Aug. 23, 1960 H. C. HEATH 2,949,861

PUMPING RIG AND METHOD

Filed July 27, 1956 3 Sheets-Sheet 1

FIG_1

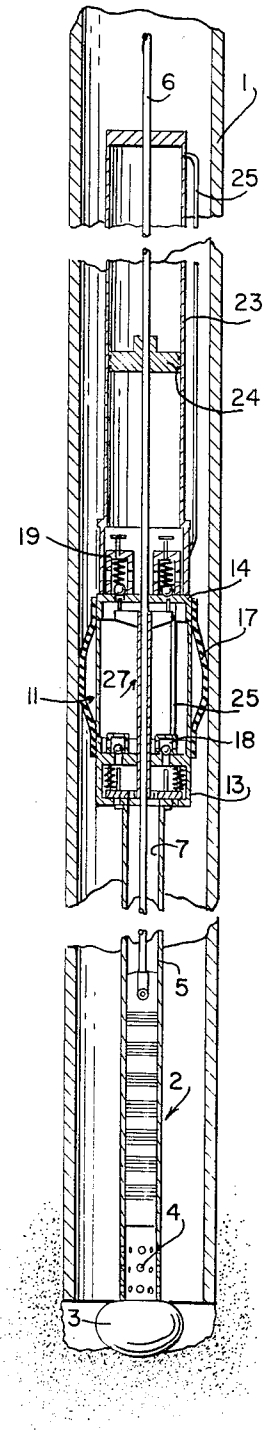
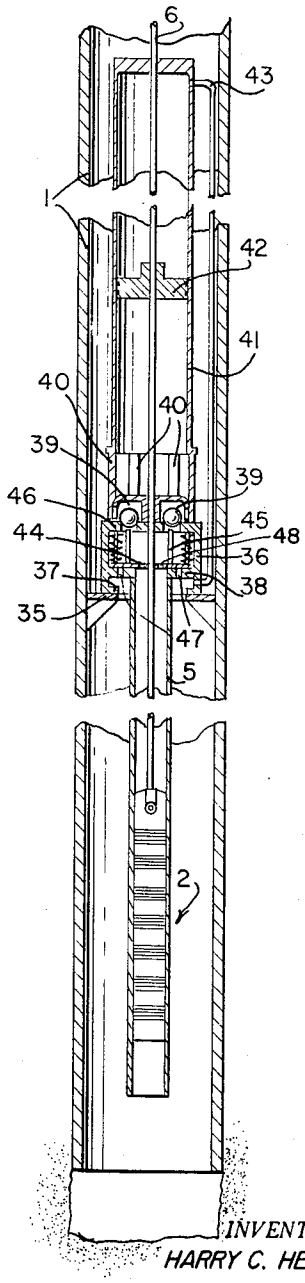


