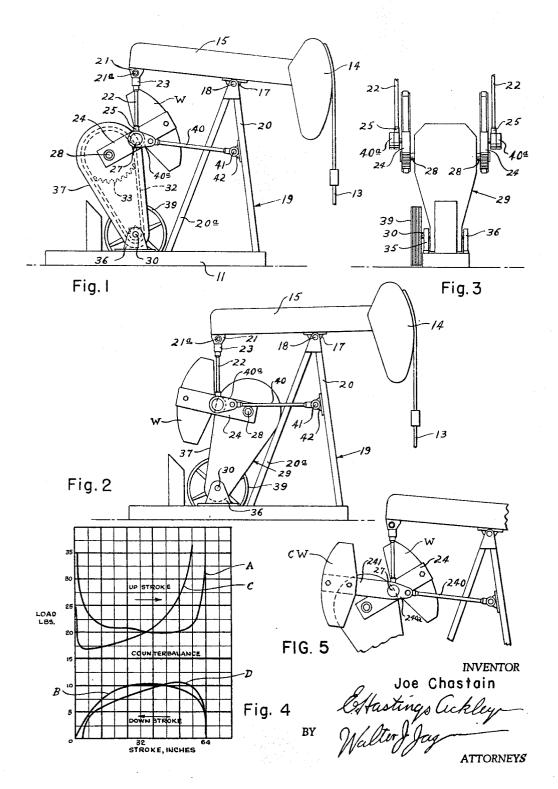
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COUNTERBALANCE MEANS

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3,277,730 COUNTERBALANCE MEANS Joe Chastain, P.O. Box 4035, Midland, Tex. Original application Nov. 13, 1961, Ser. No. 151,723, now Patent No. 3,222,940, dated Dec. 14, 1965. Divided and this application July 20, 1965, Ser. No. 482,972 4 Claims. (Cl. 74-41)

This invention relates to counterbalance means for balancing unequal loads which are moved in alternate reciprocal movements and, more particularly, to counterbalance means for reducing the peak torques on the drive shaft of a power unit which is adapted to move the unequal reciprocating loads This application is a division of my co-pending application, Serial No. 151,723, filed Novem- 15 ber 13, 1961, now Patent No. 3,222,940, patented December 14, 1965.

One object of this invention is to provide a new and improved counterbalance means for unequal reciprocating loads which are moved in reciprocation whereby the 20 peaking of torque on the drive shaft of the power unit moving such loads is reduced.

Another object of the invention is to provide a new and improved counterbalance means adapted for appli-25cation to reciprocating movement pumps and to provide load equalizing means whereby the variations in the load on the motor driving the pump are minimized during each cycle of operation of the pump.

Still another object is to provide a new and improved 30 pump, of the reciprocating movement type, having a counterbalance means which automatically varies in accordance with the reciprocating movement of the pull or lift rods of the pump to minimize the variations in the load on the motor during each cycle of operation of the pump.

A further object is to provide a reciprocating movement type pump including a pump jack and a mechanical linkage for translating the rotary motion of a drive shaft to oscillating movement of the pump jack lever wherein the driving means directly connected to the pump jack lever for oscillating the same forms one side of a parallelogram linkage which maintains the angle between the driving means and pump jack lever at approximately ninety degrees and wherein the line of force applied to one end of the pump jack lever by said driving means is parallel to the line of force applied by the opposite end of said pump jack lever to the pull or lift rods of the pump throughout the upstroke and downstroke movements of the pump jack lever, thereby effecting an efficient transfer of energy between the drive shaft and pump lift rods.

A still further object is to provide a new and improved counterbalance means adapted for application to reciprocating movement pumps wherein the effective force of a counterbalance mass or weight is varied during each cycle of operation of the pump to provide for a uniform distribution of torque on the drive shaft of the motor driving the pump.

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A still further object is to provide a new and improved counterbalance means adapted for application to reciprocating movement pumps which varies automatically in accordance with the reciprocating movement of the pull or lift rods of the pump to minimize variations in the load on the motor driving the pump and to provide for a uniform distribution of torque on the motor drive shaft during a cycle of operation of the pump without any pronounced peaking.

