Oct. 18, 1966 R. H. DOBBS 3,279,266

OIL WELL PUMPING APPARATUS HAVING IMPROVED COUNTERBALANCE MEANS

Filed Feb. 21, 1964 3 Sheets-Sheet 1

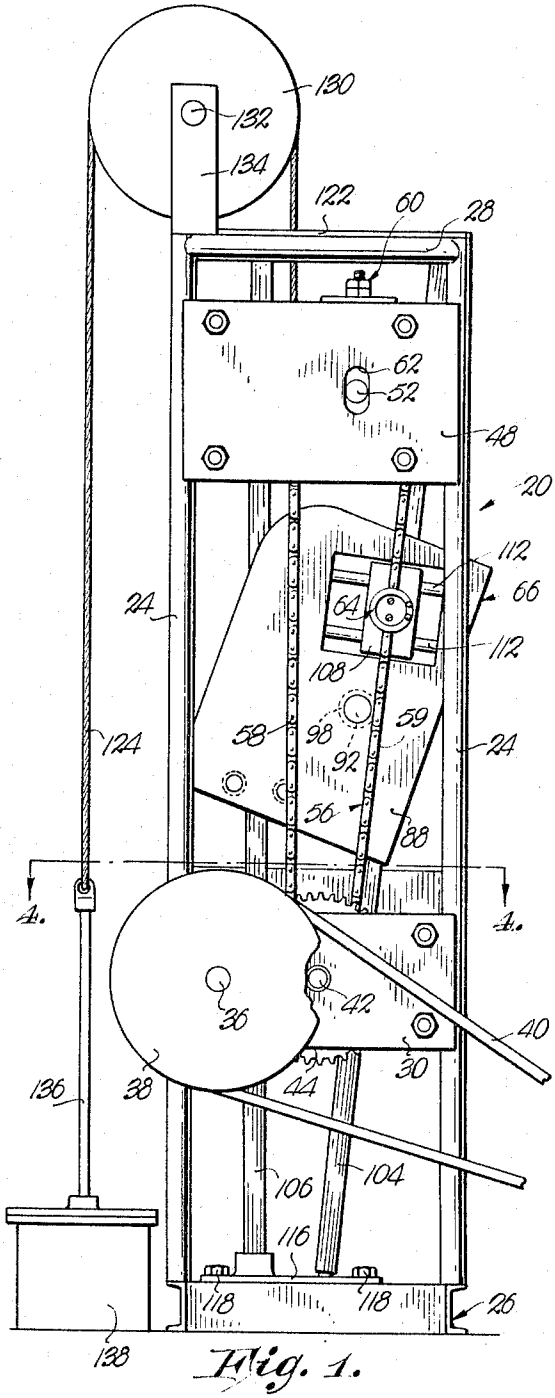


Fig. 1.

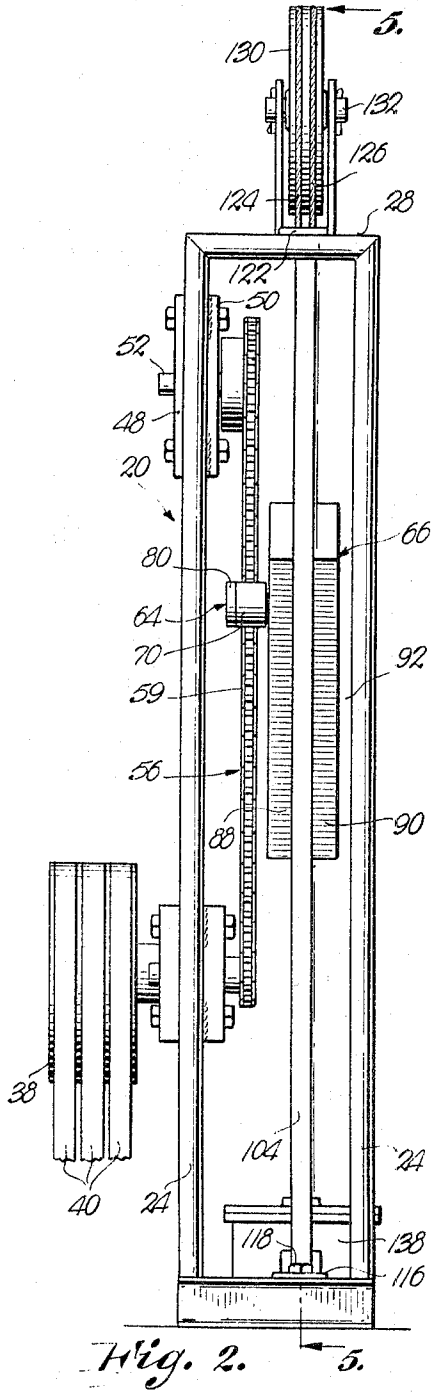


Fig. 2.