FIG_2



INVENTOR.
HARRY C. HEATH

BY

Boyken, Mohler & Wood

ATTORNEYS

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FIG_3

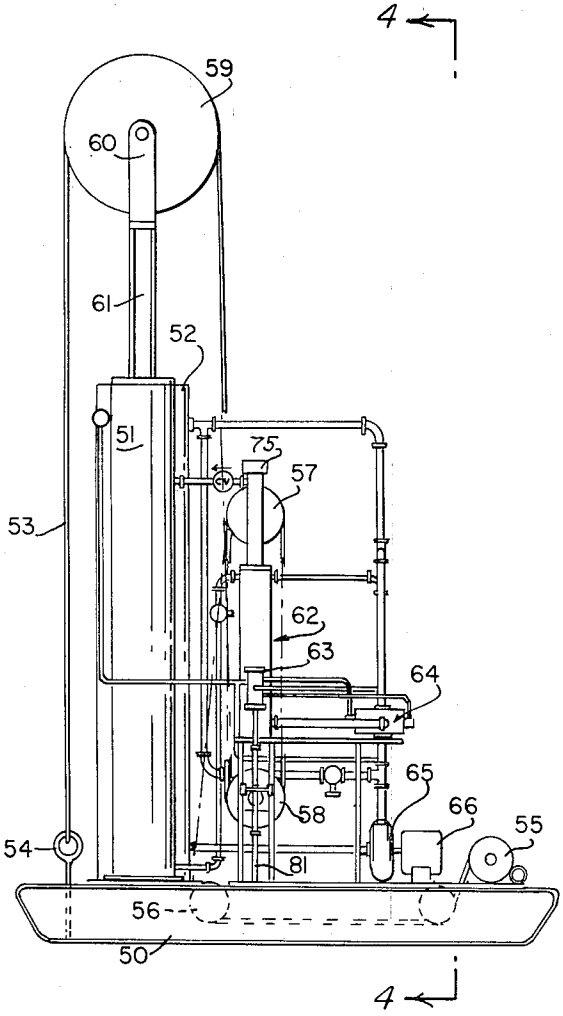


FIG_4

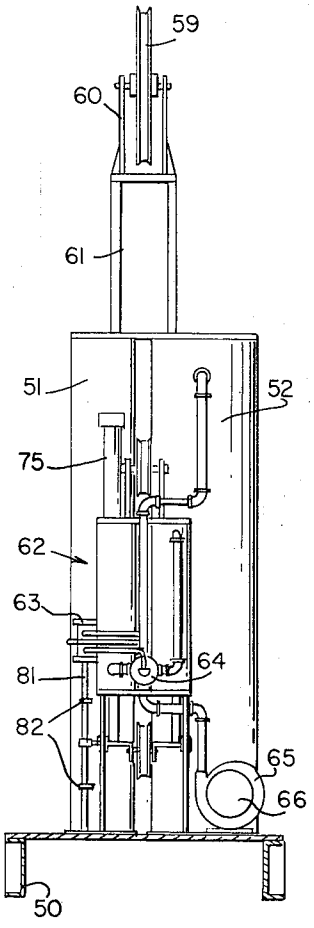
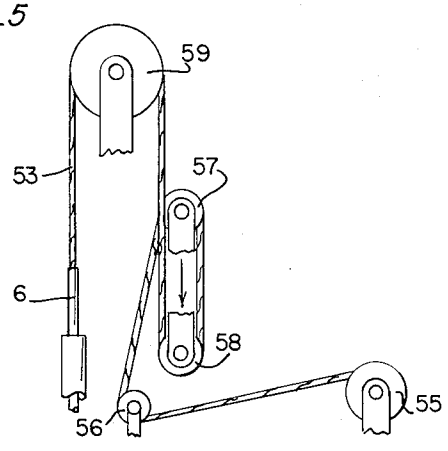


FIG_5



INVENTOR.
HARRY C. HEATH

BY

Boyken, Mahler & Wood

ATTORNEYS

Aug. 23, 1960 H. C. HEATH 2,949,861

PUMPING RIG AND METHOD

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FIG_6

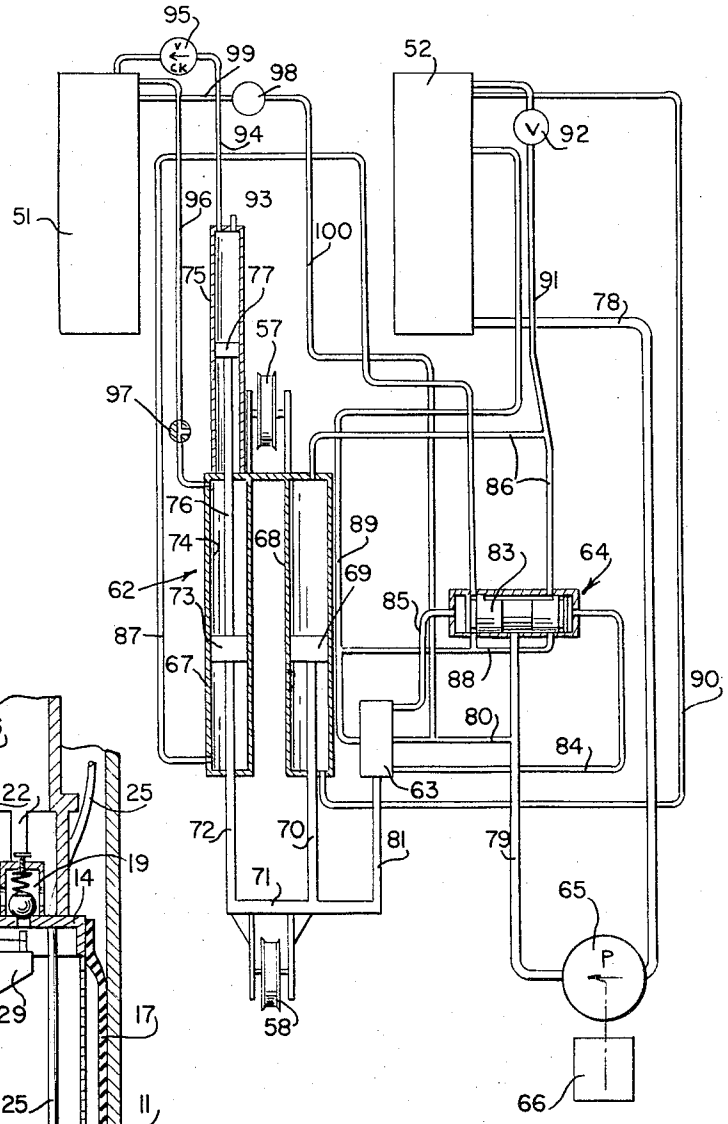
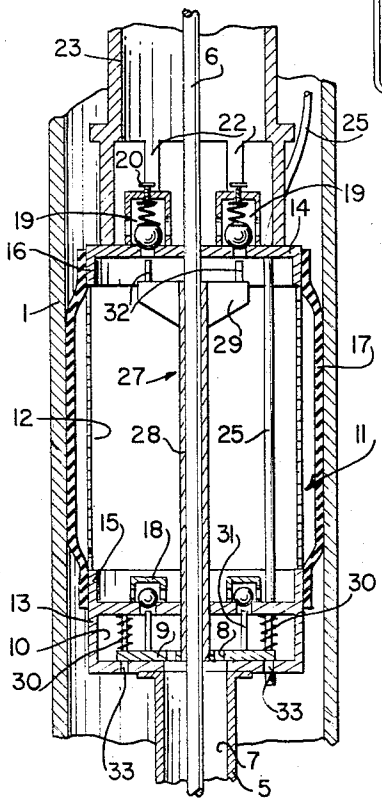


