

March 7, 1933.

B. H. SCOTT

1,900,588

LIQUID COUNTER BALANCED PUMPING SYSTEM

Filed June 2, 1930

2 Sheets-Sheet 1

Fig. 1.

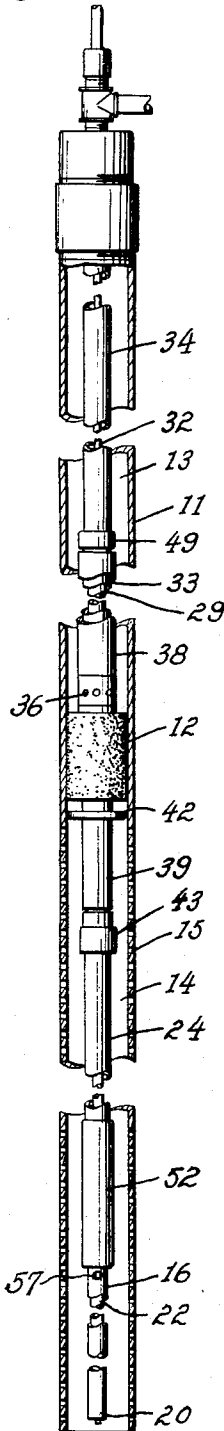


Fig. 2.

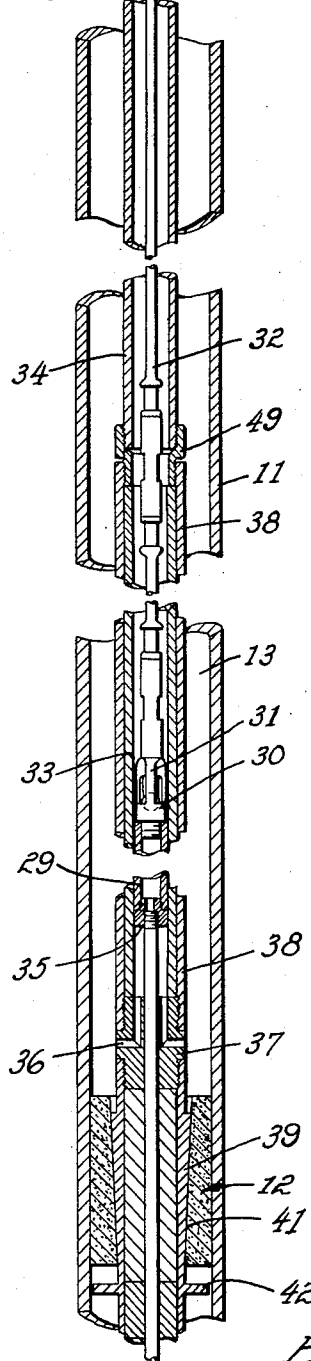
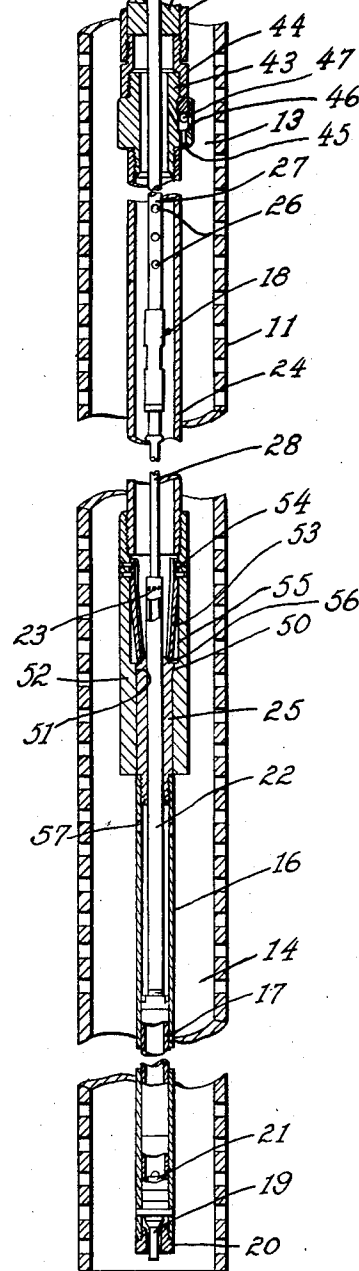


Fig. 3.