Additional objects and advantages of the invention will be readily apparent from the reading of the following description of a device constructed in accordance with the invention, and reference to the accompanying drawings thereof, wherein:

FIGURE 1 is a schematic fragmentary side view of a pump mechanism including a pump jack and counterbalance means therefor and showing the parts thereof in the positions they assume during the downstroke of the 10 pump;

FIGURE 2 is a schematic fragmentary side view of the mechanism of FIGURE 1 showing the parts thereof in the positions they assume during the upstroke of the pump

FIGURE 3 is a fragmentary end view of the pump mechanism of FIGURE 1;

FIGURE 4 is a graphic comparison of the load capacitor with a constant input torque of a unit with the counterbalance means of this invention and a unit with a conventional counterbalance means; and,

FIGURE 5 is a fragmentary side elevation of a modification of the mechanism of FIGURE 1.

Referring now particularly to FIGURES 1 to 3 of the drawings, a reciprocating movement pump jack mechanism 10 is shown mounted on a flat base or support 11. The pump, itself, may be of a type suitable for pumping wells, such as oil wells, whereby a piston (not shown) may be attached in the usual manner to the pull or lift rods 13 of the pump and slidably mounted in a well flow conductor or casing which communicates with a pool or reservoir of liquid to be pumped. The piston may be provided with a conventional by-pass valve or gasket which will permit flow of liquid in the conductor past the piston during the downward stroke of the lift rods and piston and which will prevent flow of liquid past the piston during the upstroke of the lift rods and piston, thereby causing the liquid to be lifted out of the reservoir during the upstrokes of the lift rods and piston.

The lift rods are attached to an arcuate support or horsehead 14 at the end of the pump jack lever or walking beam 15 from which they are suspended substantially vertically. A bracket 17 attached to the underside of the pump jack lever intermediate its ends is provided with a sleeve, saddle bearing or the like, for connection with 45 a horizontally disposed pivot bar or shaft 18 mounted in the upper ends of a support frame 19. The support frame may include a substantially vertical Samson post 20 and an angular brace 20a. The pivot bar 18 thus provides a fulcrum for the reciprocating oscillatory movements of the pump jack lever.

The end of the pump jack lever remote from the lift rods has a bracket 21 attached to its underside providing a tail-bearing connection with a horizontal pivot pin 21awhich is connected at its ends to a pair of pitman rods 22 55 by means of suitable bearing couplings 23. The pitman rods extend downwardly parallel to each other and are pivotally connected at their lower ends to a drive crank or arms 24 by means of pitman bearing couplings 25. Each of the couplings 25 receives a horizontally disposed crank pin or pivot 27 carried by its associated drive crank or arm at a point intermediate its ends. The drive cranks are mounted parallel to one another on opposite ends of a transmission driven shaft 28 of a speed reducer 29. The shaft 28 is driven by a drive shaft 30 of the speed reducer, being connected to the drive shaft by a drive chain 32, or other suitable means, such as a gear train, which

operatively connects a driven sprocket 33 on the transmission driven shaft with a drive sprocket 34 on the drive shaft. The drive shaft 30 is journalled in a pair of upright bearing supports 35 and 36 on the base 11. The gears and chain of the speed reducer 29 are enclosed within a housing or gear box case 37 having at its lower end a hollow bearing sleeve (not shown) which is journalled on the drive shaft 30 so that the speed reducer housing may pivot about the drive shaft. The drive shaft 30 has a pulley 39 rigidly secured thereon so that the drive shaft may be rotated by a suitable belt (not shown) driven by a motor (not shown), in the usual manner.