FIG_7



INVENTOR.
HARRY C. HEATH

BY

Boyken, Mohler & Wood

ATTORNEYS

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PUMPING RIG AND METHOD

Harry C. Heath, 825 E. State St., Boise, Idaho

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2 Claims. (Cl. 103—179)

This invention pertains to deep well pumping apparatus, and more particularly to a new and novel means for providing a counter-balance for hydraulically actuated pumping units.

The advantages of the comparatively slow moving, long stroke, hydraulic pumping units for deep wells, such as oil wells, have long been recognized. However, one major disadvantage of this type of unit over the older style mechanically operated walking beam type of unit is the fact that heretofore the hydraulic units required a considerably larger power source to accomplish the same result in production units, such as barrels per day, under like operating conditions.

To actuate the pump, which is usually placed at or near the bottom of the well, which may be 5,000 to 10,000 feet deep, and even more in some instances, it is necessary to connect the reciprocating pump's driving machinery on the surface with the pump itself many feet below the earth's surface. This is usually accomplished by means of a slender rod, connected together in sections, so as to enable the pump to be reciprocably driven by the power plant on the surface.

It is, of course, obvious that a long rod such as this can be used only in tension as it would buckle if any compressive stresses were imposed on it. Therefore the down or return stroke of the pump is effected by the force due to the weight of the "sucker rod," as the pumping rod is generally known in the trade, and the hydraulic head due to the column of oil that is being pumped or lifted up the well.

On most installations the sucker rod is about one inch in diameter and has a weight of about 280 pounds per 100 feet. For an average well of 5,000 feet depth this total rod weight of about 14,000 pounds that must be carried by the end of the rod at the top of the well.

Furthermore, the static hydraulic head created by a column of oil 5,000 feet deep is about 2,000 pounds per square inch at the pump. So with an average 2½ inch diameter pump the increased force necessary to bring the oil to the surface is about 10,000 pounds. This brings the total "polished rod load," as the section of sucker rod that passes through the stuffing box at the surface is called, to about 24,000 pounds for only a moderately deep well of 5,000 feet. It is obvious the sucker rod is always under tension due to its own weight, and the tension is further increased on the up or pumping stroke of the rod. This, of course, causes the steel sucker rod to behave elastically resulting in the rod stretching an amount that is proportional to the weight of the column of oil that is being pumped. In the above case for a one inch rod exerting a force of 10,000 pounds to lift the oil the overall stretch for 5,000 feet of rod is about two feet. This means that if the pump is to operate with, say, a six foot stroke, the length of stroke at the top of the well must be about eight feet. This problem is, of course, inherent in any long slender shaft that is subjected to varying loads, and cannot be completely eliminated.

However, a major cause of sucker rod failure is due to

the fact that in the prior art devices this fluctuating loading and resulting elastic elongation takes place in stress ranges that often times approach the elastic limit of the material. This causes more rapid fatigue of the metal which results in frequent and costly rod breakages. A solution to this problem is, of course, to reduce the effective weight of the sucker rod as it appears to the polished rod end of the well thereby allowing the stresses to be substantially reduced. This would further enable a larger pump to be utilized and/or a smaller power plant at the surface resulting in substantial economic savings.

The amount of power required to operate this type of unit could also be reduced if the hydraulic pistons at the surface that actuate the rod were counter-balanced so that the amount of effort required to lift the sucker rod on the pumping stroke was about equal to the force necessary to oppose the yieldable counter-balancing force tending to lift the rod. This ideal situation would result in the need of a much smaller power plant, hence lighter, less massive mechanism which would, of course, mean a lower initial cost, lower maintenance costs, and substantial savings in operating costs.

It is therefore with the above mentioned problems and disadvantages of the existing art in mind that this invention is proposed.

It is a major object of this invention to provide a method and device for reducing the effective or apparent weight of the sucker rod of deep well pumps.

It is a further objective of this invention to provide a device and method for reducing the effective weight of a sucker rod, of the type described, that can be adapted to reduce the effective weight of said rod by any desired percentage from zero to one hundred percent if desired, while the pump is operating.

It is another object of this invention to provide a new and novel means for reducing the amount of lifting force necessary at the polished rod end of the well thereby resulting in the need of less massive and powerful equipment resulting in substantial economic savings to the operator.

It is a further object of this invention to provide a pumping device of the character described that it simple and rugged in design, foolproof in operation, and relatively inexpensive to manufacture.

Another object of this invention is to provide a fluid operated and controlled pump actuating device that is pneumatically and yieldably counter-balanced to further result in smaller power requirements.

Yet another object of this invention is the provision of means for performing said pneumatic counter-balancing in chambers separate from the hydraulic chambers that serve to actuate and reciprocate said pump thereby obviating the possibility of the two separate working fluids intermixing and contaminating one another.

