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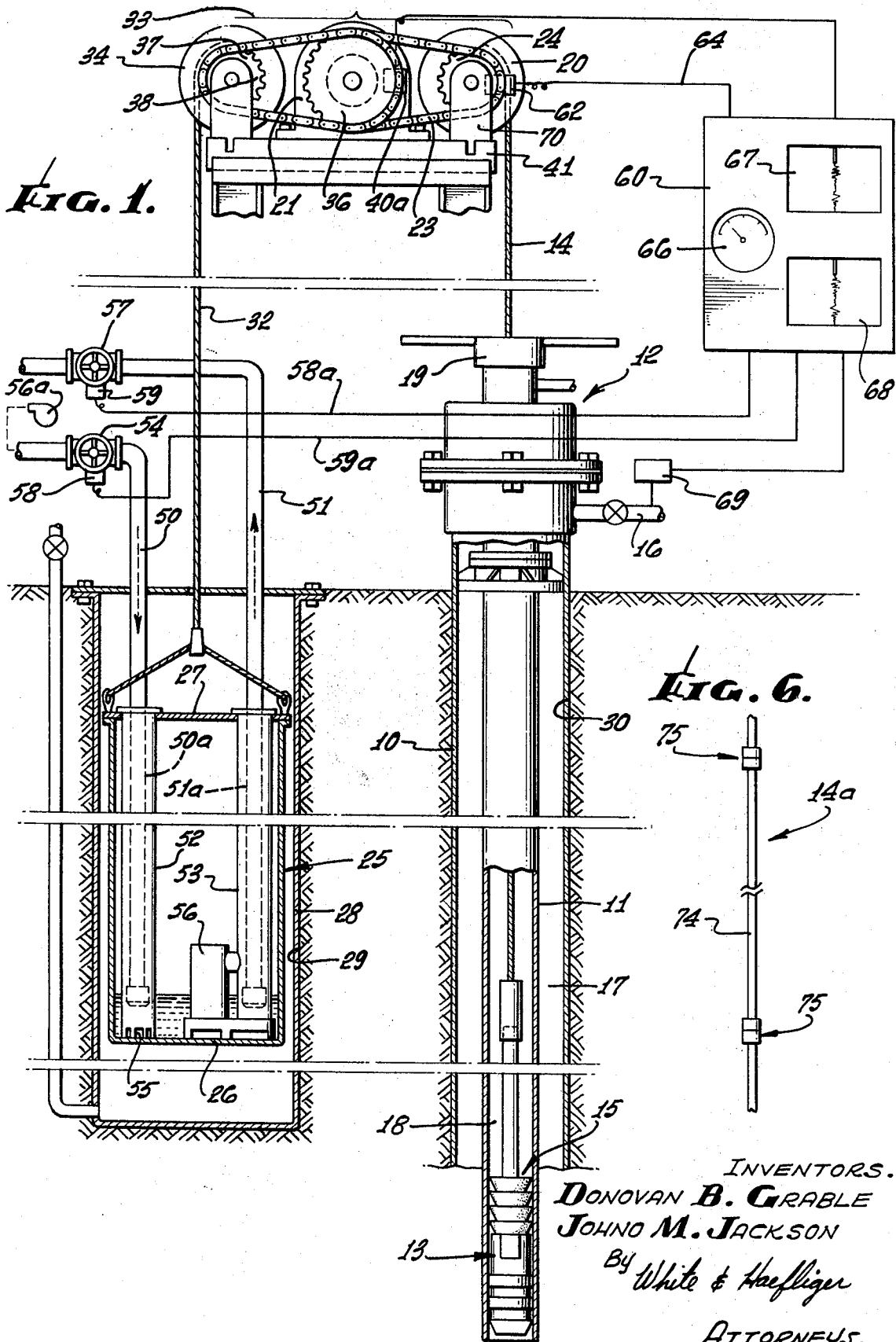
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WELL PUMPING AND SERVICING SYSTEM