Inventor
Bernard H. Scott;

By

Lyon & Lyon

Attorneys

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2 Sheets-Sheet 2

Fig. 4.

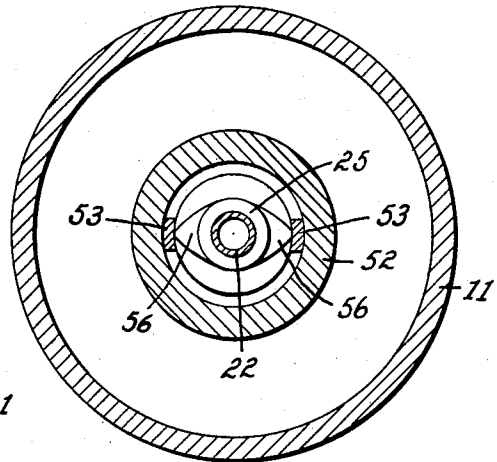
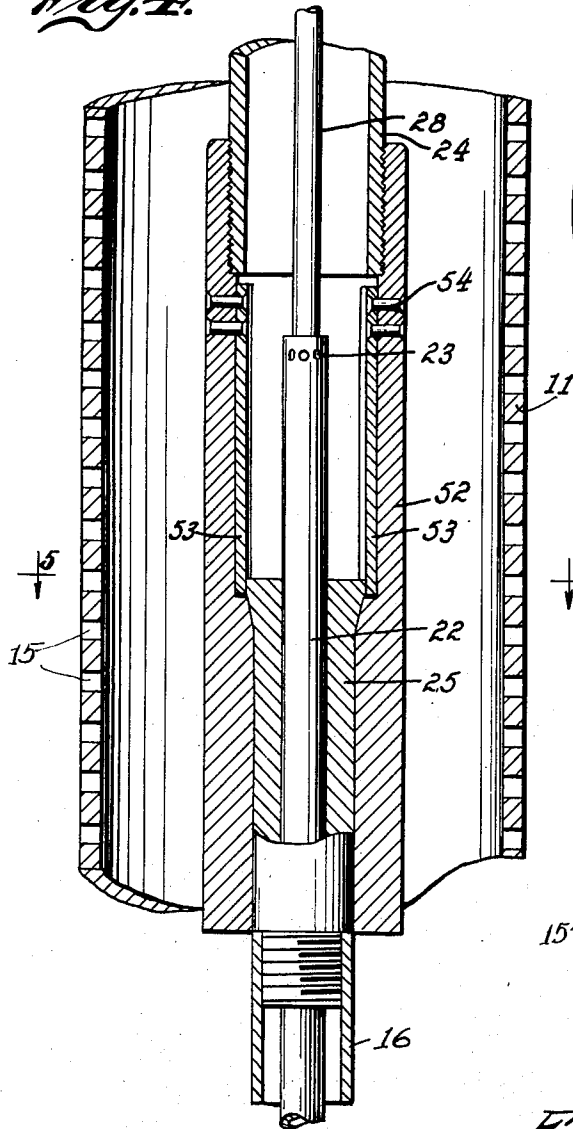


Fig. 5.

