United States Patent [19]

Grable

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[54] **WELL PUMPING CONTROL**

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[52] **U.S. Cl.** **74/590,** 254/175.5, 254/178

[51] **Int. Cl.** **G05g 1/00**

[58] **Field of Search** 74/590; 254/175.5, 178

[56] **References Cited**

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[57] **ABSTRACT**

A vertically reciprocable well pump is adjustably counterbalanced at the well head by adding metallic weights to a holder moving up and down, or removing weights from the holder. The pump may comprise a walking beam to which an adjustable counterbalancing assembly is connected at the side of the beam pivot opposite the horsehead; and the counterbalancing assembly may extend underground.

15 Claims, 3 Drawing Figures

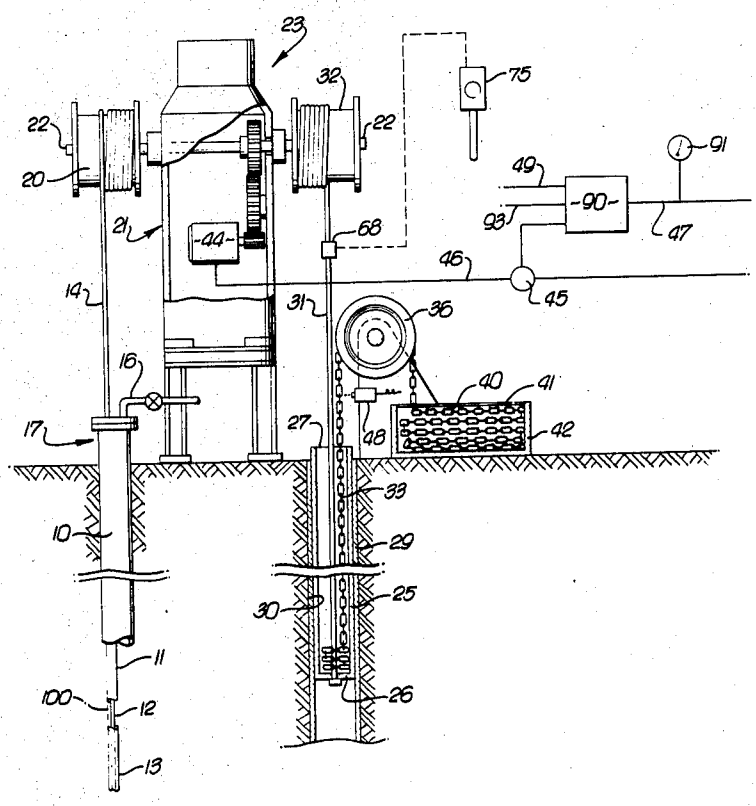


FIG. 1.

