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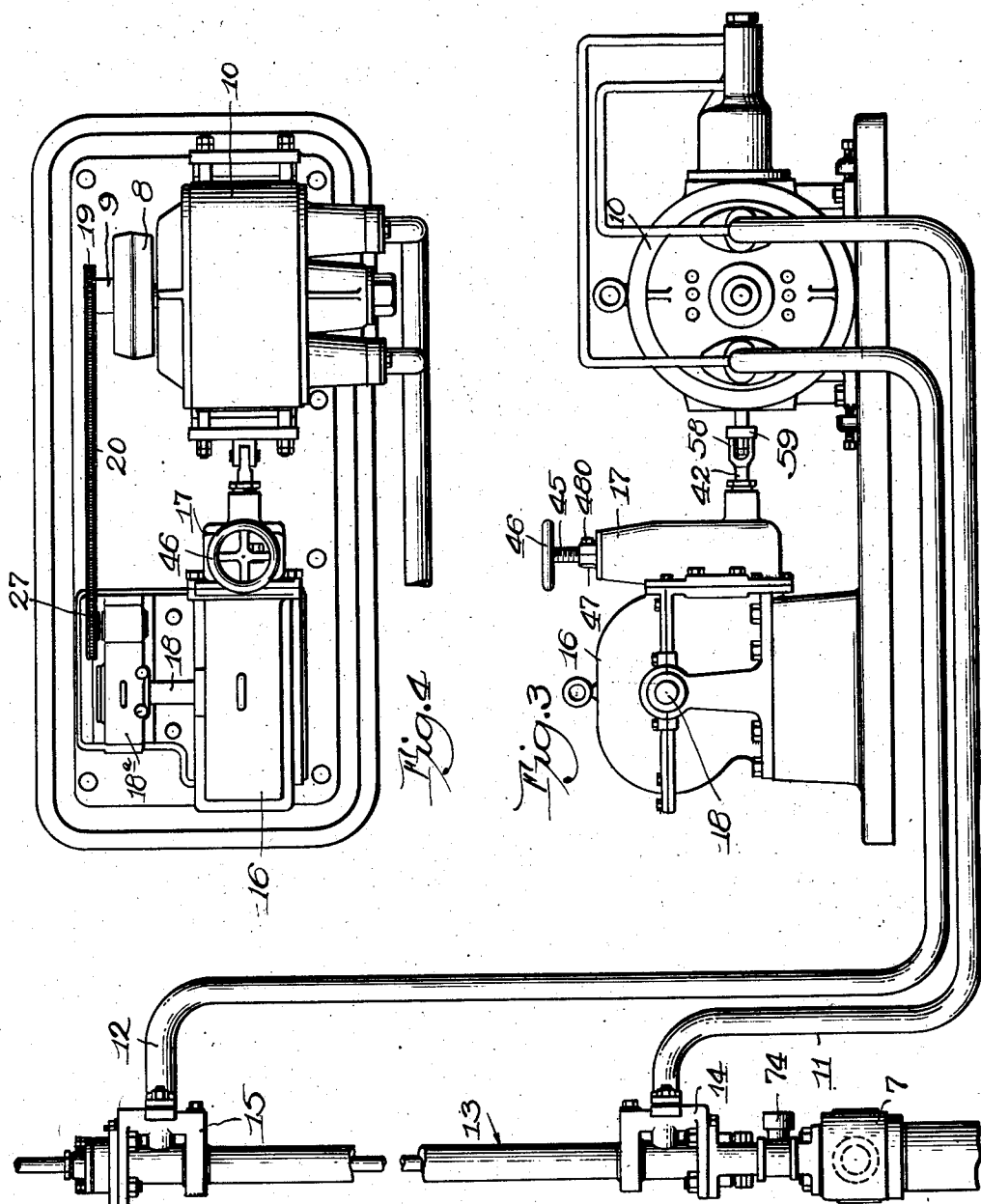
M. KAHR ET AL

2,027,104

HYDRAULIC DEVICE FOR OIL WELL PUMPING

Filed June 29, 1931

8 Sheets-Sheet 2



Witness:
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HYDRAULIC DEVICE FOR OIL WELL PUMPING