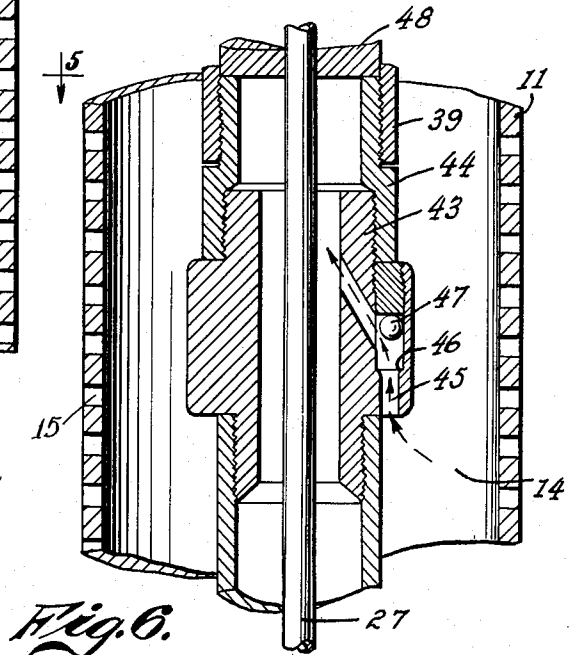
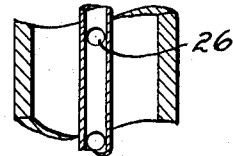


Fig. 6.



Inventor

Bernard H. Scott;

Lyon & Lyon

Attorneys

Attorneys

UNITED STATES PATENT OFFICE

BERNARD H. SCOTT, OF GLENDALE, CALIFORNIA

LIQUID COUNTER-BALANCED PUMPING SYSTEM

Application filed June 2, 1930. Serial No. 458,973.

This invention relates to liquid counter-balanced pumping systems or, in other words, to pumps in which a liquid column is employed against a shoulder on the plunger to counter-balance the column of liquid being raised by the plunger.

The commonly employed deep well pump in the oil fields has its plunger connected with a string of sucker rods which extends downwardly from the top of the well. It will be obvious that the well may attain such depth that the strain on the sucker rods may reach a value in excess of the tensile strength of the rods, thereby entailing parting or rupture of the rods.

In the pumping cycle of the commonly employed type of deep well pump, the sucker rods and pump plunger are started from a position of rest and moved upwardly by the power equipment at the surface of the earth. To accomplish this, it is necessary that the weight of the entire column of oil in the pump tubing above the plunger, plus the weight of the string of sucker rods, be started from a state of rest and moved upwardly a distance equivalent to the stroke of the pump. The amount of energy required to accomplish this is approximately 50% of the entire power consumption necessary to operate the plunger on its fluid lifting stroke. On the down stroke of the plunger the liquid in the tubing rests on the standing valve and the weight of the sucker rods aids the prime mover and, accordingly, on the down stroke very little power is required. This difference in power requirements on the two strokes of the pump is due to the unbalanced load.

In order to overcome the unbalanced load condition, it is common to employ at the earth's surface some form of counterweight that is connected with the prime mover in such manner that the weight is raised when the plunger is on its down stroke and the weight descends when the plunger is on its up stroke. While counter-balancing is achieved by this arrangement, it does not relieve the sucker rods from that very severe stress which they undergo on the up stroke of the pump.

Accordingly, the expense involved in re-

placing broken sucker rods and the monetary loss due to the stopping of production, are not materially affected by the counter-balancing done at the surface of the earth.

At the present time oil wells are being drilled, on an average, to much greater depths than was formerly the case. Production now is often obtained from depths ranging between 6,000 to 8,500 feet and it is impossible with pumps commonly used at the present time to pump such deep wells after they cease flowing. The usually employed type of pump can only be used in wells below no greater depth than approximately 5,500 feet.

A very important object of this invention is to reduce the strain on the string of sucker rods so as to minimize breakage thereof.

Another important object is to pump wells of greater depths than those which can be pumped with the pumps commonly in use in the oil fields.

I achieve the foregoing objects by applying the pressure of a counter-balancing liquid column near the base of the string of sucker rods so as to not stress the rods beyond their ultimate breaking strain. In an installation of this character, a reservoir must be provided outside of the pump tubing reaching from the surface of the earth down to the level where the pressure of the counter-balance fluid is to be applied to the moving parts of the pump. This reservoir may be formed by a portion of the well casing, which portion is separated from another portion by a suitable packer. In other words, the upper portion of the well casing constitutes the reservoir while the lower portion serves to convey the oil to the working barrel of the pump in the usual manner. The packer serves to seal off the producing zone of the well from the upper portion of the casing. Since gas present in the well, when the ordinary pump is employed, is permitted to escape through the casing, it is necessary, because of the presence of the packer, to make provision for the gas to escape from beneath the packer out of the well, and a very important object of the invention is to utilize such gas to aid in lifting the column of liquid above the pump plunger.