A pair of auxiliary beams or levers 40 are each attached at one end to a coupling 40a rotatably disposed on the crank pins or pivots 27. At its other end each 15 auxiliary beam is pivotally connected to the Samson post 20 by a pivot pin 41 mounted in a bearing bracket 42 secured to the Samson post preferably substantially vertically below the pivot bar 18 for the pump jack lever. As shown in FIGURES 1 and 2, the auxiliary beams 40 20 are disposed parallel with the walking beam or pump jack lever 15. The pitman rods 22, which are parallel to one another, are also disposed substantially parallel to the plane between the fulcrum pivot 18 and the pivots 41 on the Samson post 20 and to the pump lift rods 13, thus 25 describing a parallelogram linkage or framework wherein the auxiliary beams 40 constitute one side of the parallelogram and together with the pump jack lever 15 comprise a first pair of opposite sides, while the pitman rods 30 22 which are connected to the pump jack and auxiliary beams also form one side of the linkage and are maintained substantially parallel to the plane through the pivots 18 and 41 at the other side of the linkage. It will also particularly be seen that the pitman rods 22 are at all times maintained substantially parallel to the pump lift rods 13 by virtue of their connection with the pump jack lever 15 and the auxiliary beams 40 of the parallelogram linkage which swing from the stationary support 19 to maintain the pitman rods in a vertical position parallel to 40 such lift rods during the swinging reciprocating movement of the pump jack lever. The lift rods 13 move in a vertical line because of their flexible connection with the horsehead 14.

It will thus be apparent that the cranks 24, which are driven simultaneously in a rotary movement about the 45 transmission shaft 28 of the speed reducer, cause the pitman rods 22 and the end of the pump jack lever 15 to which the pitman rods are secured to move downwardly relative to the shaft 28 as the cranks are moved downwardly in a counterclockwise direction as shown in FIG- 50 URE 2. Further, it will be seen that the pitman rods and the end of the pump jack lever to which they are secured move upwardly relative to the shaft 28 as the cranks move upwardly in a counterclockwise direction as shown in FIGURE 1. However, because of the pro- 55 vision of the auxiliary beams 40 which hold the lower ends of the pitman rods, the gear box is forced to oscillate in a limited arc of pivotal movement about the shaft 30 as the cranks are rotated by the shaft 28. The speed re-60 ducer gear box is pivoted to the right, as shown in FIG-URE 2, when the cranks move downwardly; and io the left, as shown in FIGURE 1, when the cranks move upwardly. The arcuate distance of pivotal movement of the speed reducer gear box is preferably substantially equal 65 to the vertical stroke of the pumping unit lift rods.

Like the pump jack lever 15, the auxiliary beams 40 which hold the lower ends of the pitmans are also subjected to a limited pivotal movement about their respective pivots 41 by the rotation of the cranks. Thus, the pitmans are moved laterally toward and away from the Samson posts 20 during each cycle of rotation of the cranks, the amount of such lateral movement being very small, since the arcs described by the pivoted ends of the pump jack lever and the auxiliary beams are small as 75

compared to the length of the lever arms forced thereby. Consequently, the pitman rods 22 remain substantially vertical at all times and the force applied thereto is substantially longitudinal thereof at all times, and is parallel to the force applied on the horsehead end of the crank jack by the load acting on the pump lift rods.

It will be apparent that the torque on the drive shaft or power shaft caused by the weight of the lift rods and piston, and the column of fluid supported on the piston, will change during each cycle of operation of the pump. The peak torque load during the upstroke of the rods will have a large positive value because of the weight of the lift rods and the fluid supported on the piston, whereas during the downstroke the weight of the lift rods and such fluid as remains on the piston will act to produce a negative torque on the shaft. Thus, it will be noted that the greater the weight of the colmun of fluid lifted, the greater will be the peak torque on the driving shaft during the downstroke and upstroke in each cycle of operation of the pump, and the greater will be the loads imposed on the speed reducer and the motor.