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OIL WELL PUMPING APPARATUS HAVING IMPROVED COUNTERBALANCE MEANS

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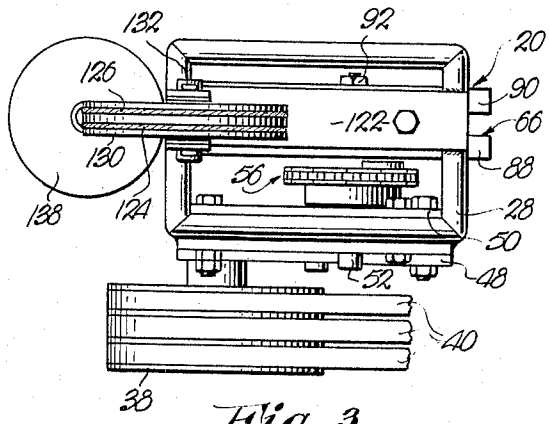


Fig. 3.

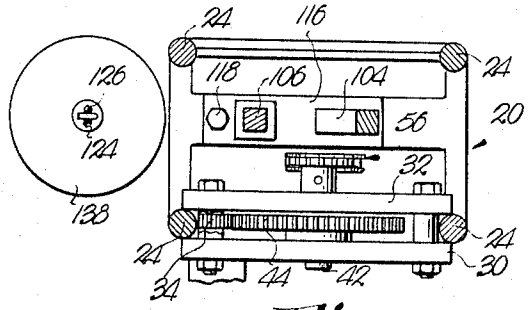


Fig. 4.

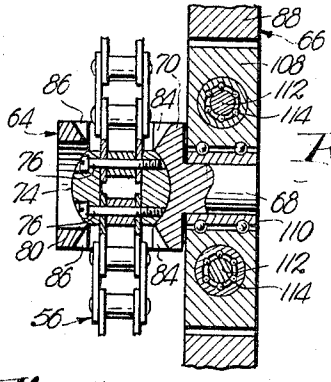
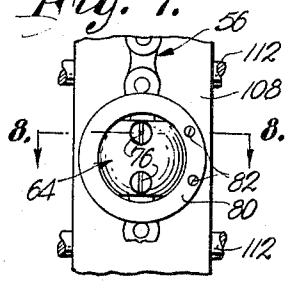


Fig. 6.

Fig. 7.



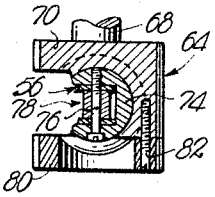
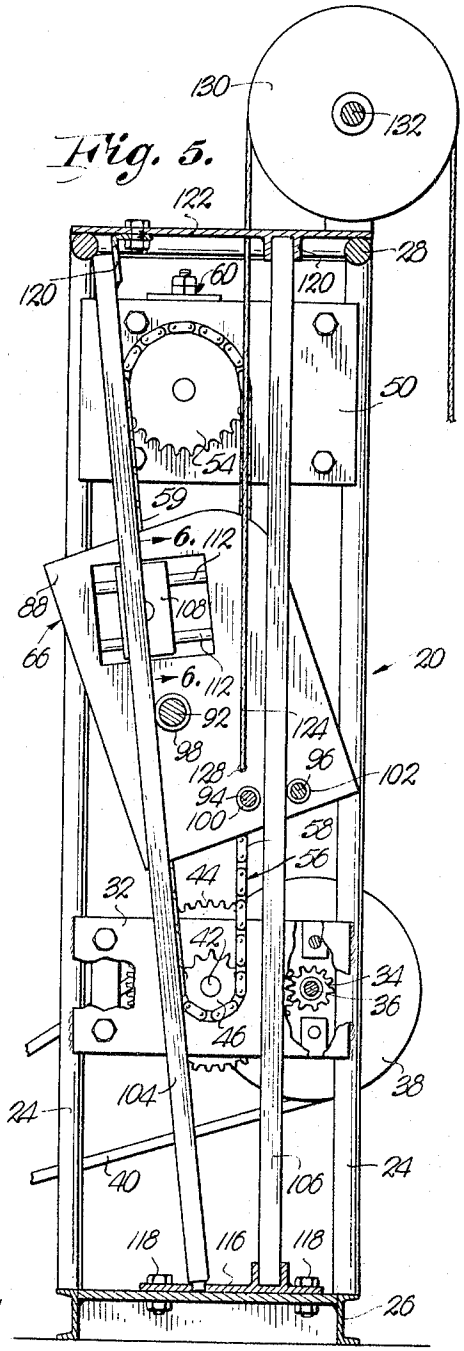


Fig. 8.