Another very important object of the invention is the prevention of a "gas lock", a condition often present in the commonly employed pumps and resulting when an accumulation of gas occurs between the pump plunger and the standing valve, said gas slipping downwardly by the plunger on the up stroke of the plunger.

Another very important object is to prevent sanding up of the pump. In the ordinary type of deep well pump, the lower end of the pump barrel screws into a seat member in which the standing valve seats and the sand accumulates around the barrel, making it very difficult to pull the pump.

I avoid this difficulty by placing the seat member above the level of the standing valve so that at least that portion of the working barrel is suspended from the seat member.

Other objects and advantages will appear in the subjoined detailed description.

The accompanying drawings illustrate the invention:

Figure 1 is a broken elevation, partly in section, of a liquid counter-balanced pumping system constructed in accordance with the provisions of this invention.

Fig. 2 is an enlarged broken longitudinal section of the upper portion of the pumping system.

Fig. 3 is an enlarged broken longitudinal section of the lower portion of the pumping system.

Fig. 4 is an enlarged sectional detail of some of the parts illustrated in Fig. 3, constituting the lock for the working barrel.

Fig. 5 is a horizontal section on the line indicated by 5-5, Fig. 4.

Fig. 6 is an enlarged sectional detail of those parts of Fig. 3 that constitute the means for releasing gas from beneath the packer into the column of liquid being pumped.

Referring to the drawings, a well casing is indicated at 11 and is divided by a packer 12 into an upper chamber or reservoir 13 and a lower chamber 14. The casing 11 is provided with the usual perforations 15, through which fluid from the producing area may flow into the pump. It is to be particularly noted that the perforations 15 communicate only with the chamber 14 that is below the packer 12.

Positioned within the chamber 14 is a working barrel 16 in which operates the hollow head 17 of a plunger which is indicated in general by the character 18, and the lower end of the working barrel is provided with a suitable standing valve 19. In this instance, the standing valve 19 is of the poppet type. The valve body 20 is threaded into the lower end of the working barrel 16. The plunger head 17 is hollow and is provided at its lower end with an inlet valve 21. Thus, upon up stroke of the plunger head 17, the valve 19 opens, while the valve 21 remains closed, thus per-

mitting liquid to flow from the chamber 14 into the working barrel below the ascending plunger. On the down stroke of the plunger head 17, the valve 19 closes and the valve 21 opens, thus permitting the fluid in the working barrel beneath the plunger to flow into the plunger head 17 and upwardly through a reduced tubular portion 22 of the plunger, said portion 22 being screwed or otherwise secured to the upper end of the head 17. The upper end of the plunger portion 22 is provided with a port or ports 23 through which the fluid flows from the plunger portion 22 into a tubular member 24, the bore of which is sealed by a tubular member 25 from the bore of the working barrel 16. The plunger portion 22 has a sliding fit in the member 25.

From the bore of the member 24, the fluid flows through a port or ports 26 into another reduced tubular portion 27 of the plunger, said portion 27 being connected with the portion 22 by a rod 28. The fluid flows upwardly through the tubular portion 27 into the lower end of the upper hollow head 29 of the plunger 18, said head 29 being provided at its upper end with an outlet valve 30 of any approved type. In this instance the upper end of the tubular portion 27 is screwed into the lower end of the plunger head 29. The cage of the valve 30 is indicated at 31 and to it is connected, in the usual manner, a string 32 of sucker rods which extend to the surface of the earth for connection with suitable pump operating mechanism, not shown.

