Sept. 24, 1946. W. H. WINEMAN 2,408,014

PUMPING APPARATUS

Filed Nov. 20, 1944 4 Sheets-Sheet 1

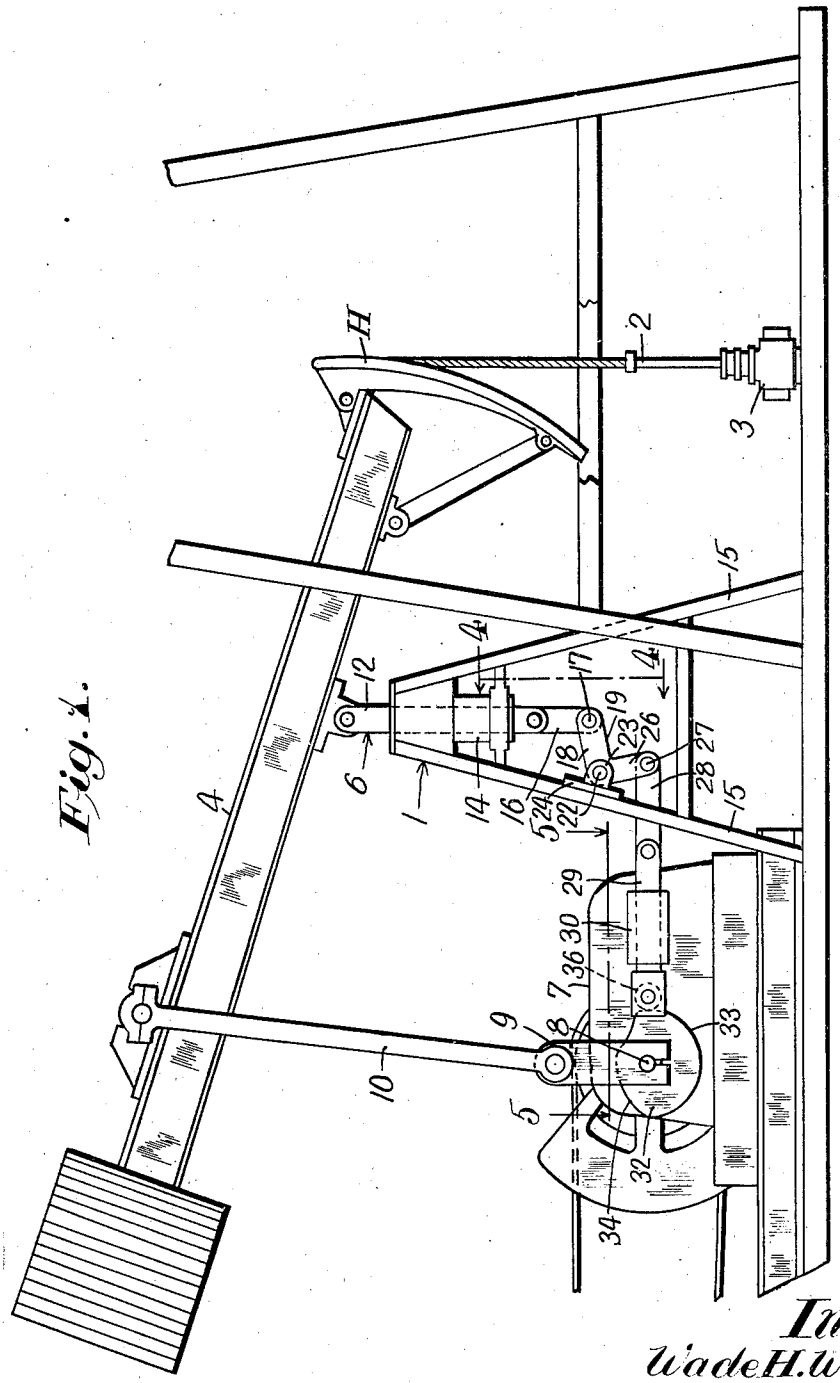


Fig. 1.

Inventor:
Wade H. Wineman.
by
Louis A. Maxson.
Atty.

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Filed Nov. 20, 1944 4 Sheets-Sheet 2

Fig. 2.