Fig. 5.



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OIL WELL PUMPING APPARATUS HAVING IMPROVED COUNTERBALANCE MEANS

Filed Feb. 21, 1964 3 Sheets-Sheet 3

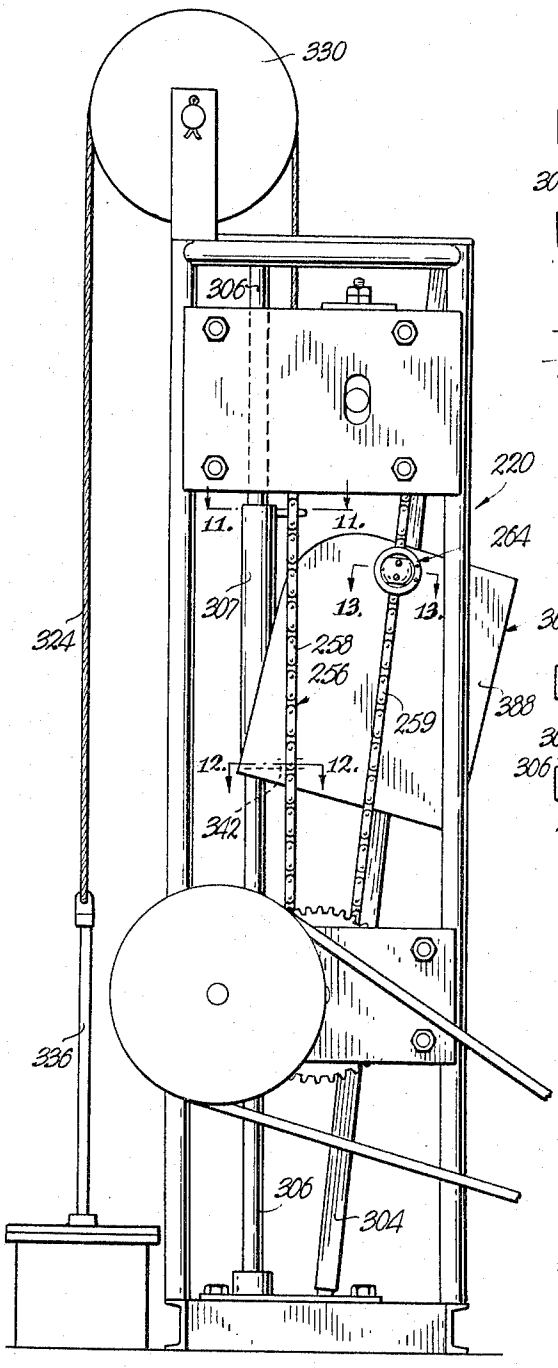


Fig. 9.

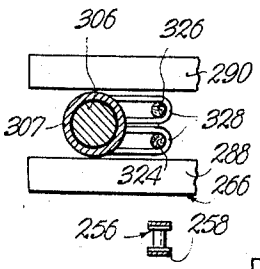


Fig. 11.

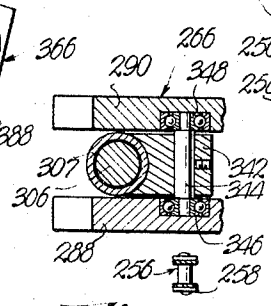


Fig. 12.

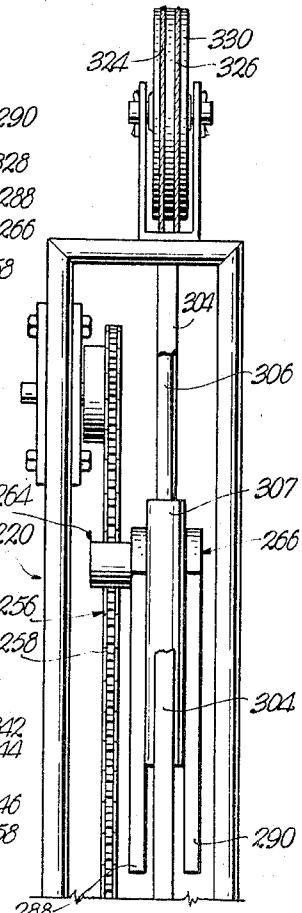


Fig. 10.

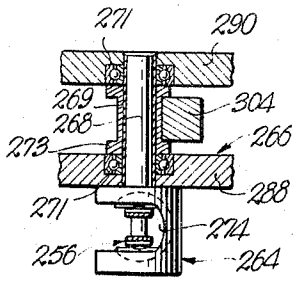


Fig. 13.