The plunger head 29 operates in a cylinder 33 and the upper end of said cylinder connects with pump tubing 34 which extends to the surface of the earth as is customary in this art. Accordingly, the fluid discharges from the plunger head 29 through the valve 30 into the cylinder 33 above said valve and thence into the pump tubing through which it flows to the surface of the earth in a manner well understood in this art.

It will be readily understood that reciprocation of the pump plunger is effected by operation of the string of sucker rods, in a manner well understood in this art and the construction for counter-balancing the liquid being raised by the pump plunger will now be described: The underface 35 of the lower end of the plunger head 29 constitutes an annular shoulder on the plunger and against this annular shoulder comes the pressure of the liquid column that occupies the reservoir 13. For example, if oil is the liquid being pumped, the reservoir 13 will be filled with oil to the surface of the earth. This oil in the reservoir has access to the cylinder 33 beneath the plunger head 29 through ports 36 in a member 37 that, in this instance, constitutes a coupling that connects a tubular jacket section 38 with another jacket section 39. The section 38 surrounds the cylinder 33 and the section 39 constitutes a packing expanding mem-

ber. The outer face of the member 39 is of conical form to fit the tapered inner face 41 of a resilient tubular packing member 12. The tapered faces taper inwardly and downwardly so that the weight of the pump expands the packer member 12 against the inner face of the well casing 11. The members 39, 12 together constitute the packer hereinbefore referred to as dividing the casing into the chambers 13, 14.

The member 39 is unseated from the member 12 by pulling the pump tubing and the member 39 is provided beneath the member 12 with an annular shoulder 42 that, when the member 12 is expanded, is spaced from the lower end of the member 12. Thus, when the member 39 is raised to release it from the member 41, said member 12 is engaged by the shoulder 42 and is withdrawn from the well when the pump is pulled.

When the pump is installed in a well producing gas, as is the case in an oil well, gas that separates from the oil within the chamber 14 cannot flow to the surface of the earth through the casing because of the presence of the packer 12, but it is necessary to relieve the gas pressure within the casing for, otherwise, the pressure would increase to such an extent as to hold back the fluids in the producing stratum. In this instance, not only is the gas pressure relieved in the chamber 14, but provision is made for utilizing said gas to aid in lifting the column of oil in the pump tubing. Accordingly, there is provided a ported means to permit of the flow of gas from the chamber 14 into the tubular member 24 and, in this instance, said ported means is constructed as follows: A tubular member 43 is screwed into a reducing coupling 44 that in turn is screwed into the lower end of the jacket section 39, and said member 43 is screwed into the upper end of the tubular member 24.

The member 43 is provided with a port 45 that communicates at one end with the chamber 14 and at its other end with the bore of the member 43. Within the port 45 is a valve seat 46 for a ball check valve 47 that opens when the pressure within the chamber 14 exceeds that in the tubular member 24. This difference in pressure is caused by reason of the plunger portion 22, tubular portion 27 and rod 28 together constituting one form of lost motion connection between the plunger heads 17, 29. In this instance, the lost motion is due to the fact that the combined lengths of the plunger portion 22, tubular portion 27 and rod 28 are sufficient so that there is a material stretching thereof, thus insuring that the upper plunger head will move upwardly a material distance before the lower plunger head begins its up stroke.

When, as above explained, the upper plunger head moves upwardly while the lower plunger head remains stationary, a lowered

pressure is produced within the tubular portion 27, and, accordingly, the fluid flows from within the tubular member 24 through the ports 26 into the tubular portion 27, thereby lowering the pressure within the tubular member 24 and bore of the member 43. Accordingly, the valve 47 will open and gas from within the chamber 14 will pass through the port 45 into the bore of the member 43, thence through the ports 26 into the tubular portion 27, thence into the upper plunger head.

On the next succeeding down stroke of the plunger head 29, when the valve 30 opens, the gas that has flowed into the plunger head 29 will pass said valve and flow up through the pump tubing, expanding as it ascends and thus aiding in raising of the liquid column in the pump tubing in the manner of the, so termed, "gas lift". It is noted that the gas that passes through the port 45 cannot pass upwardly through the jacket section 39 because in said jacket section is a plug 48.