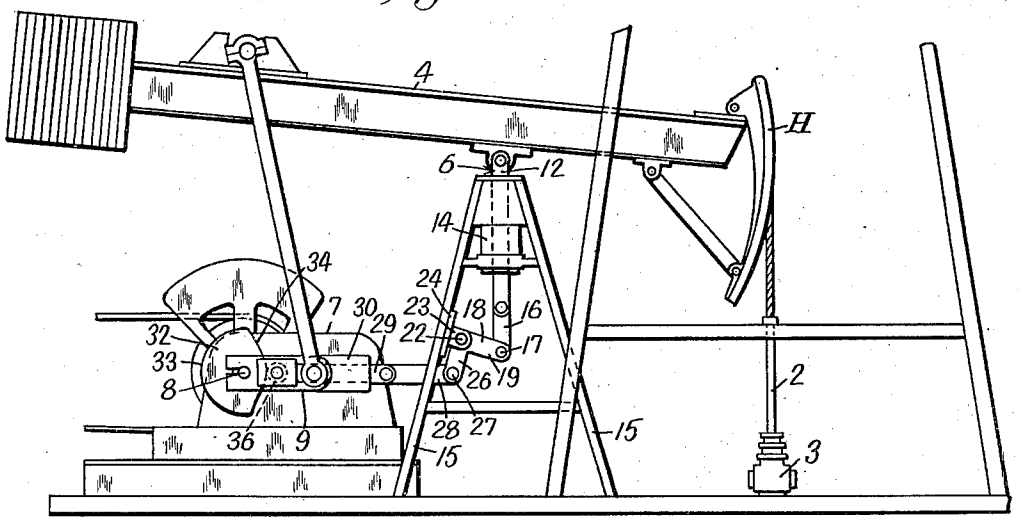
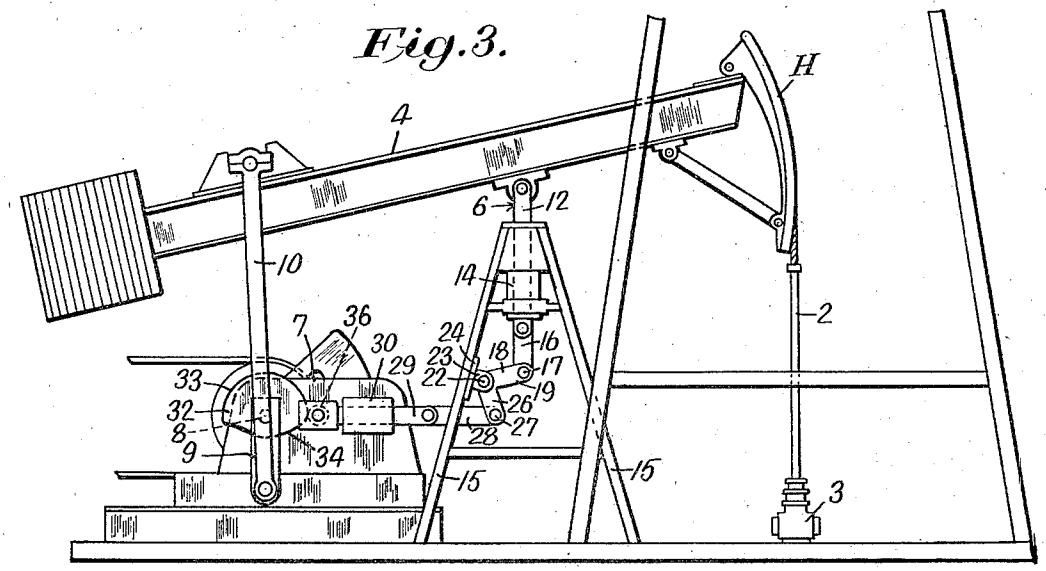


Fig. 3.



Inventor:
Wade H. Wineman.
by
Louis A. Waxon.
Atty.

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Filed Nov. 20, 1944 4 Sheets-Sheet 3

Fig. 4.

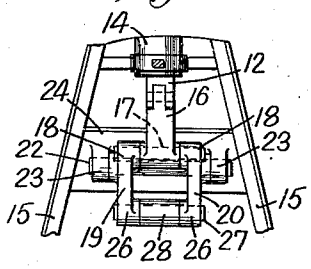


Fig. 5.

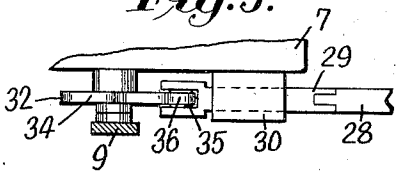


Fig. 7.

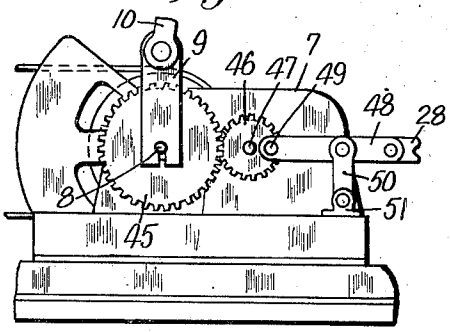


Fig. 6.