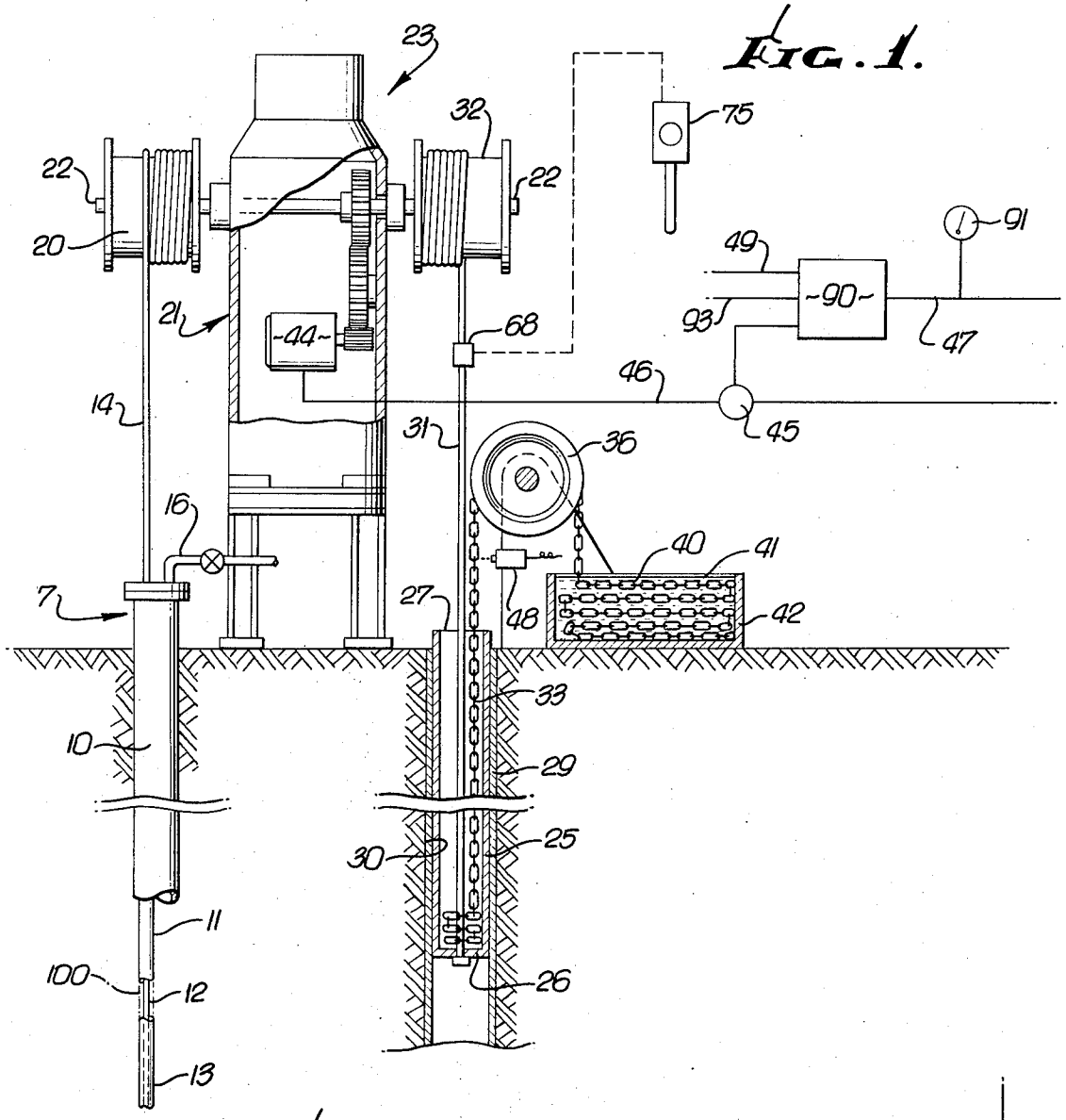

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FIG. 2.