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8 Sheets-Sheet 3

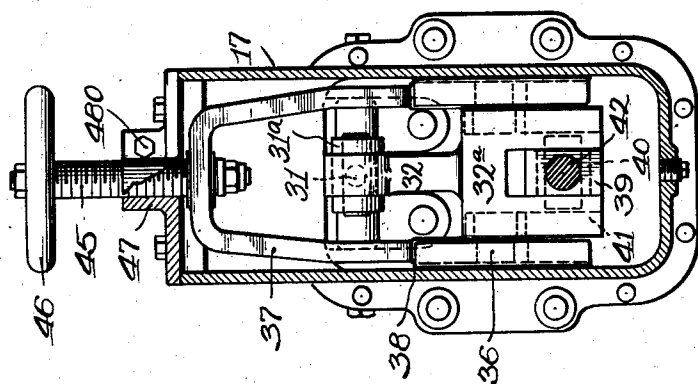


Fig. 6

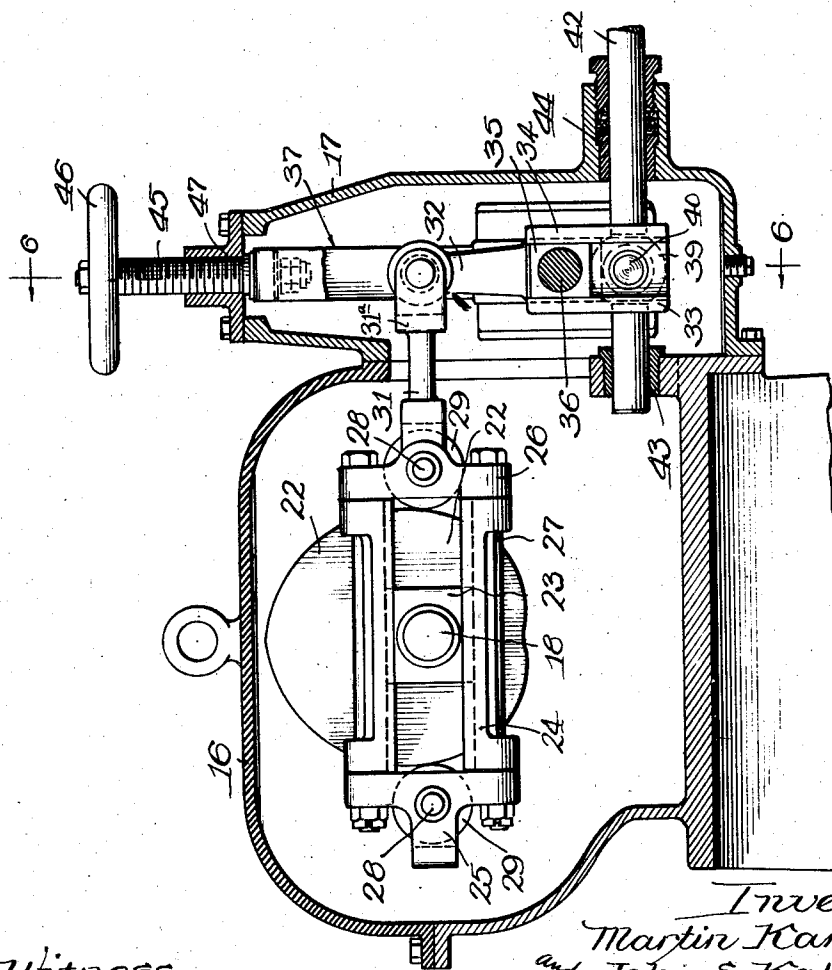


Fig. 5