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2 Sheets-Sheet 1



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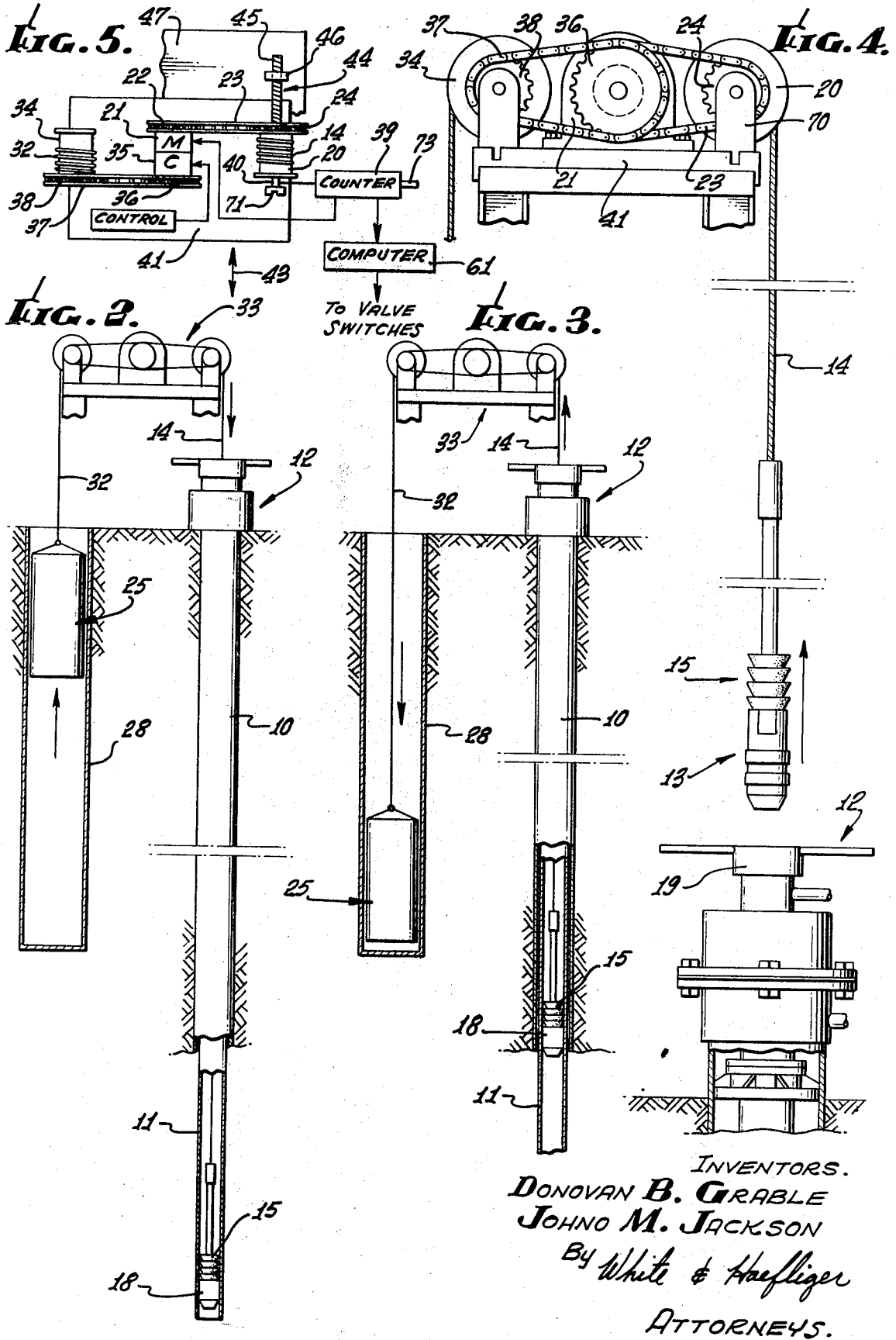
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WELL PUMPING AND SERVICING SYSTEM
Donovan B. Grable, 2515 San Francisco Ave., Long Beach, Calif. 90806, and John M. Jackson, Box 387, Santa Ynez, Calif. 93460

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19 Claims

ABSTRACT OF THE DISCLOSURE

The disclosure concerns well head apparatus including a drum for spooling well cable to which pumping means in the well is attached; a counterbalancing assembly operatively connected to such apparatus and including a liquid reservoir positioned to be moved up and down as the cable moves up and down in the well during pumping; and, means to adjust the quantity of counterbalancing liquid in the reservoir in compensating relation to variations in the load to be lifted in the well by the cable.

BACKGROUND OF THE INVENTION

This invention relates generally to the pumping of wells such as oil wells, and more particularly concerns counterbalanced winding apparatus useful in pumping oil wells and pulling pumps therefrom.

In the past, walking beam apparatus has been used for reciprocating pumping apparatus in wells, such apparatus being characterized as providing rather short stroke, relatively high frequency vertical reciprocation to the well pump. Problems associated with such apparatus include inability to provide along pump stroking as is at times desirable in low production wells; the expense of retrieving and running of long sucker rod strings operated by such walking beam apparatus, when the well is to be periodically pulled, such expense making the operation of low production wells uneconomic; and unavoidable hazards, wear problems and maintenance expense of such equipment.