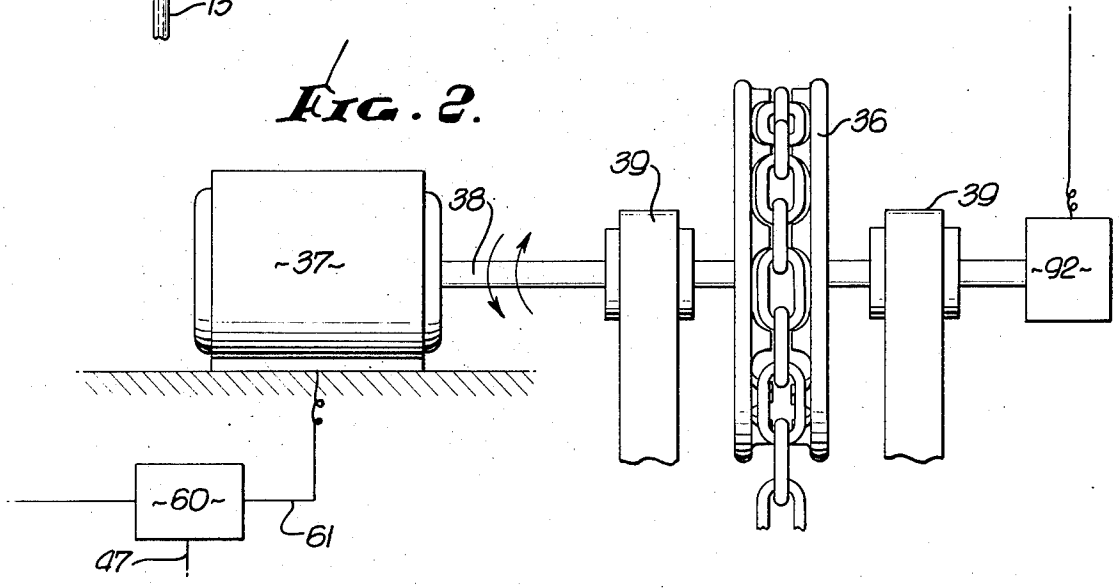
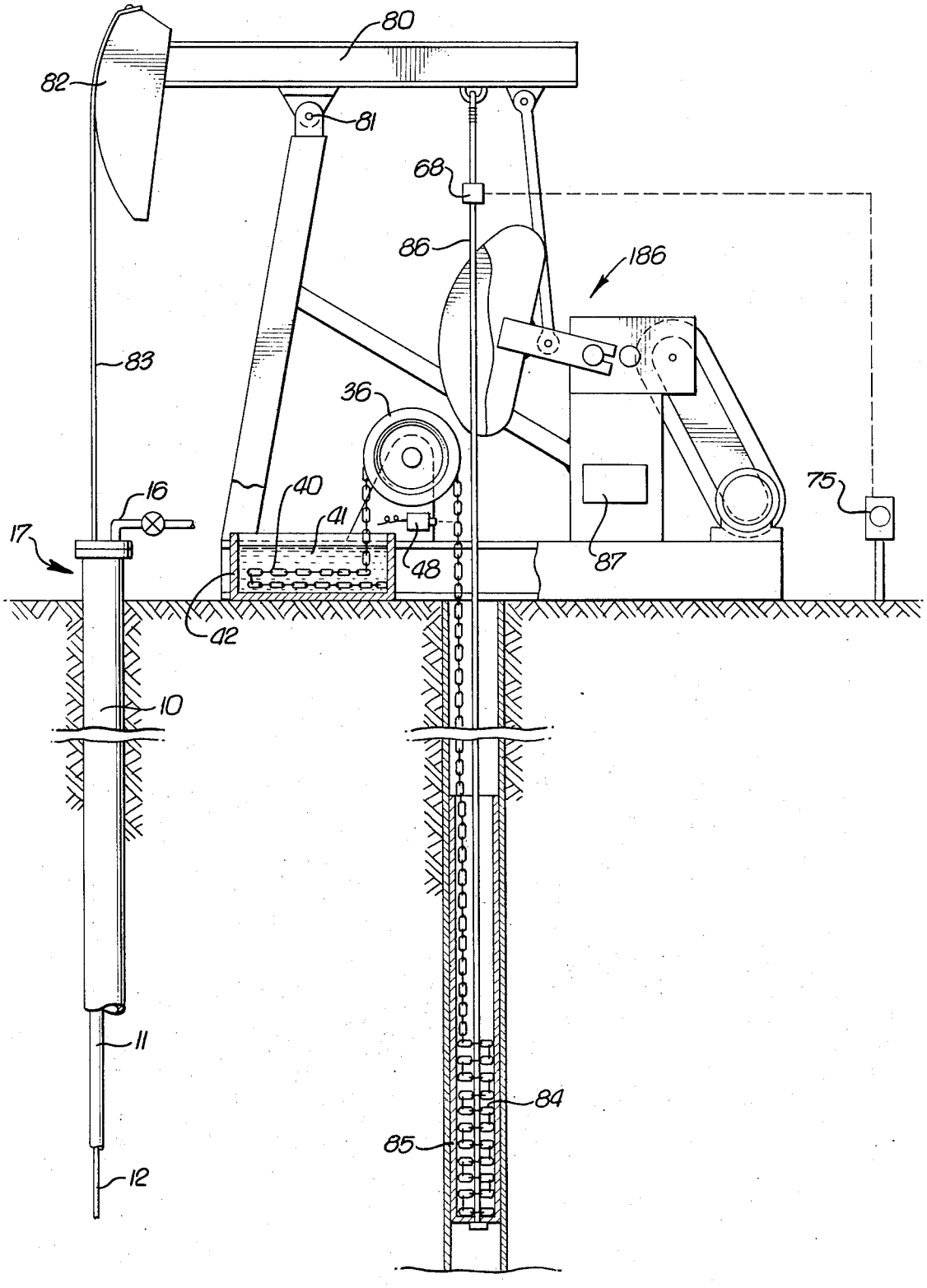

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FIG. 3.



WELL PUMPING CONTROL

BACKGROUND OF THE INVENTION

This invention relates generally to pumping of wells such as oil wells; more particularly, it concerns the counterbalancing of loads imposed by the down hole pump, rod string and fluid being elevated.