To reduce these torque peaks, a counterbalance weight W is mounted on each crank arm 24 at the end thereof which is remote from the driven shaft 28 of the speed reducer, the mass of the weights and the distances from the driven shaft 28 when the same are secured to the crank arms determining the effective force exerted by such weights. It will be noted that during the upstroke or lifting movment of the pump 10, as illustrated in FIGURE 2, the crank 24 and counterweights W apply or exert a downward force on the pitman rods and therefore on the end of the walking beam of the pump jack which is remote from the lift rods. Thus, during the upstroke movement of the lift rods, the counterweights W assist the power shaft of the prime mover in lifting the lift rods 13 and the column of fluid above the piston. During the downstroke movement of the elements, as illustrated in FIGURE 1, it will be noted that the counterweights W exert their force in opposition to the swinging movement of the crank arm and resist upward movement of the pitman rods and the end of the pump jack remote from the lift rods. It will also be noted that when the counterbalance weights W are positioned as shown in FIGURE 2, during the upstroke of the pump jack, the counterweights act in conjunction with the force applied to the pitman rods by the crank arm and thus produce a larger downward force acting on the pitman rods and on the pitman rod end of the pump jack lever to provide for the application of a greater lifting force to the lift rods 13. This arrangement therefore produces a greater effective downward force applied to the pitman end of the pump jack lever during the lifting or upstroke of the pump lift rods and a lesser or smaller effective force on the pitman rod end of the pump lift rods, whereby the force applied to the pitman rod end of the pump jack lever by the gear reducer, crank arms and counterweights varies in accordance with the load applied to the horsehead end of the pump jack lever during the up and down strokes of the lift rods. It is believed obvious that the rotation of the crank arm may be in either direction, though it has been described as counter-clockwise, and that rotation in either direction would produce the same effective force applied to the pitman rod end of the pump jack lever. The mass of the gear box always impose a slight torque acting downwardly on the pitman rods except when it is in vertical alignment with such rods.

It is also to be noted that the pitmans 22 remain or are held in a position substantially parallel to the lift rods 13 throughout the rotary movement of the cranks and the pivotal movements of the pump jack lever and the auxiliary beams. Thus, the angle between the pitmans and the pump jack lever changes but slightly throughout the up and down strokes of the pump, and never varies greatly from ninety degrees. Consequently the force exerted on the pump jack lever approaches the efficiency obtainable with an ideal infinite length pitman. Of course, the counterbalance weights do not impose any torque on the pitman rods 22 when the crank arm 24 is in vertical alignment with the pitmans 22.

It will also be seen that the torque or force applied to 5 or imposed on the pivots 27 at the lower end of the pitman rods and the outer end of the auxiliary beams by the gear reducer and counterweights during each cycle of operation of the pump will always be opposite to the torque on such pivots resulting from the weight of the 10 lift rods and piston and the column of fluid supported on the pump piston. The graphic illustration in FIGURE 4 provides a comparison of the loads which can be lifted by a conventional pumping unit with the loads which can be lifted by a pumping unit having the parallelogram 15 auxiliary beam construction of this invention. In each case a constant torque is applied from the gear reducer 23 and a given counterbalance W is mounted on the crank arm. Curve A illustrates the maximum load capacity which can be lifted on the upstroke by the unit of this 20 invention having the parallelogram auxiliary beam construction, and curve B illustrates the minimum load capacities which can be lifted on the downstroke of the same structure. The maximum load capacity which can be lifted by a conventional unit is illustrated in curve C 25 showing the maximum load capacity for the upstroke of the unit. Curve D shows minimum load capacity for the downstroke. If loads are greater on the upstroke or less on the downstroke than the values indicated in the curves, then torque overload would result, with a torque applied $_{30}$ to the gear reducer in excess of the capacity of the gear reducer. It will particularly be noted that the load capacity available applied during the major portion of the movement of the crank arm and of the pump jack unit of this invention is substantially level and gives space for 35 a rectangular substantially horizontal dynamometer card without overloading the pumping unit for the parallelogram structure of this invention, as compared with the necessarily angularly disposed dynamometer card required for the standard counterbalance structure.

It is readily apparent that, if desired, a counterbalance weight CW may be applied to each of the auxiliary beams 40 of the form of the invention described and illustrated in FIGURES 1 and 2. Such a modified structure is shown in FIGURE 5, wherein the auxiliary beam 240 is pro-45 vided with an extension arm 241 extending in longitudinal alignment therewith beyond the connecting bearing 240a by means of which the auxiliary beam is connected to the pivot 27 of the crank arm 24 of the unit first described. Obviously, the counterbalance CW in this modification of 50the invention is supplemented by the crank arm weight W in reducing the torque imposed on the transmission driven shaft 28 and the drive shaft 30 by the load exerted on the horsehead end of the pump jack lever during the upstroke of the pump lift rods. 55

It will thus be seen that the counterbalance means of both forms of the invention described herein provide for a more uniform distribution of torque without producing the pronounced peaking present in conventional units. In addition, no negative torque is imposed on the drive shaft 60 and a closer balance between maximum and minimum loads is effected.