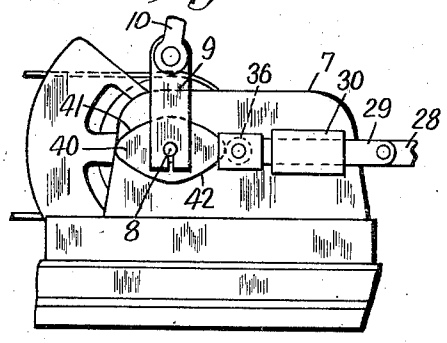


Fig. 8.

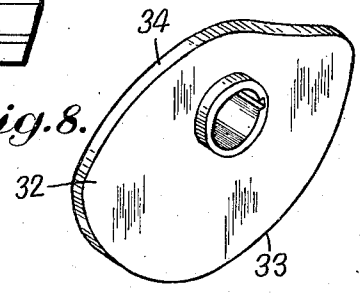
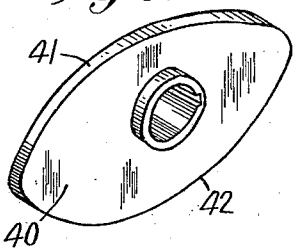


Fig. 9.



Inventor:
Wade H. Wineman.
by
Louis A. Wroten.
Atty.

Sept. 24, 1946. W. H. WINEMAN 2,408,014

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Filed Nov. 20, 1944 4 Sheets-Sheet 4

Fig. 10.

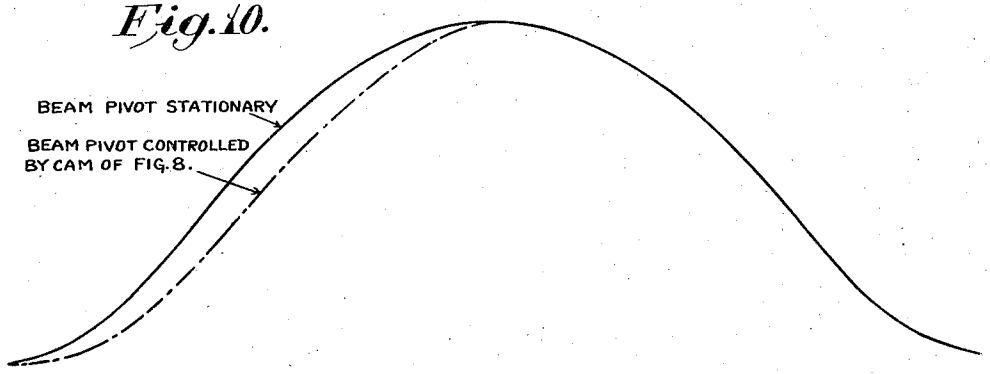


Fig. 11.

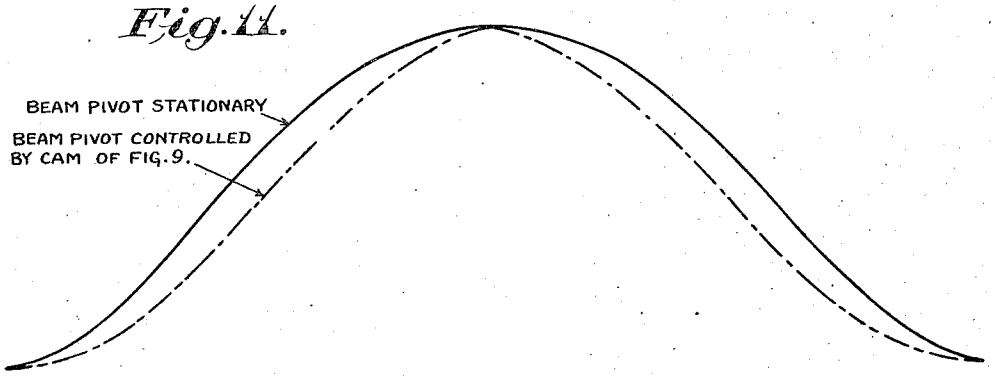
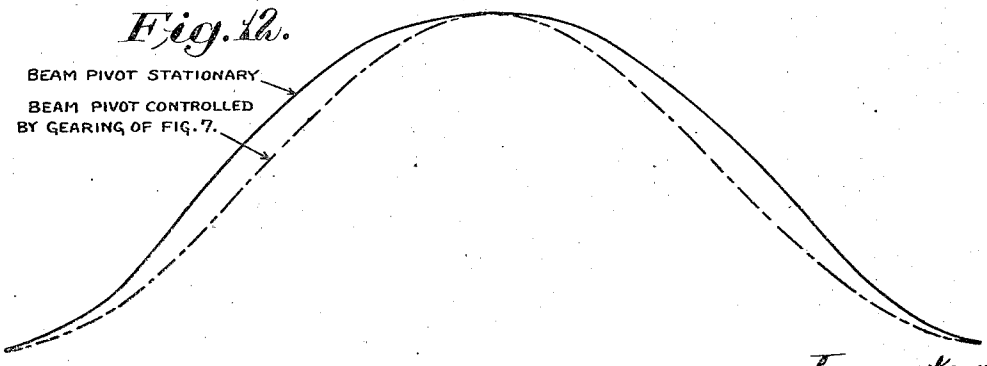