Oil production engineers everywhere are aware that the machinery being used by the oil producing industry to raise fluid from the well bore to the surface is far from being efficient, and the cost of raising a barrel of fluid to the surface is a factor they all have to reckon with. An efficient pumping operation is one that has the proper size surface lifting machinery and power source along with the right size down hole pump and the right tubing and rod string to keep the fluid pumped down to the pump shoe depth, the fluid column and the rod string counterbalanced at the surface to effect a minimum of power consumption. This type of operation is almost impossible to accomplish with the surface lifting machinery that is currently being used on many thousands of wells, unless there is a constant reading on the depth of the fluid in the well bore and a constant changing of counter balances on the units and constant changes of the strokes per minute, all of which changes are extremely difficult or too costly to implement.

It would be safe to say there are no 100 percent efficient pumping operations with beam type, counterbalanced pumping units, the reasons being the following:

If a well counterbalanced polish rod load is raising fluid from the pump shoe depth and it is not pounding fluid and the bottom hole pump is operating at 100 percent efficiency, the operation would be efficient until the first pump wear would start. A bottom hole pump is subject to wear from the first stroke it makes, so that after a few strokes the pump starts to lose some of its efficiency. Fluid in the well bore will start to accumulate over the pump, decreasing efficiency; and to capture the fluid over the pump the counterbalanced unit must be speeded up in its number of strokes per minute, or the stroke must be lengthened. If the power source is a combustion engine, speeding up the unit is quite simple; however if the power source is electrical, a lengthy operation of changing the pulleys on the electric motor is required. If the well is a large volume producer, 4 or 5 hours down time will cause fluid accumulation over the pump that may require many days and even weeks in order to pull the fluid down to the pump shoe level. In the meantime, the pumping operation is out of balance and causing excessive power consumption and useless wear and tear on surface and down hole equipment. this description would characterize an under pumping operation.

In order to overcome the above mentioned problem, some production men go to oversized surface and down hole equipment that has the capacity of keeping the fluid pumped down to the shoe depth at all times. This type of operation will recover the fluid; however, there can be no greater damaging force to surface and down hole equipment than over pumping a well. Raising a column of fluid along with the weight of a rod string and dropping it back on a void or a semi-void is the direct cause many surface and down hole equipment failures. For an example, if the polish rod load weighs 10,000 lbs. and the unit is making 10 strokes a minute, in a year's time this load is dropped back on the tubing

string 5,256,000 times. Tubing, rod strings, down hole pumps, and surface machinery pay a big price for this type of pumping operation as well as oil cleaning chemical costs to demulsify the fluid pumped from the well. There can be little doubt that this type of over pumping operation is the cause of rod wear and fatigue tubing wear and collar leaks, excessive wear especially to balls and seats in the bottom hole pump, and it is safe to state that if a fluid log reading shows over a long period of time that the fluid is at the shoe, the well is being over pumped.

Efforts have been made to overcome the above problems through provision of counterbalance arrangements employing fluid such as water in a traveling reservoir. While such efforts have achieved success, certain disadvantages remain, such as the size of the required reservoir, and the problem of freezing of water in cold climates.

SUMMARY OF THE INVENTION

It is a major object of the invention to provide method and apparatus overcoming all of the above referred to problems and disadvantages. Basically, the method of effecting counterbalance includes the step of controllably imposing metallic weight, such as chain weight for example, in counterbalancing relation to the load imposed on the drive apparatus at the surface by the sub-surface pump, rod string and column of fluid being elevated. Such operation is contemplated after the fluid level in the well has been pumped down to a desired range within which counterbalance control is optimized in relation to well production.

Further, and in its apparatus aspect, the invention employs a holder connected with the drive apparatus to be moved upwardly and downwardly as the sub-surface pump moves downwardly and upwardly; and means is provided to adjust imposition on the holder of a quantity of counterbalancing weights, as for example chain links, in compensating relation to the sub-surface load to be lifted and lowered by the drive apparatus.

In addition, the adjusting means may include a controller to sense an overload condition arising when the counterbalancing effect is either insufficient or excessive; and the controller may have an output connected with a reversable rotary drive for a chain advancing sheave to effect sheave rotation in one direction to advance chain onto the holder when the controller senses insufficient counterbalancing, and to effect sheave rotation in the opposite direction to remove chain from the holder when the controller senses excessive counterbalancing.