Also it is an important object of this invention to provide a pneumatic counter-balancing force that is automatically regulated by the amount of force necessary to operate the pump, thereby maintaining a balance of counter and direct rod actuating forces to result in minimum power requirements and optimum operating efficiency.

Furthermore, it is another object of this invention to provide a method and means for partially supporting a deep well sucker rod from its lower end in a manner which tends to reduce its effective weight during the reciprocatory pumping operations.

Further objects and advantages will become evident from the detailed specification and accompanying drawings, in which:

Fig. 1 is a sectional, foreshortened view of the lower end of a well showing the pump and a means for reducing the effective weight of the sucker rod;

Fig. 2 is a sectional, foreshortened view similar to Fig. 1 showing a modified form of the device of Fig. 1;

Fig. 3 is a side elevational view of apparatus for actuating the subsurface pump;

Fig. 4 is a partly sectional, partly end elevational view taken along line 4—4 of Fig. 3;

Fig. 5 is a schematic diagram illustrating the action of the pulleys and cable that are used to reciprocate the sucker rod;

Fig. 6 is a schematic piping diagram showing the flow of fluids that are used to actuate this invention; and,

Fig. 7 is an enlarged fragmentary section taken from the form illustrated in Fig. 1 to more clearly show the construction details of the packer mechanism.

Briefly, the means for reducing the effective weight of the sucker rod is a piston, rigidly connected to the sucker rod at some point spaced above the pump, say, about thirty feet. The piston is adapted to be reciprocated with the sucker rod in a cylinder having an open end at the bottom, and closed at top. As the pump is started and a column of crude oil is built up inside the casing or well by passing through a series of check valves, said column exerts a static thrust due to its own weight against the lower side of the piston that is attached to the sucker rod. The amount of thrust is a function of the height of the column of oil and the diameter of the piston. Of course for any one installation the piston diameter remains steady, so the upward, tension-reducing thrust on the piston due to the column of oil is proportional to the height of said column. In practice the ideal situation would be to have the column of oil exert a force on the piston that is equivalent to about 90 percent of the sucker rod weight when the column is the full depth of the well. In the previously cited example this would means the effective weight of the sucker rod is reduced by about 12,500 pounds thereby reducing the polished rod load to about 1500 pounds for the sucker rod alone.

As described herein the invention will be illustrated as being used for the pumping of crude oil from an oil well, however this is by no means restrictive as the same apparatus could as effectively be used for the pumping of other liquids, such as water, from deep wells.

In detail, with reference to Fig. 1, the numeral **1** designates the outer well casing which may be utilized on some type of wells, depending on soil conditions, however, a casing is not essential to the operation of this present invention. As seen in the figure the pump assembly, generally designated **2**, is resting on a pillow-like support **3** at the bottom of the well. Oil is sucked through the plurality of holes **4** positioned about the lower end of the pump housing **5** and is then forced up through the pump **2** in the conventional manner during the upstroke of the long, vertical, pump actuating rod **6**. This structure is conventional and is described only for the sake of clarity in understanding the operation of the invention disclosed herein. As the oil is pumped upward to the upper chamber **7** (Fig. 7) of the housing **5** it passes through apertures **8** which are formed in a generally flat annular plate element **9**, through the center of which the sucker rod **6** passes. The oil then is admitted to the generally cylindrical chamber **10** formed in the lower portion of a radially expandable, stationary sealing member generally designated **11**.

The sealing member **11** comprises an inner perforated cylinder **12** which is fitted with a double walled lower member **13**, in which is formed chamber **10**, and with a single walled upper end piece **14**. As already stated members **13**, **14** are mounted coaxially to each end of the perforated cylinder **12** and are adapted to receive sucker rod **6** centrally therethrough. Each end member **13**, **14** is fitted with a circumferential, longitudinally extending flange **15**, **16** respectively, which is adapted to form a seat for a sleeve-like cylindrical, yieldable, outer wall **17** that is adapted to be expanded radially outward due to a pressure from within. Sleeve **17** is formed of some resilient, easily deformable oil resisting material such as a material derived from the polymerization of chloroprene (monochloro-butadiene) known commercially as neoprene. It is to be understood that the ends of the sleeve **17** that are adjacent to flanges **15**, **16** are securely attached thereto as by a combination of cements and external wrappings or vulcanizing (not shown).

Further pumping of the oil will cause the oil that is contained in the said cylindrical chamber **10** to pass through the ball check valves **18** that are mounted to the upper surface of the inner wall of the lower end member **13**.

After the space within cylinder **12** is filled with oil a slight pressure is built up within said cylinder until it is great enough to overcome the resistance of the spring loaded ball check valves **19** mounted atop the upper end piece **14**. The tension on the ball check valves may be adjustably set at a predetermined amount by means of adjustment screws **20**. The oil, under pressure, within the confines of cylinder **12** causes the outer sleeve **17** to be forced radially outwardly to engage the surface of the casing **1** or if the casing is not used, the bore of the well itself. This action forms a seal or plug which separates the portion of the well above sealing member **11** from that below.