Fig. 12.



Inventor:
Wade H. Wineman.
by
Louis A. Wrytem.
Atty.

Patented Sept. 24, 1946 2,408,014

UNITED STATES PATENT OFFICE

2,408,014

PUMPING APPARATUS

Wade H. Wineman, Michigan City, Ind., assignor to Joy Manufacturing Company, a corporation of Pennsylvania

Application November 20, 1944, Serial No. 564,246

18 Claims. (Cl. 74—41)

1

My invention relates to load reducing mechanisms, and more particularly to mechanisms for reducing the peak loads on the reciprocating means for an oil well pump.

When a heavy object is caused to reciprocate, changes in the load on the reciprocating means will take place as it operates to reverse the direction of travel of the object and to increase or decrease its speed of travel. In the case of an oil well pump which is located near the bottom of the well and driven through a sucker rod connected to a reciprocating device at the surface, there will be a large increase in the load on the rod during acceleration following each reversal between its downward and upward strokes. A repeated application of a heavy load to the sucker rod causes a serious reduction in the life of the rod. If the peak loads can be reduced, less available power will be necessary and less power will be consumed in doing the necessary work.

By placing a yieldable device in the driving connections for the sucker rod, there is obtained a substantial reduction in the peak loads. The same reduction in load may be obtained by providing mechanical driving connections which permit the sucker rod to move in the same manner that it would if the yieldable device was present.

This invention contemplates the provision of mechanical means for automatically variably supporting a walking beam for an oil well pump so that the beam will be permitted to move in the same manner that it would if it was yieldably supported. It will be understood that similar mechanical means may be provided, if desired, at other points in the driving connections, such as between the power unit and the walking beam or between the walking beam and the sucker rod, to give the same results that would be obtained if some yielding means were placed at these points.

In its broad aspect the invention comprises means associated with the pivoted walking beam of a pumping mechanism, for automatically changing the location of the beam pivot in a predetermined manner to effect reduction in loads on the pumping system. From one aspect this may be accomplished by mechanism for positively raising and lowering the beam pivot as the beam is oscillated, and more specifically this may comprise mechanical connections driven through the beam oscillating mechanism. The beam is pivotally mounted on a vertically reciprocable element guided in a support and reciprocated through means driven by the mechanism which oscillates the beam. Mechanical means for predetermining the shifting of the beam pivot may be used, or liquid actuated means including a variable displacement of liquid, or a system embodying a pump and mechanically operated valve mechanism for controlling the flow of liquid with respect to the reciprocable element of a hydraulic device for positively raising and lowering the beam pivot all are within the contemplation of my invention in its broadest aspects. Also the novel mechanism may be associated with devices other than a pump where the same problem and like conditions are encountered.

2

An object of my invention is to provide an improved pumping system. Another object is to provide an improved pump actuating apparatus. Still another object is to provide an improved beam-type pumping system having means for reducing the peak loads on the sucker rod and on the pumping system. Yet another object is to provide an improved supporting structure for the beam of a beam-type pumping system. Another object is to provide an improved device for reducing the peak loads on a mechanism which operates to reciprocate a heavy object. Still another object is to provide in a mechanism for reciprocating a heavy object, improved mechanically actuated means for regulating the transmission of power to the object so that the peak loads will be substantially reduced. Yet another object is to provide in a beam-type pumping system, improved mechanically actuated means for supporting the beam in such a manner that the beam pivot is moved bodily translationally as the load varies to effect a reduction in loads on the pumping system. Other objects will appear in the course of the following description.

In the accompanying drawings there are shown several forms which my invention may assume in practice.

In these drawings:

Fig. 1 is a side elevational view of a beam-type pumping system having an illustrative form of my invention incorporated therein.

Figs. 2 and 3 are views like that of Fig. 1 but on a smaller scale and showing parts in different positions.