SUMMARY OF THE INVENTION

It is a major object of the invention to provide solutions to the above problems through the provision of apparatus enabling long stroke cycling of well pumps at low frequencies, inexpensive pulling of wells and reductions in hazards, maintenance expense and equipment wear. Basically, the invention is embodied in a system that comprises:

(a) apparatus at the well head and including a drum for spooling the cable that supports and vertically reciprocates the pump in the well;

(b) a counterbalancing assembly operatively connected to that apparatus and including a liquid reservoir located to be moved upwardly and downwardly as the cable moves downwardly and upwardly respectively in the well; and

(c) means to adjust the quantity of counterbalancing liquid in the reservoir in compensating relation to variations in the load to be lifted in the well by the cable.

As will be seen, the apparatus typically includes a rotary drive at the well head and connected to the drum, a second drum, and motor to rotate both drums simultaneously, and a second cable operatively connecting the counterbalancing assembly to the second drum. Also, the apparatus may typically include a clutch to decouple the second drum from the rotary drive when the first cable is pulled to retrieve the pumping means. Such apparatus yields the benefits referred to above, as will appear.

Other aspects of the invention include the provision

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of a load sensor connected to the drive and operable to produce a signal indicating an overload condition arising when the counterbalancing effect of the assembly is insufficient or excessive, as during start-up; the connection of the compensating means to the drive to be responsive to overloading of the drive; the provision of a carriage for one or both drums, and which is shiftable to maintain the vertical cables centered in predetermined relation; the provision of apparatus to effect reversing of the drive in response to sensing of predetermined limits of pump stroking; the provision for continuous reading at the surface of the fluid level in the well bore; the provision of finger touch means at the surface to change the pumping level in the well bore without interrupting the pumping operation; and the provision of guide conduits to flow liquid to and from the reservoir while guiding its vertical movement.

These and other objects and advantages of the invention, as well as the details of illustrative embodiments, will be more fully understood from the following description and drawings, in which:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an elevation showing one form of the invention;

FIG. 2 is a schematic elevation showing the well pumping means in down position and the counterbalancing assembly in up position;

FIG. 3 is a view like FIG. 2, but showing the well pumping means in up position, and the counterbalancing assembly in down position;

FIG. 4 is a fragmentary elevation showing the configuration of the apparatus during pulling of the pumping means from the well;

FIG. 5 is a diagrammatic plan view of the cable drums and drive as well as the shiftable carriage therefor; and

FIG. 6 is a view of a modified cable having end to end connected sections.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1, the typical oil well illustrated has casing 10 and production tubing 11 extending up through the casing head 12. Carried within the bottom of tubing 11 is a pump means 13 which is vertically reciprocable in response to up and down travel of cable 14 by which the pump means is suspended. The pump may comprise a piston or swab, with downwardly tapered cups 15 engaging the tubing bore on upstroke to elevate the column of production fluid toward outlet 16. Such fluid is transferred by the pump from annulus 17 to the tubing interior 18 in response to down stroking of the pump, as is conventional.

Cable 14 extends upwardly within tubing 11 and through stuffing box 19 to spool on winching drum 20, as also seen in FIG. 5. The apparatus at the well head for spooling the cable comprises, in addition to the drum, a rotary drive 33 connected to the drum and typically including a hydraulic motor 21, sprocket 22 driven by the motor, chain 23 driven by the sprocket and another sprocket 24 driven by the chain and rotating drum 20.

As referred to above, a counterbalancing assembly is operatively connected to the spooling apparatus for cable 14. That assembly broadly includes a liquid reservoir connected to the well head apparatus, and comprising a liquid reservoir positioned to be moved upwardly and downwardly as cable 14 moves downwardly and upwardly, whereby the motor 21 need only supply minimum power to effect the reciprocation of the pumping means, the need for large gasoline or diesel engines thereby being obviated.

More specifically, a liquid reservoir or traveling tube 25 has a bottom closure 26 and removable top closure 27. Tube 25 is accommodated for vertical movement within casing 28 of a bore 29 drilled in the earth at one side of the pumping bore or well 30 and to a depth sufficient to permit maximum travel corresponding to selected ranges for stroking of the well pump. In this regard, the invention makes possible the pumping of low production wells at abnormally long range, relatively low frequency pumping strokes. For example, the depth of casing 28 may be sufficient to accommodate travel of reservoir 25 within a range from 50 to 100 feet, and in one specific instance the vertical travel of the reservoir may be about 70 feet with the pump means cycled at a frequency of about one reciprocation per minute, or less.