The upper end of the jacket section 38 is connected by a reducing coupling 49 to the lower end of the pump tubing 34.

The working barrel 16 is screwed on, or otherwise connected with the sealing member 25 which is provided with an external tapered face 50 removably fitting a tapered seat 51 in a seat member 52. The member 25 is releasably held against upward movement by a spring arm or arms 53 which are riveted or otherwise secured at 54 in the seat member 52. The arms 53 normally spring inwardly so that their lower ends overhang the upper end of the member 25 and recesses 55 are provided in the seat member 52 to accommodate the arms 53 when said arms are retracted outwardly to permit the member 25 passing upwardly.

To effect retraction of the spring arms 53, the upper end of the member 25, as clearly shown in Fig. 5, is provided with radially extending shoulders or projections 56 which may be caused to engage and retract the spring arms 53 by rotation of the member 25 into a position where the projections 56 are in alinement with the spring arms 53. It is to be noted that sanding-up of this pump cannot occur because the pump barrel 16 is suspended from the seat member 52. In the ordinary pump, the seat member is at the lower end of the working barrel.

The construction and operation of the invention will be understood from the foregoing description and, briefly stated, the operation is as follows: The pump having been installed in a producing well, with the packer 12 in place, the reservoir 13 will be filled with oil and the operating mechanism at the surface of the earth will be connected with the string of sucker rods in a manner well understood in this art. As the lower plunger head moves upwardly, the fluid flows

into the working barrel below the plunger through the standing valve. Any slippage of gas past the plunger from the base of the liquid column above the plunger, will travel downwardly under high velocity, but instead of said gas flowing into the suction chamber of the working barrel and thus retarding inflow of liquid from the well, the gas that has passed along the plunger and that enters the working barrel above the lower plunger head 17, flows outwardly through a port or ports 57 in the upper portion of the working barrel into the chamber 14. The same thing occurs on the down stroke of the plunger.

As the ordinary rod operated pump is so designed that the seal of the pump plunger is at all times subjected to the hydrostatic pressure of the column of liquid in the pump tubing, there is no way to avoid "gas lock" resulting from gas released by agitation of the fluid, for it is impossible to design a practical pump with a working clearance sufficiently small to avoid slippage of the gas past the plunger. Therefore, in order to minimize and practically prevent slippage of gas past the plunger into the suction chamber of the working barrel, I provide a differential releasing chamber between the suction chamber and the fluid column in the pump tubing. It will be seen that the gas that passes out of the working barrel through the ports 57 passes with other gas in the chamber 14 through the port 45 when there is a pressure differential favorable to the passage of gases from the chamber 14 into the tubular member 24, and this is when the upper plunger head 29 has moved upwardly before upward movement of the lower plunger head 17 occurs. As soon as the pressure of gas within the chamber 14 falls below the pressure within the tubular member 24, the check valve 47 closes, thus preventing backflow of oil from the pump tubing into the casing.

The up stroke of the pump plunger is assisted by pressure of the oil in the reservoir against the shoulder 35, the head of oil in the reservoir being the same as that in the pump tubing, provided the discharge of the oil in the pump tubing is at the surface of the earth or, in other words, at approximately the level of the upper end of the reservoir 13. If the effective area of the shoulder 35 is the same as the effective areas of the valve 30 and the upper end of the plunger, the counter-balancing column will exactly counter-balance the fluid column above the plunger when the plunger is at the lower end of its stroke. These areas may, of course, be different and, also, if desired, the upper end of the casing may be carried to any desired height above the surface of the earth to increase the head of the counter-balancing liquid in the reservoir.

I claim:

1. A liquid-balanced pumping system comprising a working barrel, a standing valve for the working barrel, a valved plunger having a hollow head in the working barrel, a means forming a reservoir in a well for liquid, a means to apply the hydrostatic head of the liquid in the reservoir to the plunger in the direction of motion of the plunger on its pumping stroke, and a string of sucker rods mechanically connected with the plunger for actuating the latter.