Fig. 4 is an elevational view taken on the plane of the line 4—4 of Fig. 1.

Fig. 5 is a fragmentary plan view taken on the plane of the line 5—5 of Fig. 1, with the crank arm shown in horizontal section.

Fig. 6 is a side elevational view of a modified power unit for delivering power through a cam mechanism which is shaped differently from that in Fig. 1.

Fig. 7 is a view like that of Fig. 6 but showing a modification embodying a gear mechanism for transmitting power from the power unit to the supporting structure for the walking beam.

Figs. 8 and 9 are perspective views of the differently shaped cam members shown in Figs. 1 and 6, respectively.

Figs. 10, 11 and 12 show the comparisons between the motion of the beam when the beam support is stationary and when the beam support is moved, respectively, by the cams of Figs. 8 and 9 and the gears of Fig. 7.

In each of the illustrative embodiments of the invention a beam-type pumping mechanism, generally designated 1, is connected to a polished rod 2 which extends through a casing head 3 of a well and connects to a sucker rod line (not shown). The pumping mechanism 1 includes a walking beam 4, a supporting structure, generally designated 6, for the walking beam, and a power unit 7 having a power shaft 8 carrying a crank arm 9 to which a pitman 10 is pivotally connected for driving the walking beam.

The supporting structure includes a member 12 reciprocably guided for axial movement in an upright position by a guide block 14 carried by supporting legs 15. The member 12 is pivotally connected at its upper end to the walking beam at the pivot point of the latter, and is pivotally connected at its lower end through a link 16 to pin 17 which is carried, as shown in Figs. 1 and 4 by arms 18 of bell crank levers 19 and 20. These bell crank levers are pivotally supported by a pin 22 which is carried by ears 23 formed on a plate 24 attached to certain of the supporting legs 15. Other arms 26 on the bell crank levers support a pin 27 which is connected through a link 28 to a rod 29, and this rod, in the forms of the invention shown in Figs. 1 and 6, is reciprocably guided for axial movement by a guideway 30 supported by the power unit 7. In this, as in the forms later to be described, it will be understood that the object has been to show the mechanics of the embodiments and not the precise proportioning of parts, and that some parts may be made heavier or lighter, as the case may be in a commercial application of the invention.

In the form of the invention shown in Figs. 1 to 5 inclusive and Fig. 8 a cam member 32 having a relatively semicircular portion 33 (it may be so shaped that the front portion of the lowering movement is made even slower than a semicircular arc would produce) and another cam portion 34 is fixed to the power shaft 8 for rotation with the latter. The edge of the cam member extends into a slot 35 formed in the adjacent end of the rod 29 and engages a roller 36 rotatably supported by the rod. The cam member 32 is positioned and fixed on the shaft 8 relative to the crank arm 9 so that the cam portion 34 begins to move into engagement with the roller 36 when the crank arm starts to pull down on the pitman 10 so as to swing the walking beam in a direction to raise the pump rods. As the cam portion moves over the roller, the rod 29 can move axially and permit the bell crank arms to swing and allow the member 12 to be first lowered; and thereafter, at a later turn in the rotation of the cam, the cam forces the rod to the right in Fig. 1 and effects a raising of the walking beam pivot. It will be seen that a moving of the pivotal support for the walking beam in the same direction that the power actuated end of the beam moves causes a retarding in the rate of elevation of the pump rods (reduces their acceleration), and a moving of the pivotal support in the direction opposite to that of the actuated end of the beam causes a speeding up in the elevation of the pump rods. The cam portion 34 has an angular extent of approximately 180 degrees and permits the member 12 to reach its lowest position after the cam member 32 has rotated approximately ninety degrees from its position shown in Fig. 1. As the cam member turns through the next ninety degrees the member 12 will be raised.

Fig. 10 shows the relationship between the motion of the beam when the pivotal support for the beam is stationary and when it is permitted to move under the control of the cam member 32. The curves are shown for one complete revolution of the cam member in a clockwise direction from the position shown in Fig. 1. It will be seen that the motion of the beam when under the control of the cam member first lags behind the motion that would take place if the beam had a stationary support and then becomes more rapid until the points on the two curves coincide at the end of 180 degrees of rotation. Since the semicircular portion of the cam member holds the support member stationary during the next 180 degrees of rotation of the cam member, there is but one curve during this portion of rotation showing the motion of the beam.