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United States Patent Office 3,279,266 Patented Oct. 18, 1966

3,279,266

OIL WELL PUMPING APPARATUS HAVING IMPROVED COUNTERBALANCE MEANS

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Filed Feb. 21, 1964, Ser. No. 346,520
12 Claims. (Cl. 74—37)

This invention relates to oil well pumping apparatus of the type utilizing a single endless, flexible drive chain for effecting the reciprocation of a polish rod.

The use of a single drive chain in conventional oil well pumping equipment generally requires a slotted crosshead intercoupling the chain and the reversible parts of the equipment, i.e., the polish rod and the counterweight, so that the movements of the parts will be reversed after the same have been shifted in one direction through a predetermined distance under the influence of the chain. Force is thus exerted on the crosshead by the chain at two different locations for up and down movements thereof and guide structure is required at the ends of the crosshead to keep it from canting inasmuch as a torque is applied to the crosshead as it is moved by the chain.

In structures having a counterweight coupled directly to the drive chain a follower on the chain engages the counterweight to cause it to move with the chain, but the follower slides laterally in the counterweight when the latter is at the upper and lower extremities of its path of travel. Thus, the counterweight itself does not traverse the actual path of travel of the chain, but merely reciprocates vertically. Guides must, therefore, be provided at the sides of the counterweight to limit its movement to a vertical path. The canting problem again arises due to the use of such a counterweight because of the torques applied thereto by the follower. Also, the polish rod cables, the line of action of the weight of the counterweight, and one stretch of the drive chain have never been, to my knowledge, horizontally aligned and parallel with each other during the lifting stroke whereby the prime mover coupled with the drive chain is utilized solely for lifting the polish rod. Therefore, without this specific alignment the prime mover coupled with the drive chain expends work for other purposes than to lift the polish rod.

The present invention provides a pump which is more efficient than conventional pumping equipment by positioning the aforesaid parts in such a way that the work expended by the prime mover is used solely for lifting the polish rod and none of the work is used to apply torques to any of the parts. By the judicious positioning of the drive chain, the polish rod cable, and the counterweight, all three of these parts are parallel to and horizontally aligned with each other during the lifting cycle of the polish rod so as to completely eliminate all torque loads on the counterweight, for instance.

The instant invention also represents an advance over the state of the art inasmuch as an inclined guide is utilized to bear some of the weight of the counterweight during the lifting of the counterweight as the polish rod descends. Thus, the guide provides a mechanical advantage for the pump and less power is expended by the prime mover as the counterweight is elevated.

It is, therefore, the primary object of the present invention to provide a pump utilizing a single, vertical disposed drive chain and a counterweight coupled directly thereto for movement therewith along its orbital path of travel. By virtue of this construction, the counterweight can be made to move into a position with respect to the chain and a polish rod cable such that the cable, the line of action of the weight of the counterweight and one vertical stretch of the drive chain are in a common vertical plane during the lifting of the polish rod. As a result, a prime mover coupled to the drive chain will be used solely for applying a lifting force to the chain and none of the work expended by the prime mover will be used for other purposes, such as to apply a torque to any of these parts.

Another object of the invention is to provide pumping apparatus of the type described which utilizes a counterweight which can be coupled to the polish rod cable in a way such that the line of action of the weight of the counterweight and the cable are coincident with each other and horizontally aligned with and parallel to a vertical stretch of the drive chain coupled to the counterweight.

Another object of the invention is to provide a pump of the aforesaid character which utilizes inclined guide structure for bearing a portion of the weight of the counterweight as the latter is shifted upwardly and as the polish rod descends so that less work is required on the part of the prime mover coupled with the drive chain during this movement of the counterweight.

Yet another object of the invention is the provision of a pump which utilizes improved ball joint-type follower means to connect a counterweight to a vertically disposed drive chain so that the counterweight may shift, at least to a limited degree, in a plurality of directions with respect to the chain if such shifting is required.

In the drawings:

FIGURE 1 is a side elevational view of the instant pumping apparatus illustrating one embodiment of the follower connecting the counterweight to a single, vertically disposed drive chain;

FIG. 2 is an end elevational view of the apparatus shown in FIG. 1;

FIG. 3 is a top plan view of the apparatus;

FIG. 4 is a view taken along line 4—4 of FIG. 1;

FIG. 5 is a view taken along line 5—5 of FIG. 2;

FIG. 6 is an enlarged, cross-sectional view taken along line 6—6 of FIG. 5;

FIG. 7 is a view of the structure of FIG. 6 looking to the right of the same;

FIG. 8 is a view taken along line 8—8 of FIG. 7;

FIG. 9 is a view similar to FIG. 1 but illustrating another embodiment of the follower coupling the counterweight to the drive chain;

FIG. 10 is an enlarged, fragmentary, end view of the apparatus of FIG. 9;

FIG. 11 is a view taken along line 11—11 of FIG. 9;

FIG. 12 is an enlarged view taken along line 12—12 of FIG. 9; and

FIG. 13 is an enlarged view taken along line 13—13 of FIG. 9.