Reservoir 25 is connected by cable 32 with the rotary drive 33 referred to previously. Specifically, the cable 32 may be spooled on a second drum 34 connected to motor 21 by means of clutch 35, sprocket 36, chain 37 and sprocket 38 integral with drum 34. When clutch 35 is engaged as in FIG. 1, the operation of the motor serves to raise reservoir 25 and lower the pump means 13 until a limit is reached, after which the motor reverses and raises the pump means while lowering the reservoir until a second limit is reached. At that point, the motor again reverses and the cycle is repeated. Merely as illustrative, a shaft revolution counter 39 is operatively connected to the shaft 40 of the drum 20 and is operable to effect reversal of the motor, as schematically indicated in FIG. 5, when the count in the counter reaches a predetermined level for each stroke. Alternatively, the counter may be connected to the sprocket 22, as indicated at 40a in FIG. 1. Another alternative would be limit switches spaced to be operated by a stroker on either of cables 14 and 32.

FIGS. 1 and 5 indicate the provision of a movable carriage 41 to support the motor 21, clutch 35, and drums 20 and 34. Movement of the carriage, horizontally, may be controlled to generally center cable 14 with respect to the well head, and to generally center cable 32 with respect to the casing 28. In this regard, the two drums 20 and 34 may have the same cable winding diameter, and the cables 14 and 32 may be equal in cross section. The axial direction, and rate, of winding of cable 14 on drum 20 is the same as the axial direction, and rate, of unwinding of cable 32 off drum 34, and vice versa. Those directions are indicated by the arrows 43 in FIG. 5, and one device to move the carriage to compensate for such axial movement of the cables on the drums is indicated at 44. That device comprises a jack screw 45 rotated by drum 20 at the same rate as that drum rotates, the screw having threaded engagement with a nut 46 having fixed position on a fixed base 47. The lead of the screw is such as to advance and retract the carriage in exact compensating relation to axial advancement and retraction of the cable windings and unwindings on the two drums.

An important aspect of the invention concerns the provision of means to adjust the quantity of counterbalancing liquid in the reservoir in weight compensating relation to variations in the load to be lifted in the well by the cable 14. That load includes the weight of the cable and pumping means, plus the weight of the column of production fluid. Such means includes the liquid inlet and outlet conduits 50 and 51 having vertical extensions 50a and 51a received downwardly into the reservoir or chamber 25, and specifically into the guide cylinders 52 and 53 through appropriate packing at the upper ends of those cylinders. Accordingly, vertical displacement of the reservoir is guided, and seal rings are provided at the lower ends of the conduits. Liquid enters the reservoir via conduit 50, valve 54 in that conduit, cylinder 52 and ports 55 in the bottom of that cylinder. Liquid leaves the reservoir via pump 56, exhausting to cylinder 53, conduit 51 and valve 57 in that conduit.

The pump 56 may be operative at all times, as is a pump 56a delivering liquid to conduit 50; accordingly, operation of valves 54 and 57 may thereby involve adjustment of the quantity of counterbalancing liquid in the reservoir in compensating relation to variation in the load to be lifted in the well by the cable, to the end that heat energy is expended by the motor 21 in driving the well pump 13.

Operation of valves 54 and 57 may be controlled by motors 58 and 59 selectively energized by a control 60 which also receives a signal from a load sensor 61. The latter may sense an overload condition of the motor, as reflected by a drop in the counted rate of rotation of the drum 24, for example (the counter could also be run off the motor itself as seen at 40a or the drum 34). A sensor in the form of a simple computer or comparator 61 within control 60 senses this drop in rate below a selected threshold or level, and develops a signal which energizes one or the other of the valve motors 58 and 59 via lines 58a and 59a. Thus, if the overload arises due to excess weight of the well pumping means 13, valve 54 is opened to let more liquid (such as water) into the reservoir to restore the counterbalance at which time valve 54 is closed; and if the overload arises due to excess weight of the reservoir, valve 57 is opened to let liquid out of the reservoir to restore the counterbalance, at which time valve 57 is closed. These modes of operation are particularly important during the interval between start-up of well pumping and normal operation, since the production column in the tubing 11 is rising toward outlet 16 and increasing the weight imposed on cable 14. It is clear that motor 21 is thereby enabled to handle the abnormal loads during start-up, without becoming overloaded.