It will further be seen that new and improved pump jack structures have been disclosed herein providing a parallelogram counterbalance means minimizing variations in the load on the power unit or motor drive means of the pump, reducing the torque peaks acting on the power unit and reducing the fluctuation of the torques acting on the unit.

The foregoing description of the invention is explanatory only, and changes in the details of the construction illustrated may be made by those skilled in the art, within the scope of the appended claims, without departing from the spirit of the invention. What is claimed and desired to be secured by Letters Patent is:

1. A pump jack mechanism including: a support; a rotatable drive shaft carried by said support; a power transmission unit mounted on said drive shaft and swingable in an arc about said drive shaft; said transmission unit having a driven shaft spaced from the drive shaft and driven through said power transmission unit by said drive shaft; a housing for said transmission unit supporting said driven shaft in spaced relationship with respect to said drive shaft; a crank arm secured to said driven shaft and swingable about the axis of said driven shaft through a circular path and through an arcuate path with the housing about the axis of the drive shaft; an elongate walking beam supported intermediate its ends at a fixed point on said support for pivotal reciprocating movement about said fixed point on said support in a substantially vertical plane, one end of said walking beam being adapted to be connected to a reciprocably movable vertical load; a mechanical linkage connecting said crank arm with one lever arm portion of said walking beam for effecting reciprocating movement of said walking beam upon rotation of said drive shaft; said linkage comprising an auxiliary beam member pivotally mounted at one end on said support at a point spaced substantially vertically below said fixed point for swingable oscillation in a substantially vertical plane about such pivotal connection with said support; a connecting link member pivotally connected at one end to the end of the walking beam opposite said reciprocably movable load and at its other end to said auxiliary beam adjacent its outer swingable end, said link member connecting said elongate walking beam and said auxiliary beam parallel to each other, whereby said elongate walking beam is swingable about its pivotal mounting intermediate its ends by said auxiliary beam; connecting means operatively interconnecting the swingable end of said crank arm and said auxiliary beam, whereby the swingable end of said crank arm is connected with said elongate swingable walking beam opposite the end of said walking beam to which said load is adapted to be connected for causing reciprocating oscillating movement of said walking beam upon rotary movement of said crank arm by said drive shaft; and counterbalance weight means on said crank arm outwardly of said crank arm from said drive shaft beyond the connection of said crank arm with said auxiliary beam and swingable therewith for imposing a torque upon said linkage and said walking beam.

2. A pump jack mechanism of the character set forth in claim 1 and including: second counterbalance weight means mounted on said auxiliary beam at a point spaced outwardly from the point of pivotal connection of said crank arm with said auxiliary beam, said second counterbalance weight means coacting with said first counterbalance weight means on the crank arm for varying the load applied to said walking beam.

3. A pump jack mechanism of the character set forth in claim 1 wherein: said counterbalance means connected with said crank arm is disposed outwardly of said crank arm from the driven shaft beyond the point of connection of said crank arm with said auxiliary beam, whereby said counterbalance means imposes a weight load on said crank arm which is movable between a point outwardly of said auxiliary beam beyond the point of connection of said connecting link member with said auxiliary beam and a point in which said weight load is disposed inwardly of said auxiliary beam between the point of connection of said connecting link member with said auxiliary beam and the pivotal mounting of said auxiliary beam on said support for imposing a torque on said drive shaft or driven shaft which varies with the torque imposed on said driven shaft by said reciprocably movable load.

4. A pump jack mechanism of the character set forth in claim 3 wherein: second counterbalance weight means is mounted on said auxiliary beam at a point spaced out-75 wardly from the pivotal mounting of said auxiliary beam on said support beyond the connection of said beam with said connecting link member, said second counterbalance weight means coacting with said first counterbalance weight means of said crank arm for varying the load applied to said walking beam.

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