An additional object is to provide an underground counterbalancing assembly with a walking beam pump means.

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

DRAWING DESCRIPTION

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

FIG. 2 is an elevation showing a chain drive; and

FIG. 3 is an elevation showing another installation of the invention.

DETAILED DESCRIPTION

Referring to FIG. 1, the typical oil well illustrated has outer casing 10 and production tubing 11 extending therein. Carried within the lower extent of the tubing 11 is a pump means 13 which is vertically reciprocated in response to up and down travel of the cable 14 and rod string 12. The pump may comprise a swab or piston operable to elevate a column of production fluid toward flow line 16 extending from the casing head 17. Cable 14 extends upwardly of the casing head to spool on winding drum 20 driven alternately in opposite directions by drive means such as beam type pumping unit gear box 21, with output shaft 22. Elements 20–22 may be considered as one form of apparatus 23 at the well head to raise and lower the pump means in the well. The weight of the pump means 13, rod string 12, cable 14 and the column of fluid (designated by broken lines 100) defines the load to be lifted by that apparatus.

In accordance with the invention, a counterbalancing assembly is operatively connected with the well head apparatus 23, and includes a holder (as for example at 25) positioned to be moved upwardly and downwardly as the pumping means is moved downwardly and upwardly respectively, in the well; further, means is provided to adjust the imposition on the holder of a quantity of counterbalancing metallic weights in compensating relation to the disclosed load to be lifted by apparatus 23.

In the example, the holder 25 may have the form of a metal weight receiving tube with a closed bottom 26 and an open top 27. The tube is accomodated for vertical travel within casing 29 set in a rat hole 30 drilled in the earth to a depth sufficient to permit maximum travel corresponding to selected ranges for the well pump. See in this regard U.S. Pat. No. 3,516,762.

Weight holding tube 25 is connected by cable 31 with the drive 21 as via a drum 32 also connected with shaft 22, the direction of spooling of cable 31 on the drum 32 being opposite to that of cable 14 on drum 20. The quantity of chain 33 displaced into the holder tube 25 to be supported by that tube may be adjusted in weight compensating relation to variations in the load to be lifted by cable 14, such adjustment being carried out manually, or by mechanism to be described.

Extending the description to FIG. 2, the chain running mechanism includes a chain driving sheave 36, and a reversible rotary drive comprising motor 37 and drive shaft 38 interconnecting the motor and sheave. Suitable bearings 39 support the sheave, as shown. Supply chain is seen at 40 in FIG. 1, and may be immersed in oil or other liquid 41 in container 42 so as to coat the chain with an insulative film preventing spark generation when the chain strikes the tube 25 or other structure.

The means to adjust the chain weight imposition on the holder tube 25 may also include a controller to sense an overload condition arising when the counterbalancing effect of the assembly is either insufficient or excessive. For example, when motor 44 which drives reduction gearing in gear box unit 21 is subjected to overload due to imbalance between the loads exerted in drums 20 and 32, its amperage requirement increases. A sensor 45 in electrical line 46 to the motor senses the increased amperage requirement, and delivers a corresponding signal to the controller unit 90 to be compared with a pre-set input signal level at 49 resulting in an output 47 delivered to a switch 60 controlling the energization and direction of rotation of motor 37 via line or lines 61. Motor 37 effects delivery of sufficient chain to the holder 25, or chain removal from the latter, in order to remove the detected load imbalance. In this regard, a tachometer 92, or chain link counter 48, may supply a signal to the controller at 93 corresponding to the amount of chain delivered to, or removed from, the chain holder 25, in order to assure shut-down of motor 37 when balance has been restored. For manual operation, an undesirably increased amperage requirement of motor 44 may be displayed at 91, calibrated to indicate the amount of chain needed to be fed to or from the holder 25. The operator may then operate the motor 37 to advance or withdraw the correct amount of chain, as indicated by tachometer 92 or counter 48.

The output of a load cell 68 in line 31 may be fed to a meter 75 for displaying the loading transmitted by the cell. Since the system is in approximate balance, the cell output also indicates the load transmitted by cable 14, and if the weight of the suspended equipment is subtracted at the device 75, the weight of the suspended column of fluid may also be delivered and displayed. Knowing the cross sectional area of the well tubing, the height of the column of well fluid may also be displayed.