FIG. 1 illustrates another type of load sensor at 62, which weighs the load imposed by the cable, as it may be sensed in the form of downward loading on drum 20 as via support 70. A signal line 64 runs from that sensor to the control 60. A suitable computer in control 60 may calculate the weight of liquid in reservoir or chamber 25, for display at 66. Chart recorders such as at 67 and 68 may record the weight of liquid in reservoir 25, the pressure of production liquid in line 16 (a pressure sensor in that line being seen at 69), and the fluid level in the well bore or annulus 17, suitable computation means in 60 (such as 61 for example) being usable for this purpose. The chart may be at the well site or at a central production field operation point. In this regard, the motor 21 and/or counter 39 may be adjustable (as at 73) to provide for manual (finger touch) control of the level of the pumping range or action of the pump in the well, permitting changing of that level for pumping efficiency without interrupting the pumping operation.

FIG. 4 illustrates a mode of operation in which the clutch 35 is disconnected and the well pumping means 13 is pulled to the surface for repair. In this instance, the motor 21 may be used to lift the pump in the absence of the counterbalancing effect of reservoir 25, as for example if the well is shallow; or if the well is deep, an auxiliary heavy duty motor or drive may be coupled at 71 to the drum 20 for lifting purposes.

FIG. 6 illustrates the provision of modified cable 14a, elongated sections 74 of which may be successively coupled at 75 to one another and run in the well, the cable 14 being connected to the uppermost section 14a. If it is desired to change the level of the pump 15 by an amount greater than the length of a section 14a, the appropriate number of sections 14a may be added or removed (coarse adjustment) and thereafter the control 73 adjusted to reach the final desired pump level (fine adjustment). Fillers (sleeves) may be placed over drum 20 to compensate for use of sections 14a.

It will be understood that, in the above, the sensing devices and controls may be hydraulic, or hydraulically operated, instead of electric or electrically operated.

We claim:

1. For combination with a vertically reciprocable cable in a well and to which vertically reciprocable pumping means in the well is operatively connected, a system comprising

- (a) apparatus at the well head and including a drum for spooling said cable to raise and lower said pumping means,
 - (b) a counterbalancing assembly operatively connected to said apparatus and including a liquid reservoir positioned to be moved upwardly and downwardly as the cable moves downwardly and upwardly respectively in the well, and
 - (c) means to adjust the quantity of counterbalancing liquid in said reservoir in compensating relation to variations in the load to be lifted in the well by the cable.
2. The system of claim 1 including said cable and pumping means in the well.
3. The system of claim 1 wherein said apparatus includes a rotary drive connected to said drum.
4. The system of claim 3 including a load sensor connected to said drive and operable to produce a signal indicating an overload condition arising when the counterbalancing effect of said assembly is either insufficient or excessive, and from which a measure of the fluid level in the well bore may be derived.
5. The system of claim 3 wherein said means (c) is connected to and responsive to overloading of said drive for controlling liquid flow to and from said reservoir to eliminate said overloading.
6. The system of claim 3 wherein said drive comprises an electric motor.
7. The system of claim 3 wherein said drive comprises a fluid motor.
8. The system of claim 1 including a carriage for said drum, the carriage being movable generally horizontally to generally center the cable with respect to the well head as the cable is being spooled by the drum.
9. The system of claim 2 wherein said pumping means comprises a swab in the well to pass well fluid to the upper side of the swab in response to downward movement of the swab in the well, and to block passage of well fluid to the lower side of the swab in response to upward movement of the swab on the well.
10. The system of claim 1 wherein said reservoir is movable between upper and lower positions, the separation of which is in excess of 40 feet.
11. The system of claim 3 including apparatus to

reverse said drive in response to predetermined drive displacement of said cable.

12. The system of claim 3 including a line connecting said drive to said assembly, and a clutch operable to disconnect said drive and line during operation of the drive to wind the cable on drums for returning said pumping means.

13. The system of claim 1 wherein said last named means includes conduit means communicating with said reservoir for flowing liquid to and from the reservoir, pump means for displacing liquid to flow to and from the reservoir, and valve means to control said flow.

14. The system of claim 13 wherein said conduit means include a conduit extending vertically into the reservoir and having vertical movement guiding relation therewith.

15. The system of claim 3 wherein said apparatus includes a second drum and a motor to rotate both drums simultaneously, and including a second cable operatively connecting said counterbalancing assembly to said second drum.

16. The system of claim 3 wherein the apparatus includes a clutch to decouple the second drum from the rotary drive when the first cable is pulled to retrieve the pumping means.

17. The system of claim 4 including indicator means responsive to said signal to provide a substantially continuous indication of said fluid level in the well bore, and manually controllable means at the well head to change the level of reciprocation of said pumping means in the well without interrupting said reciprocation.

18. The system of claim 1 including manually controllable means at the well head to change the level of reciprocation of said pumping means in the well without interrupting said reciprocation.

19. The system of claim 18 including said cable and pumping means in the well, and the cable including multiple sections having releasable end-to-end coupling.

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