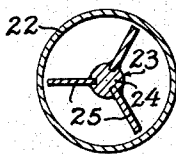
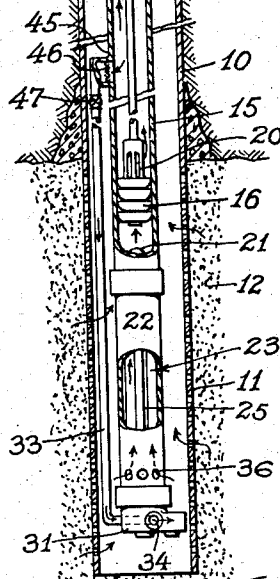


Fig. 2.



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2,285,169

WELL PUMP

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Application June 27, 1938, Serial No. 216,086

12 Claims. (Cl. 103—5)

This invention relates to improvements in the separation of liquid and gas mixtures and specifically to the separation of oil and gas within a pumping oil well by means known as a "gas anchor."

The primary object of this invention is to provide a method and apparatus for increasing the volumetric efficiency of an oil well pump by effecting separation of a substantial proportion of the dispersed and dissolved gases from the oil flowing into the well bore before it reaches the pump cylinder. Another object of the invention is to provide an improved device which will effectively separate oil and gas, and which can be readily attached to the inlet of the conventional well pump cylinder located and supported by the tubing at or near the bottom of the well. Another object of the invention is to provide means for agitating the produced oil containing dissolved gas, prior to its entrance into the pump cylinder whereby equilibrium is promoted and gas is caused rapidly to come out of solution and be separated from the oil prior to the entrance of the oil into the pump cylinder.

With these objects in view this invention resides broadly in a method and apparatus for effecting agitation of the produced gas-containing oil at the bottom of a pumping well whereby gas is separated therefrom prior to its entrance into the pump cylinder and whereby the volumetric efficiency of the pump is increased. The invention more specifically resides in means for applying centrifugal force and agitation to the oil in a pumping well whereby gas is separated from the oil prior to its entrance into the pump cylinder. These and other objects and features of novelty will become evident hereinafter.

In the drawing which illustrates a preferred embodiment of the invention and in which numerals of like character designate similar parts throughout the several views.

Fig. 1 is a partial sectional elevation of the "gas anchor" separator mechanism in place in the well together with a partial sectional view of the pump to which it is attached.

Fig. 2 is a cross-section taken at 2—2 of Fig. 1.

Fig. 3 shows a general arrangement of the apparatus of Fig. 1 as it relates to the typical pumping oil well.

Referring to the drawing, 10 is an oil string or casing carrying a perforated section 11 opposite the producing sands 12 and connected at the top of the well to a casing head 13 all in the conventional manner. The oil tubing 14 is also suspended in the well from the casing head 13 in

the conventional manner and may extend downward into the well to a point adjacent the producing zone 11. At the lower end of the tubing is attached a pump barrel 15 in which a pump plunger 16 is operated by means of suitable sucker rods 17 extending to the top of the well and reciprocated by means of the walking beam 18. The pump carries a traveling valve 20 and a standing valve 21 in the plunger and at the lower end of the pump barrel respectively.

Extending from the lower end of the pump and coupled to the pump inlet connection is a cylindrical casing 22 forming a gas separating chamber and containing a rotor 23 axially positioned therein. The rotor comprises a shaft carrying a number of radially positioned vanes 25 and rotatably mounted upon bearings 26 and 27 at the upper and lower ends respectively.

The lower end of the rotor shaft 24 extends through a stuffing box 30 to a fluid pressure operated motor of the conventional positive displacement gear type 31. The motor is suitably housed in a unit under the shaft bearing 27 and the stuffing box 30 and is coupled to and forms the bottom end closure of the cylindrical casing 22. Fluid under pressure is supplied to the motor through inlet pipe 33 and is discharged therefrom through outlet 34.

The cylindrical casing 22 is provided near the lower end with a plurality of openings 36 through which liquid can pass from the surrounding space in the casing into the space within cylindrical casing 22. At the upper end of the casing 22 and downwardly extending from the rotor bearing 26 is a short concentrically disposed sleeve forming an inner annular space 37 and a concentric outer annular space 38. The inner annular space 37 is vented to the outside of the gas separating chamber through a port 39 and the outer annular space 38 is connected to the suction inlet of the pump through the standing valve 21 by means of passages 40 and 41.