The present invention provides oil well pumping apparatus utilizing a single endless, flexible link chain disposed in a vertical plane and having at least one stretch thereof extending along a vertical line. Means is provided for coupling a counterweight directly to one link of the chain so that the counterweight will traverse the actual path of travel of the chain rather than merely reciprocate vertically as in conventional apparatus. The line of action of the weight of the counterweight will, therefore, extend paralel to the vertical stretch of the chain as the coupling means moves therealong.

A flexible cable is adapted to be coupled to a polish rod and to extend at all times in parallelism with the vertical stretch of the chain. When the coupling means moves along the vertical stretch of the chain, the cable, the line of action of the weight of the counterweight, and the vertical stretch all lie in a common plane normal to the plane of the chain. Thus, a vertical lifting force will be applied to the cable and thereby the polish rod as the counterweight moves downwardly along said vertical stretch and, therefore, a prime mover coupled with the

drive chain will be utilized solely for lifting the polish rod.

Another significant feature of the present invention is an inclined guide disposed adjacent an inclined stretch of the chain to bear a portion of the weight of the counterweight during the time when the latter moves from its lowest point to its highest point on the chain. The load on the prime mover is thus reduced during this time interval because the guide provides a mechanical advantage for the system.

Ball joint structure is used to couple the counterweight to the drive chain to permit the counterweight to shift in a plurality of different directions when such becomes necessary.

Pumping apparatus **20** shown in FIGS. 1–8, includes an upright support **22** comprised of a number of vertically disposed legs **24** arranged in pairs, extending upwardly from a base **26** and terminating at a rectangular, open frame **28** at the top of support **22**.

A pair of plates **30** and **32** are rigid to one pair of legs **24** and are spaced apart to receive a spur gear **34** therebetween rigid to a shaft **36** coupled to a drive pulley **38** adjacent plate **30** as shown in FIG. 1. For purposes of illustration, pulley **38** is of the multiple groove type and has a number of drive belts **40** interconnecting pulley **38** with a suitable prime mover such as a gasoline powered engine.

Plates **30** and **32** also journal a horizontal shaft **42** spaced laterally from shaft **36**. A spur gear **44** having a diameter greater than gear **34** is rigid to shaft **42** and in mesh with gear **34**. A sprocket **46** rigid to the end of shaft **42** adjacent plate **32** is rotated with gear **44** under the influence of pulley **38**.

A pair of plates **48** and **50** rigid to the same pair of legs **24** support a shaft **52** which is journaled thereon and coupled to a sprocket **54** having a diameter larger than the diameter of sprocket **46** as shown in FIG. 5. An endless flexible link chain **56** is coupled with sprockets **46** and **54** for movement in a corresponding direction as pulley **38** is rotated. One stretch **58** of chain **56** is aligned with a true vertical as shown in FIGS. 1 and 5, while the other stretch **59** of chain **56** is inclined relative to stretch **58**. Means **60** is provided for releasably maintaining shaft **52** in any one of a number of fixed locations relative to and within aligned slots **62** in plates **48** and **50**. Thus, chain **56** can be made to be substantially taut and to remain so at all times.

A follower **64** directly intercouples chain **56** to a counterweight **66** so that the latter will move with the chain and traverse the orbital path of movement of one link thereof. Follower **64** includes a stub shaft **68** having a first socket member **70** integral therewith. Member **70** is provided with a concave surface **72** which is complemental to a sector of a sphere and extends outwardly from the junction of shaft **68** and member **70** in the manner shown in FIG. 8. Member **70** receives a ball **74** having the configuration of a sector of a sphere as shown in FIGS. 7 and 8. Ball **74** complementally engages surface **72** so that it forms a universal joint ball and socket connector with member **70**. Ball **74** is coupled with chain **56** by a pair of pins **76** and thus forms a link of chain **56**. Chain **56** is flexible at the junction thereof and ball **74** permits chain **56** to pass over and under sprockets **54** and **46** respectively.

A second, annular socket member **80** cooperates with member **70** to releasably retain ball **74** in place. Member **80** is coupled to first socket member **72** by a pair of screws **82** which are threaded into the outermost face of member **70** as shown in FIG. 8. Member **80** is substantially a ring, but has an inner, annular face which is complemental to ball **74** so that the latter may pivot relative to members **70** and **80** but at the same time, be retained thereby. Members **70** and **80** are recessed at areas **84** and **86** respectively, to permit ball **74** to pivot at least through a limited arc about an axis normal to shaft **68** and to the outer face of member **70**. Also, opposed regions (not shown) of member **70** adjacent areas **84** and **86** may be recessed to permit ball **74** to rotate through a limited arc about the axis of shaft **68** in either direction.