Continued pumping of oil now causes the check valves **19** to intermittently open and admit the oil to the portion of the casing above member **11**. Above member **11** the casing **1** or well is adapted to form the conduit to carry the oil to the surface.

It is evident that after a long column of oil is above member **11** the pressure due to said column is considerable, however, due to the action of the spring loaded check valves **19**, the differential of pressure within the perforated cylinder **12** and the static pressure due to the hydraulic head is still maintained, and it is this differential of pressure that effects the sealing of the sleeve **17** to the casing **1** or well bore.

Mounted above and connected to the upper end member **14**, by means of a plurality of radially placed posts **22**, is a relatively long, thick-walled, open-bottom cylinder **23** (Figs. 1, 7). Cylinder **23** is closed at the top and is adapted to receive therethrough the sucker rod **6**.

Rigidly connected to the sucker rod **6** is a piston **24** which is complementarily fitted to the inner wall of cylinder **23**. When the sucker rod **6** is at the bottom or lowermost position of its stroke the piston **24** is adapted to be spaced just above the open end of the cylinder **23** within the same. The static pressure due to the weight of the column of oil within casing **1** above sealing member **11** acts upon the lower face of piston **24** thus tending to force piston **24** upward. By proper dimensioning of piston **24** and cylinder **23** with respect to the anticipated head and suspended sucker rod weight, any desired amount of the tension experienced by said sucker rod, due to its weight, may be eliminated.

The space in cylinder **23** above piston **24** is at a reduced pressure, near atmospheric, and is vented by means of conduit **25** (Fig. 1) to the portion of the well, below plug element **11**, that is also at atmospheric pressure.

It is, of course, undesirable to reduce the tension in sucker rod **6** to the point where said rod is under any substantial compression as buckling would then result. Also it is necessary to maintain some weight on sucker rod **6** so that it can accomplish the return stroke of the pump **2**, this being done by the force of gravity and usually requiring a force of at least 1000 pounds.

It is evident that cylinder **23** must be long enough to accommodate a reciprocatory travel of piston **24** that is as long as the stroke of pump **2**.

To recapitulate, the operation of the device shown in Figs. 1, 7 is as follows: Oil from the oil bearing sands surrounding the well is admitted to the pump **2**, pumped therethrough into the upper portion **7** of the pump housing **5**. From there the oil is forced into the cylindrical chamber **10** formed within the double walls of the lower

end piece 13 of the sealing plug 11. From chamber 10 the oil is forced through the ball check valves 18 and fills the space within the perforated cylinder 12. Pressure is built up within the cylinder 12 due to the force that is necessary to open the adjustable spring loaded check valves 19. After passing through the check valves 19 the oil is conducted, by the casing 1 or well bore if no casing is provided, to the surface by continued pumping. The pressure within the perforated cylinder 12 forces the deformable sleeve 17 against the casing thus effecting a seal between the part of the casing above plug 11 from the part below. The oil within the confines of plug 11 is always at a slightly higher pressure than the oil above the member 11 by the amount of pressure necessary to open the spring urged check valves 19.

The static head created by the weight of the oil exerts an upward force on the piston 24 which is rigidly connected to the portion of sucker rod 6 that is reciprocated within the vertical, open bottom cylinder 23. The fact that there is virtually no pressure above the piston 24 in cylinder 23 allows the piston 24 to exert an upward force on the sucker rod 6 thereby substantially reducing its effective polished rod weight.

In order to permit removal of the pump from the bottom of the well a means must be provided for unloading the oil from within the plug 11, and also to allow all the oil entrapped in the casing 1 above the plug 11 to be drained through the check valves 19 and 18 and the plug 11, as the pump 2 and cylinder 23 are being raised to the surface.

This is accomplished by means of an unloading mechanism generally designated 27 (Fig. 7). When the sucker rod 6 is being pulled toward the surface the top of the reciprocating portion of the pump 2 is brought into engagement with the lower side of the annular plate element 9 hereinbefore referred to. Plate 9 is mounted to the lower end of a sleeve or bushing 28 that slidably receives the sucker rod 6, within sealing plug 11. Continued upward movement of the pump 2 against the plate 9 causes the sleeve 28, plate 9 and the cross bar 29 mounted atop sleeve 28 to move upwardly against the urgency of springs 30 that yieldably urge plate 9 downward to its normal operating position.

Mounted atop plate 9 and cross bar 29 so as to be in alignment with the balls of the check valves 18, 19 are two pairs of upwardly directed finger-like projections 31, 32, respectively.

These projections open the valves to allow the oil to flow downward through the same and out of the sealing plug 11 via apertures 33 formed in the lower wall of bottom member 13. In the normal operating or pumping condition apertures 33 are closed off by the annular plate 9. With the unloading device it is possible to pull the apparatus shown in Fig. 1 upward any desired distance, while allowing the oil entrapped in casing 1 thereabove to drain through said apparatus.

With reference now to Fig. 2, a slightly modified form of this invention is shown.

Here the weight of the pump 2 and cooperating mechanisms is supported by an annular, horizontal shelf or ledge 35 that is rigidly attached to the inner surface of the casing 1 at the desired position in the well.