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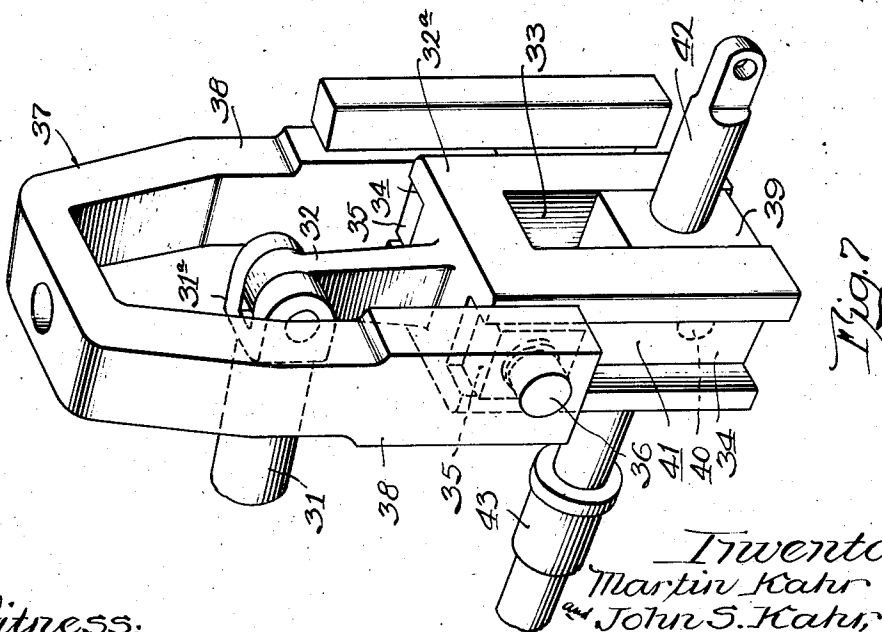
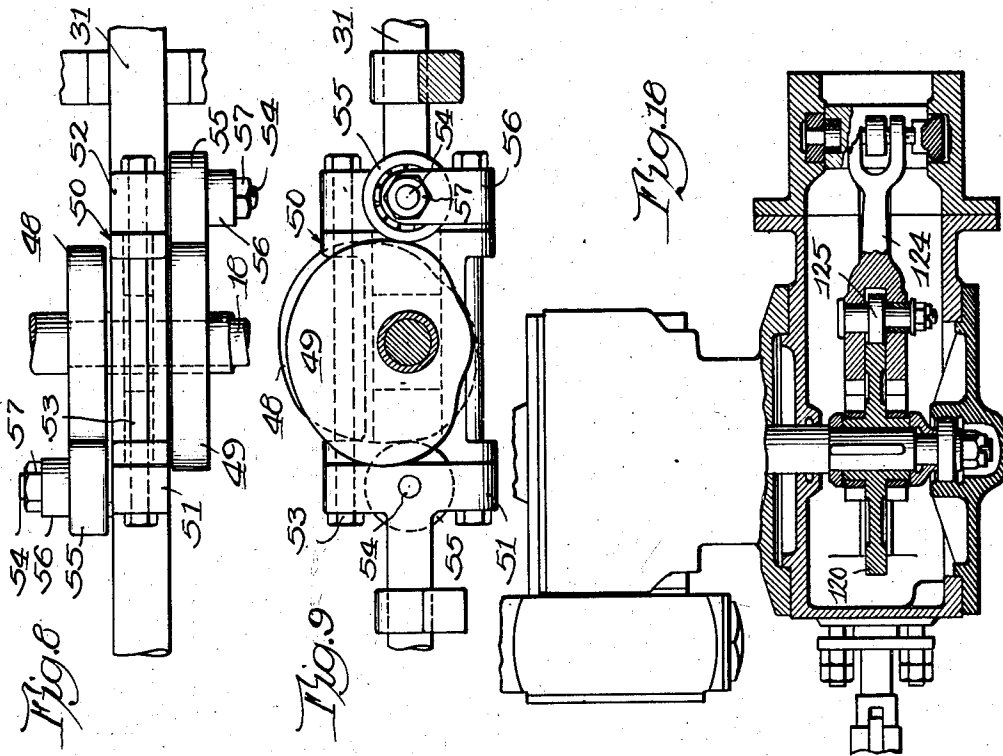
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HYDRAULIC DEVICE FOR OIL WELL PUMPING