The fluid pressure pipe 33 leading to the motor 31 makes connection with the tubing 14 at a point 45 above the pump barrel whereby it is maintained under the static pressure of the fluid column therein. A screen 46 is provided at the entrance of the pipe 33 where it connects with the tubing to exclude particles of sand or dirt, which may be entrained in the liquid produced from reaching the fluid operated motor. A valve 47 is provided in the pipe 33 to control the pressure of the fluid supplied to the motor 31.

The operation of the apparatus of the inven-

tion, for example, as applied to a pumping oil well is as follows:

Oil under the force of gravity or by the residual expulsive force of gas or water flows from the surrounding formation 12 through the perforated casing 11 and accumulates in sufficient quantity within the casing to flow into the separator shell 22 through the openings 36. The oil under the pressure of the head accumulated in the casing continues in its flow upward in the separator shell 22 through the outer annular space 38, passages 40 and 41 and finally through the standing valve 21 into the pump cylinder. The oil thus reaching the pump cylinder is lifted to the surface of the well through the tubing 14 by means of the pump plunger 16 and its associate apparatus in the conventional manner.

Under normal operating conditions and while the pump is operating a column of oil is maintained above the pump plunger 20 which extends to the top of the well and flows under the force of said pump to production through pipe 48. The oil pressure in the tubing near the bottom of the well at the point 45 is thus under a high pressure which is dependent upon the depth of the well, the density of the fluid and the back pressure upon the delivery line. At this point in the oil well above the pump the pressure pipe 33 makes a connection with the tubing 14 and oil under pressure in the tubing is allowed to flow through the screen 46, throttle valve 47 and through the pipe 33 into the inlet of the fluid operated motor 31. The oil which is thus supplied to the motor 31 is exhausted through the outlet 34. The pressure available for operating the said motor 31 is differential between the tubing pressure at 45 and the bottom hole pressure at the level of the motor outlet port 34 and this differential pressure in the case of a low pressure formation and a moderately deep well may range from one thousand to three thousand pounds per square inch. The differential pressure actually applied to motor 31 may be adjusted as by means of the throttle valve 47 prior to the lowering of the apparatus into the well. Under average operating conditions, the motor 31 and the rotor 23 carrying the radial vanes 25 are operated at a speed ranging between one thousand and three thousand revolutions per minute. The oil containing dissolved and entrained gas which fills the separator shell 22 as hereinbefore described is thus imparted a rapid rotational movement as it passes upward toward the pump cylinder. Under the effect of the agitation and the centrifugal force imparted to the oil by its rotation a substantial amount of the dissolved gas is caused to be released from solution and the thus released and entrained gas under the influence of the said centrifugal force being of greatly different specific gravity than the oil from which it is thus separated is forced toward the center of the separating chamber 22 and into a region which immediately surrounds the rotor shaft 24. The separated gas passes upward along the surface of the shaft 24 parallel with the flow of the oil until it is entrapped within the inner annular space 37 and from there it is exhausted from the apparatus through the outlet port 39. The oil from which the gas has thus been removed flows upward into the outer annular space 38 and from there continues upward through the passages 40 and 41, through the standing valve 21 and into the pump cylinder. The oil thus reaching the pump cylinder has, by the action of the before described centrifugal separator, been relieved of

a substantial amount of its dissolved and entrained gas. The oil reaching the pump cylinder is therefore considerably more gas-free than the oil initially entering the separating chamber and the pump is thereby enabled to operate at a substantially increased volumetric efficiency. Pounding and other undesirable results of gaseous oil in the pump are also largely eliminated. The gas which is removed from the oil in the separating chamber 22 and exhausted therefrom through port 39 rises to the top of the well in the annular space between the casing 10 and the tubing 14 and is withdrawn to the gas disposal system through the pipe 50.

The fluid operated motor 31 for the purpose of illustration is shown as a positive displacement gear type. However, other suitable types of motors may be substituted. For example a reaction turbine impulse wheel or even a suitable type of fluid operated expansible cylinder motor may be employed for imparting rapid rotation to the rotor 23.