Since the sucker rods are secured to the beam through the well known cable and horsehead construction shown at H, it will be obvious that the walking beam cannot at any time push the sucker rods downwardly and that the downward movements of the rods are due to gravity alone. Under these circumstances, if it were desired to utilize a mechanism which would give like motions of the walking beam pivot both during the lowering of the rods and during the raising of them this would not result in any serious disadvantages or in the development of any stresses comparable to those during the raising of the sucker rod line, and this would permit, if desired, the utilization of cams having like surfaces in each of their opposite 180° sections, or the utilization of other forms of mechanism or cams for controlling the position of the walking beam pivot. In Figs. 6 and 9 I have shown a cam member 40 rotated by the power shaft 8 of the power unit, and the edge of this cam member engages the roller 36 for controlling the position of the member 12 in the same general manner as described with respect to the first embodiment of the invention. In this case, however, the cam member 40 has cam portions 41 and 42 which are alike, or at least generally so, and the cam portion 42, as well as the cam portion 41, is flatter at its central portion than at its end portions. The motion accomplished during raising of the sucker rod line, by reason of the presence of the cam portion 41, is substantially the same as that described in connection with the preferred embodiment of the invention first described. During the lowering of the sucker rod line, the cam portion 42 will operate to effect, during approximately the first half of the lowering portion, a repeated lowering of the walking beam pivot which will simply permit a more rapid lowering of the sucker rod line. During the second half of the lowering motion, approximately speaking, the pivot to the pump will be raised again, and this will result in the last portion of the lowering motion of the sucker rod line being slower than would be the case were the beam pivot stationary.

Fig. 11 shows a comparison of the motions that would be obtained with the device of Figs. 6 and 9

with an arrangement in which the beam pivot is fixed against all motion.

In the further modified form of the invention shown in Fig. 7, a gear **45** is connected to rotate with the power shaft **8**, and a gear **46** having half the number of teeth of the gear **45** meshes with the gear **45** and is rotatably supported on a stub shaft **47** fixed to the power unit **7**. A rod **48** is pivotally connected at one end to the link **28** and at its other end is pivotally connected to a crank pin **49** which is fixed to the gear **46** at a point spaced from the center of the latter. A link **50** is pivotally connected at one end of the rod **48** between the ends of the latter, and at its other end is pivotally connected to a bearing block **51** supported in any suitable manner by the power unit **7**. This link **50** supports the link **48** as the crank pin **49** is rotated.

With this arrangement, as shown in Fig. 12, the upward motion of the pumping end of the beam will be slower than would be the case were the beam pivot stationary, and a mode of operation very similar to that described with respect to Figs. 6 and 9 will take place. Specifically, by the time the arm **9** reaches a horizontal position 90° clockwise from that shown in Fig. 7, the crank pin **49** will be diametrically opposite the position shown in Fig. 7, with the result that the beam pivot will have been brought to its lowest position. By the time the crank arm **9** is in bottom position the beam pivot will be returned to the position which it occupies with the crank pin **49** in the position shown in Fig. 7. Again during the third quadrant of motion of the arm **9**, the beam pivot will be lowered, and again during the fourth quadrant of motion of the arm **9** the arm pivot will be raised. However, the raising and lowering of the beam pivot during the third and fourth quadrants of motion of the arm **9** will not be of material significance, while the motion accomplished during the first two quadrants will be highly beneficial.

The factor of angularity of crankshafts or their equivalents will some affect the resulting motions, but will not unduly reduce the beneficial advantages of the mechanisms shown. It is possible, if such refined motion is desired, in the forms of the invention shown in Figs. 1 to 5 and 8 and Figs. 6 and 9, to take this factor into consideration in the determination of cam contours in a manner well known to machine designers, but, for simplicity, I have not complicated the problem by altering the shapes of the cams to compensate for this effect.

In determining the contours of the cams, one desirable method of procedure is to determine the motions which actually take place when a walking beam is provided with an alleviator, so-called, such as is shown in my Patents 2,259,020 and 2,259,021. With the aid of a motion picture camera, for example, it is easily possible to determine the position occupied by the sucker rod line at all points of walking beam movement, and then by determining the instantaneous positions of the sucker rod line with respect to different angles of the arm **9**, the design of a cam which will cause the beam pivot to be shifted in position in such a manner as to cause the actual power movement of the rod line to correspond substantially with the empirically found-to-be-desired movement determined with the aid of an alleviator, is an easy matter, a smooth curve being selected, the points in which coincide as nearly as possible to the points determined by the method above mentioned. Specifically, one

might proceed as follows: There would be laid off on a horizontal line different points corresponding to different angular positions of the beam swinging arm. There would be plotted vertically relative to this line and to the points mentioned therein the actual positions occupied by a given point in the sucker rod line with the beam pivot stationary. Through these points a curve would be passed. There would then be plotted the positions found preferable for the given point in the sucker rod line, and another curve would be passed through these points. The vertical distances between the points in the two curves are what the cam has to be determined to provide. If the lever arms of the walking beam are the same length a cam will be laid out with its curvature such as to provide adjustments of the walking beam pivot one-half the vertical distances between the points in the curve, at the corresponding positions of the beam swinging crank arm. Theoretical calculation of the curve may be resorted to if preferred, but highly beneficial results will be secured by the procedure just outlined.