Counterweight **66** includes a pair of generally rectangular, flat plates **88** and **90** coupled together in spaced relationship by a central pin **92** and a pair of lower pins **94** and **96**. A roller **98** is mounted for rotation on pin **92** and rollers **100** and **102** are mounted on pins **94** and **96**, respectively. Roller **98** is disposed between a pair of transversely square, upright guides **104** and **106** and rollers **100** and **102** are disposed on opposed sides of guide **106** as shown in FIG. 5. Guides **104** and **106** are coupled with support **22** in a manner hereinafter described and are disposed between plates **88** and **90**. Pins **92**, **94** and **96** thus retain counterweight **66** shiftably coupled to guides **104** and **106**, and rollers **100** and **102** limit the lateral movement of counterweight **66** adjacent its lower extremity, it being clear that rollers **100** and **102** are spaced apart a distance greater than the transverse width of guide **106**.

A flat plate member **108**, as shown in FIGS. 1, 6 and 7, has a ball bearing **110** coupled with stub shaft **68** to mount follower **64** on a pair of parallel shafts **112** carried by plate **88** and disposed substantially transversely between the side margins thereof. Bearings **114** are mounted in bores through member **108** aligned with shafts **112** to permit sliding action of member **108** longitudinally of shafts **112**. When counterweight **66** moves along stretch **59**, member **108** shifts along shafts **112** until roller **98** engages and bears against the inner face of guide **104** as shown in FIG. 5. As counterweight **66** moves along stretch **58**, member **108** assumes another position relative to shafts **112**.

A rigid plate **116** is coupled by fasteners **118** to base **26** to anchor the lower extremities of guides **104** and **106** to support **22**. Brackets **120** coupled with the underside of a plate **122** rigid to frame **28** anchors the upper extremities of guides **104** and **106** to support **22**. Guide **106** extends along the vertical, whereas guide **104** is inclined with respect to the vertical as shown in FIG. 5. Means may be provided at either extremity of guide **104** to vary the inclination thereof.

A pair of flexible cables **124** and **126** pass througfh aligned holes in plate **122** and are coupled to plates **88** and **90** respectively, at locations **128** therebetween, only one of locations **128** being shown in FIG. 5. Cables **124** and **126** pass upwardly and around a sheave **130** journaled on a shaft **132** carried by a bracket **134** secured to and extending upwardly from frame **28**. Cables **124** and **126** extend downwardly from sheave **130** and are coupled with a reciprocating polish rod **136** extending into the casing **138** of an oil well adjacent which base **26** is disposed.

In operation, apparatus **20** is disposed adjacent casing **138**, belts **40** are coupled with a suitable prime mover to rotate pulley **38**, and cables **124** and **126** are secured to polish rod **136**. When the prime mover is actuated, pulley **38** rotates in a counterclockwise sense when viewing FIG. 1 to drive chain **56** so that follower **64** moves downwardly along stretch **58** and upwardly along stretch **59**. As follower **64** moves downwardly, counterweight **66** is suspended from chain **56** and the line of action of the weight of counterweight **66** is parallel with stretch **58**.

Cables **124** and **126** are maintained substantially parallel to stretch **58** at all times by rollers **100** and **102**, and since cables **124** and **126** are symmetrically disposed between plates **88** and **90**, the effective tension of cables **124** and **126** is coincident with the aforesaid line of action of the weight. Also, cables **124** and **126**, the line of action of the weight, and stretch **58**, all lie in a common vertical plane normal to the vertical plane in which stretches **58** and **59** are disposed. In view of this, effective downward force on cables **124** and **126** is truly vertical and there is no torque applied to counterweight **66**

inasmuch as the aforesaid downward force is applied along a line coincident with the line of action of the weight of counterweight **66**. Therefore, all of the work expended by the prime mover coupled to belts **40** is used to raise polish rod **136** as counterweight **66** descends along stretch **58** and no work is wasted by the needless application of a torque to counterweight **66**. Hence, no guides are required to limit counterweight **66** to a vertical path of travel, as in the prior art.

As follower **64** passes beneath sprocket **46** and then upwardly along stretch **59**, member **108** will shift longitudinally of shaft **112** and plates **88** and **90** will pivot about the point where roller **100** engages guide **106** until roller **98** engages guide **104**. A portion of the weight of counterweight **66** will then be borne by guide **104** during upward travel of counterweight **66**. This portion can be calculated from the formula:

$$M.A.=\frac{W}{F}=\frac{L}{H}$$

where:
W is the weight of counterweight **66**;
F is the weight borne by guide **104**;
L is the length of guide **104**; and
H is the height through which counterweight **66** is raised

The ratio, *W/F*, is defined as the actual mechanical advantage of the system containing counterweight **166** and guide **104**. Neglecting friction, this actual mechanical advantage of the system equals the ideal mechanical advantage thereof. Guide **104** thus provides a means for reducing the load on the prime mover as counterweight **66** is elevated.