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8 Sheets-Sheet 4



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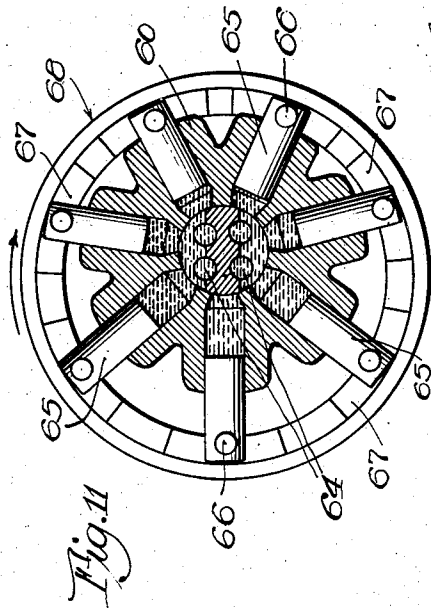
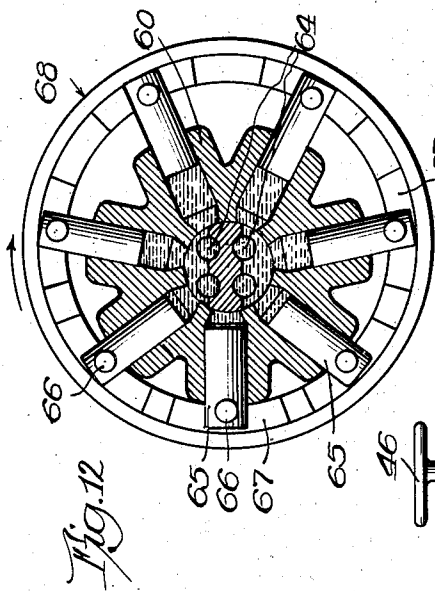
M. KAHR ET AL

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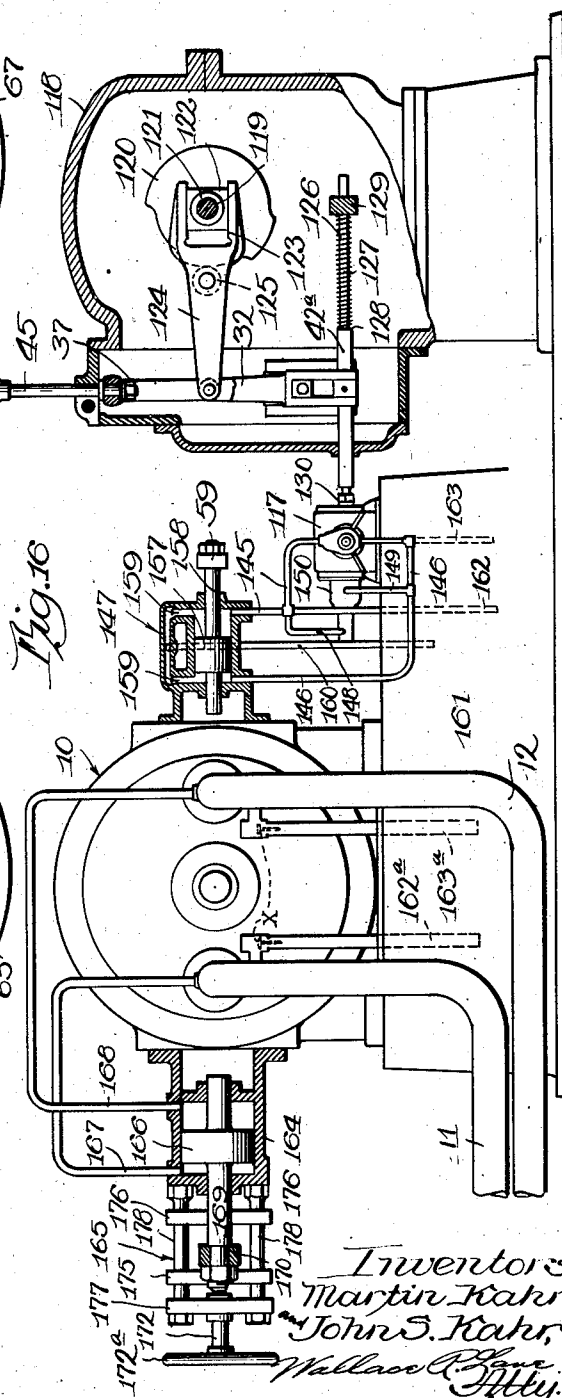
HYDRAULIC DEVICE FOR OIL WELL PUMPING