As a result of this invention there will be provided improved means for regulating the motion of a sucker rod line so as to minimize the stresses therein, while yet at all times, during the raising of the rod line, definitely mechanically determining its position through positive connections rather than permitting, through the use of such a device as an alleviator, lags through the variable displacement of a fluid under pressure. Obviously, other means of obtaining the desired results not illustrated in detail may fall within the scope of my invention as defined in the appended claims, and the invention, while having particular adaptability to pumping, appears to be capable of use where similar problems and similar circumstances are encountered.

While there are in this application specifically described several forms which the invention may assume in practice, it will be understood that these forms of the same are shown for purposes of illustration and that the invention may be modified and embodied in various other forms without departing from its spirit or the scope of the appended claims.

What I claim as new and desire to secure by Letters Patent is:

1. In a pump actuating mechanism, in combination, a walking beam, power actuated means operatively connected to one end of said walking beam for swinging the latter, means for connecting the other end of said walking beam to a pump, adjustable means for pivotally supporting said walking beam between its ends, and power actuated means for adjusting said supporting means so that the pivotal axis of said walking beam moves in a vertical plane in a predetermined manner during swinging of said walking beam.

2. In a pump actuating mechanism, in combination, a walking beam, power actuated means operatively connected to one end of said walking beam for swinging the latter, means for connecting the other end of said walking beam to a pump, means including an upright longitudinally reciprocable member for pivotally supporting said walking beam between its ends, and power actuated means for reciprocating said member in a predetermined manner during swinging of said walking beam.

3. In a pump actuating mechanism, in combination, a walking beam, power actuated means

operatively connected to one end of said walking beam for swinging the latter, means for connecting the other end of said walking beam to a pump, means including an upright longitudinally reciprocable member for pivotally supporting said walking beam between its ends, power actuated means for reciprocating said member in a predetermined manner during swinging of said walking beam, said last mentioned power actuated means operating to lower and then raise said member during the upward swing of the pumping end of said walking beam, and operating to hold said member stationary during the downward swing of the pumping end.

4. In a pump actuating mechanism, in combination, a walking beam, power actuated means operatively connected to one end of said walking beam for swinging the latter, means for connecting the other end of said walking beam to a pump, means including an upright longitudinally reciprocable member for pivotally supporting said walking beam between its ends, and power actuated means for reciprocating said member in a predetermined manner during swinging of said walking beam, said last mentioned power actuated means operating to lower and then raise said member equal distances during both the downward and the upward swing of the pumping end of said walking beam.

5. In a pump actuating mechanism, in combination, a walking beam, power actuated means operatively connected to one end of said walking beam for swinging the latter, means for connecting the other end of said walking beam to a pump, means including an upright longitudinally reciprocable member for pivotally supporting said walking beam between its ends, power actuated means for reciprocating said member in a predetermined manner during swinging of said walking beam, said last mentioned power actuated means operating to lower and then raise said member during the upward swing of the pumping end of said walking beam, and operating to lower again and then raise said member during the downward swing of the pumping end.

6. In a pump actuating mechanism, in combination, a walking beam, a power unit having a power shaft operatively connected to one end of said walking beam for swinging the latter, means for connecting the other end of said walking beam to a pump, means including a member movable in a vertical plane for pivotally supporting said walking beam between its ends, and means including a cam member fixed to said power shaft for moving said member in a predetermined manner during the swinging of the walking beam.

7. In a pump actuating mechanism, in combination, a walking beam, a power unit having a power shaft operatively connected to one end of said walking beam for swinging the latter, means for connecting the other end of said walking beam to a pump, means including a member movable in a vertical plane for pivotally supporting said walking beam between its ends, means including a cam member fixed to said power shaft for moving said member in a predetermined manner during the swinging of the walking beam, said last mentioned means operating to lower and then raise said member during the upward swing of the pumping end of said walking beam, and operating to hold said member stationary during the downward swing of the pumping end.

8. In a pump actuating mechanism, in combination, a walking beam, a power unit having a power shaft operatively connected to one end of said walking beam for swinging the latter, means for connecting the other end of said walking beam to a pump, means including a member movable in a vertical plane for pivotally supporting said walking beam between its ends, and means including a cam member fixed to said power shaft for moving said member in a predetermined manner during the swinging of the walking beam, said last mentioned means operating to lower and then raise said member equal distances during both the downward and the upward swing of the pumping end of said walking beam.