2. A liquid-balanced pumping system comprising a casing, a packer in the casing to provide a reservoir for liquid in the casing thereabove, a working barrel in the casing, a standing valve for the working barrel, a cylinder in the casing provided with a port near its lower end opening into the casing above the packer, a valved plunger having a hollow head in the working barrel and provided with a shoulder in the cylinder, and mechanical connecting means extending from said plunger up through said casing to positively reciprocate the plunger.

3. A liquid-balanced pumping system comprising a casing, a packer in the casing to provide a reservoir for liquid in the casing thereabove, a working barrel in the casing, a standing valve for the working barrel, a cylinder in the casing provided with a port near its lower end opening into the casing above the packer, a valved plunger having a hollow head in the working barrel and provided with a shoulder in the cylinder, and a string of sucker rods mechanically connected with the plunger for actuating the latter.

4. A liquid-balanced pumping system comprising a casing, a packer in the casing to provide a reservoir for liquid in the casing thereabove, a working barrel in the casing, a standing valve for the working barrel, a cylinder in the casing having a port near its lower end opening into the casing above the packer, valved heads in the working barrel and cylinder, a ported tubular member connected with the heads, a tubular member connected with the working barrel and cylinder and sealed from the cylinder, and ported means to discharge gas from the casing below the packer into the last mentioned tubular member.

5. A liquid-balanced pumping system comprising a casing, a packer in the casing to provide a reservoir for liquid in the casing thereabove, a working barrel in the casing, a standing valve for the working barrel, a cylinder in the casing, valved heads in the working barrel and cylinder, a ported tubular member connected with the heads, a tubular member connected with the working barrel and the cylinder and sealed from the cylinder, and ported means to discharge gas from the casing below the packer into the last mentioned tubular member.

6. A liquid-balanced pumping system com-

prising a casing, a packer in the casing to provide a reservoir for liquid in the casing thereabove, a working barrel in the casing, a standing valve for the working barrel, a cylinder in the casing having a port near its lower end opening into the casing above the packer, valved heads in the working barrel and cylinder, a lost motion connection between the heads including a ported tubular member, a tubular member connected with the working barrel and cylinder and sealed from the cylinder, and ported means to discharge gas from the casing below the packer into the last mentioned tubular member.

7. A liquid-balanced pumping system comprising a casing, a packer in the casing to provide a reservoir for liquid in the casing thereabove, a working barrel in the casing, a standing valve for the working barrel, a valved plunger having a hollow head in the working barrel, a cylinder in the casing provided with a port near its lower end opening into the casing above the packer, the plunger provided with a shoulder in the cylinder, means other than said standing valve to discharge gas from the casing below the packer into the plunger, and means to reciprocate the plunger.

8. A liquid-balanced pumping system comprising a casing, a packer in the casing to provide a reservoir for liquid in the casing thereabove, a working barrel in the casing, a standing valve for the working barrel, a cylinder in the casing, valved heads working in the cylinder and working barrel, ported tubular members connected and communicating with the valved heads, a rod connecting the ported tubular members, a tubular member connected with the working barrel and cylinder and sealed from the cylinder and communicating with the working barrel, ported means to discharge gas from the casing below the packer into the last mentioned tubular member, and means to reciprocate the plunger.

9. A liquid-balanced pumping system comprising a casing, a packer in the casing to provide a reservoir for liquid in the casing thereabove, a working barrel in the casing, a standing valve for the working barrel, a cylinder in the casing, valved heads in the cylinder and working barrel, ported tubular members connected and communicating with the valved heads, a rod connecting the tubular members, a means to reciprocate the plunger, and a means to apply the hydrostatic head of liquid in the casing above the packer to the plunger in the direction of motion of the plunger on the pumping stroke.