Referring to FIG. 3, a walking beam well pumping unit is shown incorporating the invention. The beam 80 is pivoted at 81, and the load imposed on the horsehead 82 by cable 83 supporting the pumping unit, rod string and elevated fluid in the well is counterbalanced by the chain 84 in the holder tube 85 suspended from the walking beam by cable 86. The apparatus to oscillate the walking beam is indicated at 186, and includes a motor shown at 87, the method of control being the same as in FIGS. 1 and 2.

An hydraulic motor may be substituted for the drive motor 44 in FIG. 1, and 87 in FIG. 3, and increased fluid pressure required by the motor due to system load imbalance may be sensed for correction purposes as described above.

I claim:

1. For combination with vertically reciprocable pumping means in a well, a system comprising
   a. apparatus at the well head to raise and lower said pumping means,
   b. a counterbalancing assembly operatively connected with said apparatus and including a holder positioned to be moved upwardly and downwardly as the pumping means is moved downwardly and upwardly respectively in the well, and
   c. means to adjust imposition on the holder of a quantity of counterbalancing metallic weights in compensating relation to variations in the load to be lifted by said apparatus, said means comprising mechanism to feed the weights onto and off the holder independently of movement of the holder.

2. The system of claim 1 including said quantity of metallic weights carried by the holder.

3. The system of claim 2 wherein said weights are defined by interconnected chain links.

4. For combination with vertically reciprocable pumping means in a well, a system comprising
   a. apparatus at the well head to raise and lower said pumping means,

b. a counterbalancing assembly operatively connected with said apparatus and including a holder positioned to be moved upwardly and downwardly as the pumping means is moved downwardly and upwardly respectively in the well, and

c. means to adjust imposition on the holder of a quantity of counterbalancing metallic weights in compensating relation to variations in the load to be lifted by said apparatus, comprising mechanism to feed chain onto and off the holder.

5. The system of claim **4** wherein said mechanism comprises a chain driving sheave at the well head and a reversible rotary drive operatively connected with said sheave.

6. The system of claim **1** including said pumping means in the well.

7. The system of claim **6** wherein said apparatus includes a drum at the well head, and including cable spooled on the drum for supporting said pumping means in the well.

8. The system of claim **6** wherein said apparatus includes a walking beam at the well head.

9. The system of claim **5** wherein said means includes a controller to sense an overload condition arising when the counterbalancing effect of said assembly is either insufficient or excessive.

10. The system of claim **9** wherein the controller has an output connected with said reversible rotary drive to effect rotation thereof in one direction to advance chain onto the holder when the controller senses insufficient counterbalancing by said assembly, and to effect rotation thereof in the opposite direction to withdraw chain from the holder when the controller senses excessive counterbalancing by said assembly.

11. The system of claim **10** wherein the controller includes a chain link counter.

12. The system of claim **4** including the chain which is coated with electrically insulative material.

13. In the operation of apparatus at a well head to reciprocate a pump in and lengthwise of the well, thereby to lift well fluid in the well, said apparatus including an electric drive, and wherein the load imposed on said apparatus is to be counterbalanced by metallic weight imposed on a reciprocating holder, there being mechanism to feed weight onto and off the holder, the steps that comprise,

a. sensing changing amperage requirements of the drive, and

b. operating said mechanism in response to said sensing to feed said weight onto and off the holder at the well head in counterbalancing relation to changes in said imposed load.

14. The method of claim **13** wherein said weight consists of metallic chain and said last step is carried out by controllin the supply of metallic chain to effect the counterbalance.

15. For combination with a vertically reciprocable pumping means in a well, a system comprising

a. apparatus at the well head to raise and lower said pumping means, said apparatus including a walking beam having a pivot and structure at one side of the pivot to receive weight imposed by the pumping means.

b. a counterbalancing assembly operatively connected with the beam at the opposite side of said pivot, said assembly including a vertically reciprocating weigh holder extending underground, and

c. means to adjust imposition on the holder of counterbalancing weight in compensating relation to variations in the load to be lifted by said apparatus, said means comprising mechanism to feed weight onto and off the holder independently of vertical reciprocation of the holder.

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