As follower **64** passes over sprocket **54**, member **108** will shift relative to shafts **112** until plates **88** and **90** are once again directly suspended from follower **64**. When this occurs, the line of action of the weight of counterweight **66** will become vertical and move into parallelism with stretch **58**.

The use of the ball point connection of follower **64** permits limited movement of chains **56** in a plurality of directions with respect to counterweight **66**. This feature permits continued operation of apparatus **20** even though some of the parts begin to wear away and disrupt the original alignments of the parts.

A modification of the invention is illustrated in FIGS. 9–13 and comprises pumping apparatus **220** similar in all respects to apparatus **20** except for the way in which the counterweight is coupled to the chain and the polish rod cables.

An endless flexible drive chain **256** is disposed in a vertical plane and has a pair of stretches **258** and **259**, stretch **258** being vertical and stretch **259** being inclined. A follower **264**, comprising a ball and socket joint **274** similar in all respects to that described above, connects a counterweight **266** to chain **256** for movement along the orbital path thereof. Follower **264** does not shift laterally of counterweight **266** as does follower **64** of apparatus **20**. A stub shaft **268** of follower **264**, however, is longitudinally shiftable within a bushing **269** extending through both of plates **288** and **290** comprising counterweight **266** and rotatable relative thereto by virtue of bearings **271**. A roller **273** is carried on bushing **269** for rotation relative thereto and for engagement with an inclined guide **304** as counterweight **266** moves upwardly along the inclined stretch **259** of stretch **256**.

Follower **264** is secured to counterweight **266** adjacent the upper extremity thereof and centrally disposed with respect to the sides thereof so that, when follower **264** moves downwardly along vertical stretch **258** of chain **256**, the line of action of the weight of counterweight **266** will be parallel to stretch **258**.

A vertical guide **306** is cylindrical and is disposed, together with guide **304**, between plates **288** and **290**. A

sleeve **307** reciprocates along guide **306** and has a pair of loops **328** rigid to and extending laterally therefrom at the upper end thereof. Cables **324** and **326** are secured to loops **328** and pass up to, over and downwardly from a sheave **330** disposed thereabove. Cables **324** and **326** are coupled to the upper end of a polish rod **336**.

A lug **342** is rigid to and extends laterally from the lower end of sleeve **307** in alignment with loops **328**. Lug **342** has a shaft **344** extending therethrough, shaft **344** being provided with reduced ends journaled in bearings **348** in plates **288** and **290**, respectively. Counterweight **266** is thus pivotally connected to sleeve **307** and thereby coupled with cables **324** and **326**. A follower **264** moves downwardly along stretch **258**, counterweight **266** will be effectively suspended from chain **256**, and the line of action if the weight of counterweight will be parallel to stretch **258**. Also, the line of action of the weight, the effective tension of cables **324** and **326** and stretch **258** all lie in a common plane normal to the plane of chain **256**. Since plates **288** and **290** are on opposed sides of guides **304** and **306**, the line of action of the weight of counterweight **266** will be substantially coincident with the effective tension on cables **324** and **326**. There will thus be no torque applied to counterweight **266** as it descends.

The operation of apparatus **220** is the same as that of apparatus **20** except that the lower end of sleeve **307** is forced downwardly by counterweight **266** to in turn pull cables **324** and **326** downwardly. As in apparatus **20**, guide **304** bears some of the weight of counterweight **266** as the latter is elevated. By shiftably mounting shaft **268** in bushing **269**, counterweight **266** is shiftable to a limited degree laterally of the follower **264**. This allows a tolerance for wear on the various moving parts.

The diameter of the upper sprocket coupled to the drive chain is preferably made large, not only to provide an inclined stretch for the drive chain, but to assure a relatively long time lag between the time when the polish rod reaches the bottom of its path of travel and a time when it once again begins to move upwardly. Thus, the polish rod cannot be abruptly jerked upwardly so as to damage or even snap the rod string.