9. In a pump actuating mechanism, in combination, a walking beam, a power unit having a power shaft operatively connected to one end of said walking beam for swinging the latter, means for connecting the other end of said walking beam to a pump, means including a member movable in a vertical plane for pivotally supporting said walking beam between its ends, means including a cam member fixed to said power shaft for moving said member in a predetermined manner during the swinging of the walking beam, said last mentioned means operating to lower and then raise said member during the upward swing of the pumping end of said walking beam, and operating to lower again and then raise said member during the downward swing of the pumping end.

10. In a mechanism of the character described, the combination with a pivoted walking beam operatively connected to a device to be actuated, of means associated with said walking beam for positively raising and lowering the beam so that its pivotal axis moves in a vertical plane in a predetermined manner during oscillation of the beam to effect reduction in loads on the mechanism.

11. In a mechanism of the character described, the combination with a pivoted walking beam operatively connected to a device to be actuated, and mechanism for oscillating said beam, of means driven through said oscillating mechanism for mechanically positively raising and lowering the beam so that its pivotal axis moves in a vertical plane in a predetermined manner during oscillation of the beam to effect reduction in the loads on the mechanism.

12. In a mechanism of the character described, the combination with a pivoted walking beam operatively connected to a device to be actuated, of means associated with said walking beam for positively lowering the beam pivot as the end of the beam operatively connected to the device swings downwardly a predetermined distance from its uppermost position and for positively raising the beam pivot as said end continues to swing downwardly to effect reduction in the loads on the mechanism.

13. In a mechanism of the character described, the combination with a pivoted walking beam operatively connected to a device to be actuated and a support therefor, of means associated with said walking beam for positively raising and lowering the beam pivot in a predetermined manner during oscillation of the beam to effect reduction of the loads on the mechanism, said means including an element guided for vertical reciprocation on said support and on which said beam is pivotally mounted, and mechanism for positively reciprocating said element to coordinate the movement thereof with the oscillatory motion of the beam.

14. In a pump actuating mechanism, in combination, a walking beam, means for supporting

said walking beam between its ends including a vertically adjustable pivotal mounting for said beam, power actuated means operatively connected to said beam adjacent one of its ends for swinging the latter, means for connecting the other end of said walking beam to a pump, and means for mechanically lowering and then raising said pivotal mounting during the upward movement of said other end so as to effect first a reduced accelerated movement and then an increased accelerated movement of said other end while causing the overall movement of said connecting means to be the same as if the beam supporting pivot remained stationary.

15. In a pump actuating mechanism, in combination, a walking beam, means for supporting said walking beam between its ends including a vertically adjustable pivotal mounting for said beam, power actuated means operatively connected to said beam adjacent one of its ends for swinging the latter, means for connecting the other end of said walking beam to a pump, and means for mechanically lowering and then raising said pivotal mounting during the upward movement of said other end and holding said pivotal mounting stationary during the downward movement of said other end, said last mentioned means including a cam rotatable to control the position of said pivotal mounting.

16. In a pump actuating mechanism, in combination, a walking beam, means for supporting said walking beam between its ends including a vertically adjustable pivotal mounting for said beam, power actuated means operatively connected to said beam adjacent one of its ends for swinging the latter, means for connecting the other end of said walking beam to a pump, and

means for mechanically lowering and then raising said pivotal mounting during both the upward and downward movements of said other end so as to effect a varying accelerated movement of such end, said last mentioned means including a cam rotatable to control the position of said pivotal mounting and having opposite sides thereof substantially alike.

17. In a pump actuating mechanism, in combination, a walking beam, means for supporting said walking beam between its ends including a vertically adjustable pivotal mounting for said beam, power actuated means operatively connected to said beam adjacent one of its ends for swinging the latter, means for connecting the other end of said walking beam to a pump, and means for mechanically lowering and then raising said pivotal mounting during both the upward and downward movements of said other end so as to effect a varying accelerated movement of such end, said last mentioned means including gearing operating to position said pivotal mounting during each direction of movement of said other end.

18. In a pump actuating mechanism, in combination, a walking beam, a power unit having a power shaft operatively connected to one end of said walking beam for swinging the latter, means for connecting the other end of said walking beam to a pump, means including a member movable in a vertical plane for pivotally supporting said walking beam between its ends, and means including a cam member rotated upon rotation of said power shaft for moving said member in a predetermined manner during the swinging of the walking beam.

WADE H. WINEMAN.