The rotor 23 may also be varied somewhat in design. For example the rotor blades or valves 25 instead of extending radially from the shaft 24 may extend at a slight angle therefrom. The rotor blades 25 may also be spirally arranged around the shaft in such a manner as to aid in lifting the fluid from the inlet ports 36 toward the top of the gas separating cylinder.

It is to be understood that the foregoing is illustrative of but one apparatus and method and that the invention is not limited thereby but may include any method and apparatus which accomplishes the same within the scope of the invention.

I claim:

1. In a pumping well the combination of a well tubing, a pump at the lower end of said tubing, a gas separating chamber connecting with the inlet of said pump, fluid pressure actuated means to agitate liquid in said chamber, means associated with said chamber to separate liquid and gas, means to transfer liquid from which gas has been separated from said chamber to said pump and means for transferring liquid under pressure from said pump to actuate said agitating means.

2. In a pumping well the combination of a well tubing, a pump at the lower end of said tubing, a gas separating chamber communicating with the inlet of said pump, means to impart rapid rotation to liquid in said chamber, means to separate gas and liquid in said chamber, means to exhaust separated gas from said chamber, means to transfer liquid from which gas has been separated from said chamber to said pump, and means to transmit hydrostatic head from well tubing to actuate the said means for imparting rotation.

3. In a pumping well the combination of a well tubing, a pump at the lower end of said tubing, a gas separating chamber connecting with the inlet of said pump, a rotor in said gas separating chamber, positive means to rotate said rotor in said chamber, an inlet for admitting liquid containing gas into said chamber, means to separate liquid and gas in said chamber and means to transfer liquid from which gas has been separated from said chamber to said pump.

4. Apparatus according to claim 3 wherein the means to rotate said rotor comprises a fluid pressure driven motor.

5. Apparatus according to claim 3 wherein the means to rotate said rotor comprises a fluid pres-

sure driven motor and means to deliver liquid under pressure from said pump to said motor.

6. In a pumping well the combination of a well tubing, a pump at the lower end of said tubing, a gas separating chamber communicating with the inlet of said pump, a rotor in said gas separating chamber, positive means to rotate said rotor in said chamber, an inlet for admitting liquid containing gas into the lower portion of said chamber, means to separate liquid and gas in the upper portion of said chamber, means to exhaust separated gas from the upper portion of said chamber and means to transfer liquid from which gas has been separated from said chamber to the inlet of said pump.

7. In a pumping well the combination of a well tubing, a pump at the lower end of said tubing, a cylindrical gas separating chamber communicating with the inlet of said pump, an elongated rotor having a shaft axially disposed within said chamber and having a plurality of substantially radially extending vanes, an inlet for liquid containing gas at one end of said chamber, means to separate liquid and gas at the opposite end of said cylinder, means connected to one end of said shaft for rotating said rotor, and means for transferring liquid from which gas has been separated from said chamber to the inlet of said pump.

8. Apparatus according to claim 7 in which the means for rotating said rotor comprises a fluid operated motor and means to transfer liquid under pressure from said tubing to said motor.

9. In a pumping well the combination of a well tubing, a pump at the lower end of said tubing, a

vertically positioned, cylindrical gas separating chamber extending from the lower end of and communicating with the inlet of said pump, an elongated rotor having a shaft axially disposed within said cylindrical chamber and having a plurality of substantially radially extending vanes, an inlet for liquid containing gas in the lower portion of said chamber, means to separate liquid and gas in the upper portion of said chamber, means to exhaust separated gas from the said separating means and from said cylinder, means to transfer liquid from which gas has been separated from said cylinder to the inlet of said pump and means connected with the lower end of said rotor shaft for imparting rapid rotation to said rotor.

10. In a pumping well, the combination of the well tubing, a pump at the lower end of said tubing, a gas separating chamber connected with the inlet to said pump, means to agitate liquid in said chamber, means associated with the chamber to separate gas and liquid, means to transfer liquid from which gas has been separated from said chamber to said pump, and means to pass liquid under hydrostatic head in said well tubing from said tubing to actuate said means for agitating liquid in said chamber.

11. Apparatus according to claim 3 wherein the means to rotate the rotor is a device driven by the hydrostatic head in the well tubing.

12. Apparatus according to claim 6 wherein the means to rotate said rotor is a device driven by the hydrostatic head from the well tubing.

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