By eliminating torques on the counterweight, I have eliminated the canting problem and thereby the need for guides which prevent canting. My invention is, therefore, much simpler in construction and operation and hence more efficient for substantially continuous, trouble-free operation.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent is:

1. In oil well pumping apparatus including a cable attached to a vertically reciprocative polish rod, and a movable, endless drive chain having a first stretch extending along the vertical and a second stretch inclined relative to said first stretch, the combination with said chain and cable of:

a counterweight;

means connecting the counterweight to said chain for movement therewith, said cable being coupled with and extending upwardly from said counterweight, said cable and the line of action of the weight of said counterweight being substantially coplanar with said stretch of the chain as said connecting means moves along said stretch, whereby said counterweight will be utilized solely for applying a substantially rectilinear force to the cable when the connecting means moves downwardly along said stretch; and

an inclined guide adjacent the second stretch of the chain and disposed to partially support said counterweight as the connecting means moves along said second stretch.

2. In oil well pumping apparatus including a cable attached to a vertically reciprocative polish rod, and a movable, endless drive chain having a first stretch extending along the vertical and a second stretch inclinded relative to

said first stretch, the combination with said chain and cable of:

a counterweight;

universal joint means connecting the counterweight to said chain of movement therewith along the path traversed thereby and for movement relative thereto in a number of different directions, said cable being coupled with and extending upwardly from said counterweight, said cable and the line of action of the weight of said counterweight being substantially coplanar with said stretch of the chain as said connecting means moves along said stretch, whereby said counterweight will be utilized solely for applying a substantially rectilinear force to the cable when the connecting means moves downwardly along said stretch; and

an inclined guide adjacent the second stretch of the chain and disposed to partially support said counterweight as the connecting means moves along said second stretch.

3. In oil well pumping apparatus as set forth in claim 2, said inclined guide being parallel to said second stretch, said counterweight having antifriction means engaging the inclined guide when the latter supports the counterweight.

4. In oil well pumping apparatus as set forth in claim 3, said counterweight including a pair of interconnected plates, said guide being disposed between said plates, and bearing means carried by said plates for engaging the guide as the latter supports the counterweight.

5. In oil well pumping apparatus including a cable attached to a vertically reciprocative polish rod, and a movable, endless drive chain having a first stretch extending along the vertical and a second stretch inclined relative to said first stretch, the combination with said chain and cable of:

a counterweight having a shaft thereon:

a follower carried by the chain for movement therewith;

means pivotally mounting the follower on said shaft to thereby connect said counterweight with said chain for movement with the latter along its path of travel, said shaft being disposed substantially transversely of said path, said mounting means being slidable along said shaft to permit tilting of the counterweight, said cable being coupled with and extending upwardly from said counterweight, said cable, the line of action of the weight of said counterweight, and said first stretch being disposed in a common plane when said follower moves along said stretch, whereby said counterweight will be utilized solely for applying a substantially rectilinear force to the cable when the follower moves downwardly along said first stretch; and

an inclined guide adjacent the second stretch of the chain and disposed to partially support the counterweight as the latter moves upwardly in a tilted condition along said second stretch under the influence of said follower.

6. In oil well pumping apparatus as set forth in claim 5, and a vertically disposed guide adjacent said first stretch, and means coupling the counterweight to the last-mentioned guide to permit the tilting of the counterweight and

to prevent any substantial lateral movement of said counterweight as said follower moves along said first stretch.

7. In oil well pumping apparatus as set forth in claim 5, said counterweight including a pair of spaced plates, said cable being coincident with the line of action of the combined weight of said plates.

8. In oil well pumping apparatus including a cable attached to a vertically reciprocative polish rod, and a movable, endless drive chain having a first stretch extending along the vertical and a second stretch inclined relative to said first stretch, the combination with said chain and cable of:

a counterweight;

a follower carried by said chain and pivotally mounted on said counterweight to connect the latter with said chain for movement therewith along the path traversed thereby;

a sleeve;

means mounting the sleeve for vertical reciprocation, said cable being secured to and extending upwardly from said sleeve;

means pivotally coupling the counterweight to said sleeve, said cable, the line of action of the weight of said counterweight and said first stretch being disposed in a common plane when said follower moves along said first stretch, whereby said counterweight will be utilized solely for applying a substantially rectilinear force to the cable when the follower moves downwardly along said first stretch.

9. In oil well pumping apparatus as set forth in claim 8, and an inclined guide adjacent to and extending along said second stretch, said guide being disposed for partially supporting the counterweight when said follower moves along said second stretch.

10. In oil well pumping apparatus as set forth in claim 8, said cable being connected to said sleeve at the upper end thereof, said coupling means being secured to the lower end of the sleeve, the upper end of said sleeve being above the upper extremity of said counterweight.

11. In oil well pumping apparatus as set forth in claim 8, said follower having a shaft, said counterweight having a bushing slidably receiving said shaft, said sleeve mounting means being normally in engagement with said counterweight to prevent lateral movement of the latter away from said follower.

12. In oil well pumping apparatus as set forth in claim 8, said counterweight including a pair of spaced plates, said cable being coincident with the line of action of the combined weight of said plates.

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