10. A liquid-balanced pumping system comprising a casing, a packer in the casing to provide a reservoir for liquid in the casing thereabove, a working barrel in the casing, a standing valve for the working barrel, a cylinder in the casing having a port near its

lower end opening into the casing above the packer, valved heads in the cylinder and working barrel, ported tubular members connected and communicating with the valved heads, a rod connecting the tubular members, a tubular member connected with the working barrel and cylinder and sealed from the cylinder and communicating with the working barrel, a shoulder on the plunger in the cylinder, ported means to discharge gas from the casing below the packer into the last mentioned tubular member, and means to reciprocate the plunger.

11. A liquid-balanced pumping system comprising a casing, a packer in the casing to provide a reservoir for liquid in the casing thereabove, a working barrel in the casing provided with a port near its upper end communicating with the casing below the packer, a standing valve for the working barrel, a plunger having a hollow valved head in the working barrel, a sealing means at the upper end of the working barrel, the plunger provided above said head with a reduced tubular portion slidably fitting in said sealing means, means to discharge gas from the casing below the packer into said reduced tubular portion of said hollow plunger at a point above said sealing means, and means to reciprocate said reduced tubular portion.

12. A liquid-balanced pumping system comprising a casing, a packer in the casing to provide a reservoir for liquid in the casing thereabove, a working barrel in the casing provided with a port near its upper end, a standing valve for the working barrel, a cylinder in the casing having a port near its lower end opening into the casing above the packer, valved heads in the working barrel and cylinder, a tubular member connected with the working barrel and cylinder and sealed from the cylinder and communicating with the working barrel, a sealing means at the upper end of the working barrel, the plunger provided with a reduced tubular portion slidably fitting in said sealing means, said reduced tubular portion provided with a port, a tubular member connected with the working barrel and cylinder and sealed from the cylinder, ported means to discharge gas from the casing below the packer into the last mentioned tubular member, and means to reciprocate the reduced tubular portion of the plunger.

13. A liquid-balanced pumping system comprising a casing, a packer in the casing to provide a reservoir for liquid in the casing thereabove, a working barrel in the casing provided with a port near its upper end opening into said casing below the packer, a standing valve for the working barrel, a cylinder in the casing having a port in its lower portion communicating with said reservoir, valved heads in the cylinder and working barrel, ported tubular

members connected and communicating with the valved heads, a rod connecting the tubular members, a tubular member between the working barrel and cylinder and sealed from the cylinder, a sealing means at the upper end of the working barrel, one of the ported tubular members having a portion of less diameter than the lower head slidably fitting in said sealing means, and means to reciprocate the upper head.

14. A deep well pump comprising pump tubing, a seat member provided with a tapered seat, a means connecting the seat member with the pump tubing, a sealing member provided with a tapered face fitting the tapered seat, a working barrel provided with a port near its upper end and connected at its upper end with the sealing member, the sealing member provided with a shoulder, an arm carried by the seat member and yieldingly held in position to overhang said shoulder, means operable by relative rotation between the sealing member and seat member to retract the arm out of the vertical path of movement of the shoulder, and a plunger having a hollow valved head in the working barrel, the plunger provided with a reduced tubular portion slidably fitting in and sealing with said sealing member.

15. A deep well pump comprising pump tubing, a seat member provided with a tapered seat, a means connecting the seat member with the pump tubing, a sealing member provided with a tapered face fitting the tapered seat, a working barrel provided with a port near its upper end and connected at its upper end with the sealing member, the sealing member provided with a shoulder, an arm carried by the seat member and yieldingly held in position to overhang said shoulder, means operable by relative rotation between the sealing member and seat member to retract the arm out of the vertical path of movement of the shoulder, a plunger having a hollow valved head in the working barrel, the plunger provided with a reduced tubular portion slidably fitting in and sealing with said sealing member, and a radially extending shoulder on the sealing member engageable with the arm by relative rotation between the sealing member and seat member to move the arm outwardly from the vertical path of movement of the shoulder.

Signed at Los Angeles, California, this 26th day of May, 1930.

BERNARD H. SCOTT.