The sealing and check valve mechanism in this present illustration consists of a generally cylindrical housing 36 from which the pump housing 5 depends. The side walls of housing 36 below the point from which pump housing 5 depends are slightly extended, and terminate in a radially inwardly directed horizontal annular flange 37 which is adapted to seat against the upper annular surface of shelf 35. Coaxial with, and spaced upwardly from flange 37 is another horizontal, radially inwardly directed flange 38 to which is fitted said pump housing 5. On the upper surface of housing 36 are mounted ball type check valves 39 which allow the oil to be passed upwardly therethrough but prevent it from returning to the portion of the well below housing 36.

Mounted atop posts 40 which are arranged radially about the upper surface of housing 36 and extend upwardly therefrom is a cylinder 41, similar to cylinder 23, that is open at the bottom and closed at the top. Sucker rod 6 is adapted to pass therethrough, coaxially, as it does through housing 36 to communicate with the plungers of pump 2.

Adapted to reciprocate with sucker rod 6 and rigidly attached thereto is piston 42 which is complementarily fitted to the inner cylindrical surface of cylinder 41.

The resultant action of piston 42 is the same as for piston 24 of Fig. 1. When the oil column is built up within casing 1 the static head created by the weight of said column exerts an upward force against the underside of piston 42 within cylinder 41. This upward force tends to reduce the tension in sucker rod 6, that is due to its own suspended weight, in the same manner as the tension is reduced for the sucker rod in Fig. 1.

Venting of the upper chamber of cylinder 41 is accomplished by conduit 43 that extends to the lower reduced pressure portion of housing 36.

To permit withdrawal of pump 2, housing 36, and cylinder 41 from the well an unloading device in the form of a flat annular plate 44 to which are fastened a pair of longitudinally extending, upwardly directed fingers 45 is provided.

Annular plate 44 is adapted to normally reside against the upper surface of the annular, radially inwardly directed flange 38 of housing 36, and be yieldably urged thereagainst by means of helical coil springs 46. Plate 44 is also provided with apertures 48, similar in construction and operation to apertures 8 in plane 9.

When sucker rod 6 is pulled upwardly to a point above its normal operating stroke, the inner reciprocating mechanism of pump 2 is forced against the lower surface of plate 44 thereby lifting the same against the urgency of springs 46.

Fingers 45 which are connected to plate 44 are adapted to engage and lift the balls of check valves 39, thereby opening the same and allowing the oil above housing 36 to now be drained downwardly therethrough and out apertures 47 formed in the annular flange 38. Apertures 47 are normally closed off by plate 44 and are only open to passage of oil therethrough when plate 44 is unseated from flange 38.

It is seen that the provision of a method of supporting the pump actuating rod from below by the application of the force of the fluid head in a full well greatly reduces the load carried by said rod on the upstroke of the pump and therefore greatly reduces the stretch in the rod. Not only is rod failure greatly reduced by lowering the tensile stress in the rod by this method and apparatus, but a greater portion of the rod stroke is available at the subsurface pump resulting in the possibility of use of a larger pump and therefore greater production.

Figs. 3, 4 show the mechanism that is mounted on the surface and effects the reciprocatory motion of the sucker rod 6.

Mounted on a portable skid-type frame 50 are a pair of cylindrical tanks 51, 52 which are utilized as air and hydraulic fluid storage reservoirs respectively.

Sucker rod 6 is reciprocated by means of a flexible steel cable 53 that is attached to the upper end of the polished steel rod as by the eye type connection 54. The lifting of sucker rod 6 is accomplished by means of cable 53 as now to be described.

The end of cable 53 remote from the connection 54 is securely fastened to a capstan or winch 55 (Fig. 5) that is provided with a braking means to prevent rotation and resultant unwinding of cable 53 therefrom. Cable 53 is then passed around an idler pulley 56 which is rotatably mounted to the frame 50 of the pumping

rig. From pulley 56 the cable is adapted to run over a rotatably mounted pulley 57 that is mounted securely to the tops of the fluid operated cylinders that will subsequently be described. Pulley 57 is adapted for rotation only as it cannot move from its fixed axis. The cable is now passed around another sheave or pulley 58 that is rotatably mounted to the lower end of the connected piston rods that extend from said fluid operated cylinders. Pulley 58 is adapted for rotation about its axis and for motion in a vertical plane, said plane motion being caused by the reciprocation of the pistons within said cylinders.

After passing around pulley 58 the cable 53 is directed upward to thence pass around a large idler pulley 59 rotatably mounted to a bifurcated extension 60 of the support frame 61 that is mounted on the top of tanks 51 and 52.

Since the remote end of cable 53 is tied to winch 55 and cannot move, the downward travel of pulley 58 causes the sucker rod 6 to be pulled upwardly (Fig. 5) by an amount that is twice as great as the travel of pulley 58. Of course it is evident that more pulleys could be placed alongside pulleys 57, 58 and an even greater multiplication of displacement could be obtained.

When the occasion arises that the sucker rod 6 is to be pulled out of the well, or lowered deeper into the well all that has to be done is to deactivate the fluid operated cylinders and raise or lower the cable by means of winch 55. If desired the cable 53 can be unwound from the differential pulleys 57, 58 and be connected directly over pulley 59 via idler sheave 56.

The major elements of the apparatus that are mounted on the skid frame 50 consist of the air reservoir tank 51, oil reservoir tank 52, an operating cylinder unit 62, a pilot valve 63, a balanced spool type master control valve 64, hydraulic pump 65 and motor 66 (Figs. 3, 4).

As best seen in the schematic illustration of Fig. 6 the operating cylinder unit 62 consists of a pair of parallel, vertically extending cylinders 67, 68 which may be integral with each other or separated as shown. Cylinder 68 is a single acting hydraulically operated cylinder that is used to lift the sucker rod 6 by exerting a downward thrust on piston 69 that is reciprocally contained therein. Attached to piston 69 is a piston rod 70 that connects to a yoke 71. Also joined to yoke 71 is the rod 72 of piston 73 that is contained within the double acting cylinder 67.

Cylinder 67 is the counter-balancing cylinder and this counter-balance is achieved by the admission of compressed air from reservoir 51 to the upper chamber 74 of cylinder 67. Thus the compressed air in chamber 74 exerts a downward thrust on piston 73 ultimately tending to raise the sucker rod 6, however the pressure of the air contained within chamber 74 is not adapted to be sufficient to raise the rod 6 by itself and an additional force exerted on the cooperatively acting piston 69 of cylinder 68 is required to perform the up stroke of said rod 6.

The operation of the schematically illustrated mechanism shown in Fig. 6 will now be described starting with the charging of the air reservoir tank 51 with compressed air. This step of charging tank 51 is necessary before the actual oil pumping operation can be initiated if the advantages of the counter-balance cylinder 67 are to be utilized.

Prior to the pumping of oil from the well the tank 51 may be charged with compressed air by an auxiliary air compressor independent of the mechanism shown in Fig. 6. However, means utilizing an air compressor unit 75 that is mounted to the upper portion of counter-balance cylinder 67 is shown herein. A rod 76 which is connected to the piston 73 of cylinder 67, is slidably journalled for an air-tight fit through the integral cylinder head that is common to both cylinder 67 and compressor 75, and is further fitted to a piston 77 that is adapted to reciprocate within the compressor 75 when the cooperatively acting cylinders 67, 68 are actuated.

By slackening or otherwise disconnecting cable 53 from sheaves 57, 58 the interconnected cylinders 67, 68 may be actuated without causing reciprocation of the sucker rod 6 thus permitting compressor 75 to charge tank 51 with compressed air.

The hydraulic fluid for activating pistons 69, 73 is supplied from tank 52 to pump 65 via suction line 78. From pump 65 the hydraulic fluid is pumped to the master control balanced spool type valve 64 by line 79 and to the pilot valve 63 by means of line 80 which branches off line 79.

Pilot valve 63 is operated by an adjustable control rod 81 (Figs. 3, 4, 6) that in turn is controlled by the reciprocation of the piston rods 70, 72. Adjustment for control rod 81 is provided by means of a pair of collars 82 that are positioned on rod 81 (Fig. 4).

Pilot valve 63 controls the admission of fluid to the ends of the master control valve 64 which in turn acts upon the spool 83 contained therein to alternately supply the hydraulic fluid from pump 65 to the cylinders 67, 68. Lines 84, 85 run from the pilot valve 63 to opposite ends of the spool valve 64 for this above mentioned purpose.

In the position shown in Fig. 6 the hydraulic fluid is being admitted to valve 64 and therethrough to line 86 that conducts it to the upper end of cylinder 68 thus forcing piston 69 and interconnected piston 73 downwardly.

The discharging of hydraulic fluid from the lower chamber of cylinder 67 is now conducted through line 87 back through the other port of valve 64 through the return feeder manifold 88 into line 89 which carried it back to reservoir tank 52. Line 89 also accepts the discharge from the pilot valve 63.

A scavenger line 90 to conduct the seepage that gets past piston 69 joins the lower end of cylinder 68 with the reservoir tank 52.

A branch line 91 from line 86 is provided with a manually operable valve 92 for the purpose of allowing the motor 66 and pump 65 to be operated without activating cylinders 67, 68. This is done when valve 92 is open and is sometimes desirable when the system is first started for purposes of priming pump 65 and warming the engine if that is what is being used in place of motor 66.

When piston 69 has reached the bottom of its stroke pilot valve 63 is reversed by rod 81 thereby reversing the pressure on spool 83 by channeling fluid to the right side of valve 64 in Fig. 6 through line 84. The movement of spool 83 to the left causes the fluid under pressure from line 79 to be ported to line 87 for pushing piston 73, and interconnected piston 69, upwardly. The oil from the upper portion of cylinder 68 is exhausted through line 86, valve 64, and lines 88 and 89 to reservoir 52. The cycle again reverses as pistons 69, 73 reach the top of their stroke.

With the system thus started, and cable 53 inoperative, the flow of hydraulic fluid alternately from the master valve 64 to cylinders 67, 68 places the air compressor 75 in operation.

Air at atmospheric pressure is admitted to compressor 75 by inlet valve 93 and on the up stroke of piston 77 is forced through line 94 and check valve 95 into the air storage tank 51.

To prevent the air from merely circulating through tank 51 and out of the same by means of line 96 into the upper chamber 74 of cylinder 67 a three-way valve 97 is closed to prevent the escape of the compressed air from tank 51. The purpose of the three-way valve 97 is to allow the piston in cylinder 67 to move freely while the compressor 75 is in operation.

After sufficient pressure is built up within tank 51 to

allow the pumping of the oil from the well to begin, the apparatus may be stopped, the cable 53 placed in operating position, and then the pumping started.

When first starting to pump a well that has the oil level below the sealing elements 11 or 36 hereinbefore described, there is no bouyant effect on the sucker rod 6. This means that at first the counter-balance cylinder must carry the full weight of the sucker rod 6, hence, a much higher air pressure is required than later when the column of oil begins to reach the surface and the sucker rod 6 is being substantially supported by the buoyant effect of the column as before described. Therefore the initial air pressure in the counter-balance chamber 74 of cylinder 67 is high and is progressively reduced as the buoyancy effect of the piston 24 and cylinder 23 in the well begin to carry more of the weight of the sucker rod 6.

This reduction of pressure is achieved by means of a regulator 98 (Fig. 6) placed in line 99 which connects tank 51 to said regulator 98. The other side of the balanced diaphragm regulator 98 is connected by line 100 to the hydraulic pressure line 80.

Since the pressure in line 80 is only great enough to perform the described operation of cylinders 67, 68 it signals to regulator 98 that pressure, regulator 98 then maintains a balance in pressure between the air in tank 51 and the working pressure of the hydraulic fluid in line 100 by allowing the excess air in tank 51 to be exhausted to the atmosphere.

When actually pumping the three-way valve 97 is turned so that line 96 communicates with chamber 74 of cylinder 67 thus allowing the compressed air to be cycled through said line during the reciprocation of pistons 69, 73.

The air pressure within chamber 74 is adapted to be sufficient to support the effective weight of the sucker rod 6. This varies, as just described, during the build up of the column of oil within the well, and when the oil is at the surface the air pressure need only be great enough to support the remaining load that is unsupported by the bouyant effect of piston 24 and cylinder 23.

It is seen by this disclosure that the power requirements of motor or engine 66 are substantially reduced from what they would be if thre was no counter-balancing of the rod weight and cylinders 67, 68.

In the previously cited example of a 5000 foot well and a total rod load of 14,000 pounds and 10,000 pounds pumping effort, the total force may be reduced to about one-third this value by use of these above described counter-balances. If the piston 24 within cylinder 23 relieves the sucker rod of 90 percent of its effective weight then the sucker rod would appear to weigh only about 1500 pounds.

On the pumping stroke an additional 10,000 pounds of force are required, thus the total force that must be exerted by cable 53 on connection 54 is 11,500 pounds. With the counter-balance chamber 74 carrying approximately one-half this load the force exerted by the working fluid from pump 65 would only need be about 6,000 pounds.

So it is evident that a substantial savings in power requirements is accomplished by means of these above described novel types of counter-balances that comprise this invention.

It is obvious to those schooled in the art that many modifications could be resorted to on this invention, yet these modifications would not depart from the spirit of the invention or the scope of the following claims.

I claim:

1. In deep well pumping apparatus, a subsurface pump adapted to be positioned in the bottom of a well for pumping fluid therefrom to the ground surface, a reciprocating rod extending from the ground surface to said pump and connected thereto for operating said pump, sealing means positioned above said pump including conduit means having one-way valve means therein communicating between said pump and the upper side of said sealing means and adapted to seat with respect to the well and to be supported thereon for sealing the well against flow of the pumped fluid from said upper side of said sealing means to said pump, a cylinder supported on said sealing means coaxial with said rod and having a closed upper end and a lower end open to the well above said sealing means, and a piston slidably received in sealing engagement with said cylinder between said ends and secured to said rod for applying the force of the fluid head of the fluid filled well above said piston to said rod in an upward direction.

2. In deep well pumping apparatus, a subsurface pump adapted to be positioned in the bottom of a well for pumping fluid therefrom to the ground surface, a reciprocating rod extending from the ground surface to said pump and connected thereto for operating said pump, sealing means positioned above said pump including conduit means having one-way valve means therein communicating between said pump and the upper side of said sealing means and adapted to seat with respect to the well and to be supported thereon for sealing the well against flow of the pumped fluid from said upper side of said sealing means to said pump, a cylinder supported on said sealing means coaxial with said rod and having a closed upper end and a lower end open to the well above said sealing means, and a piston slidably received in sealing engagement with said cylinder between said ends and secured to said rod for applying the force of the fluid head of the fluid filled well above said piston to said rod in an upward direction, the diameter of said piston and cylinder being related to the amount of said fluid head and the weight of said rod such that a major portion of said weight is supported by said force.

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