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8 Sheets-Sheet 6



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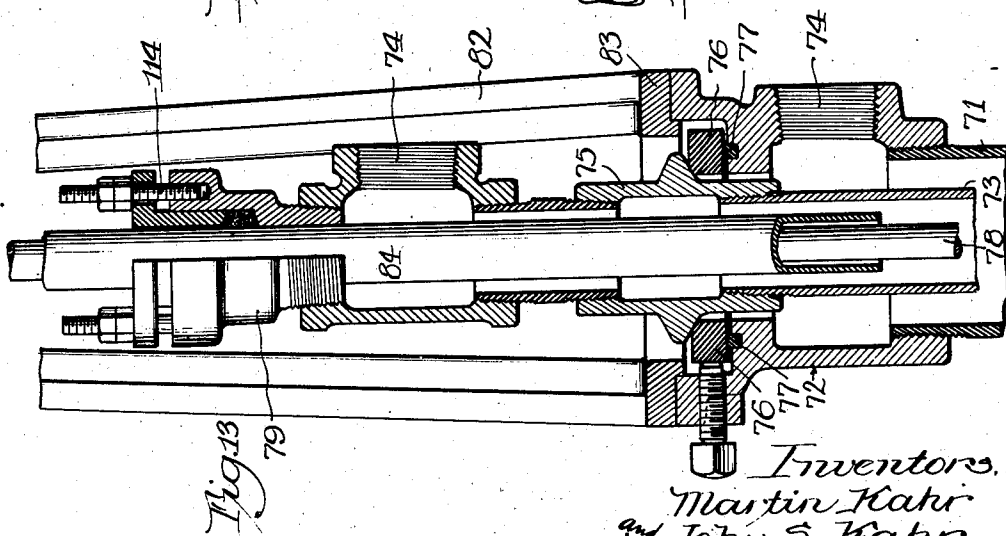
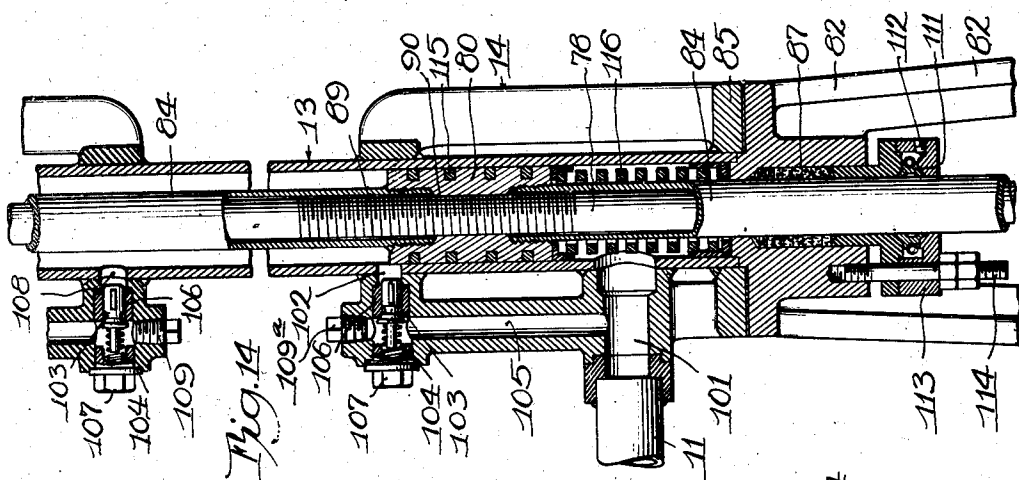
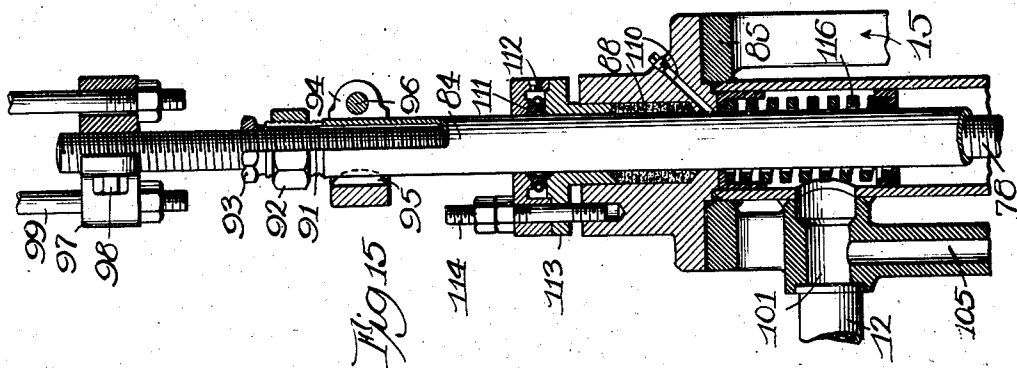
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HYDRAULIC DEVICE FOR OIL WELL PUMPING

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8 Sheets-Sheet 7



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HYDRAULIC DEVICE FOR OIL WELL PUMPING

Filed June 29, 1931

8 Sheets-Sheet 8

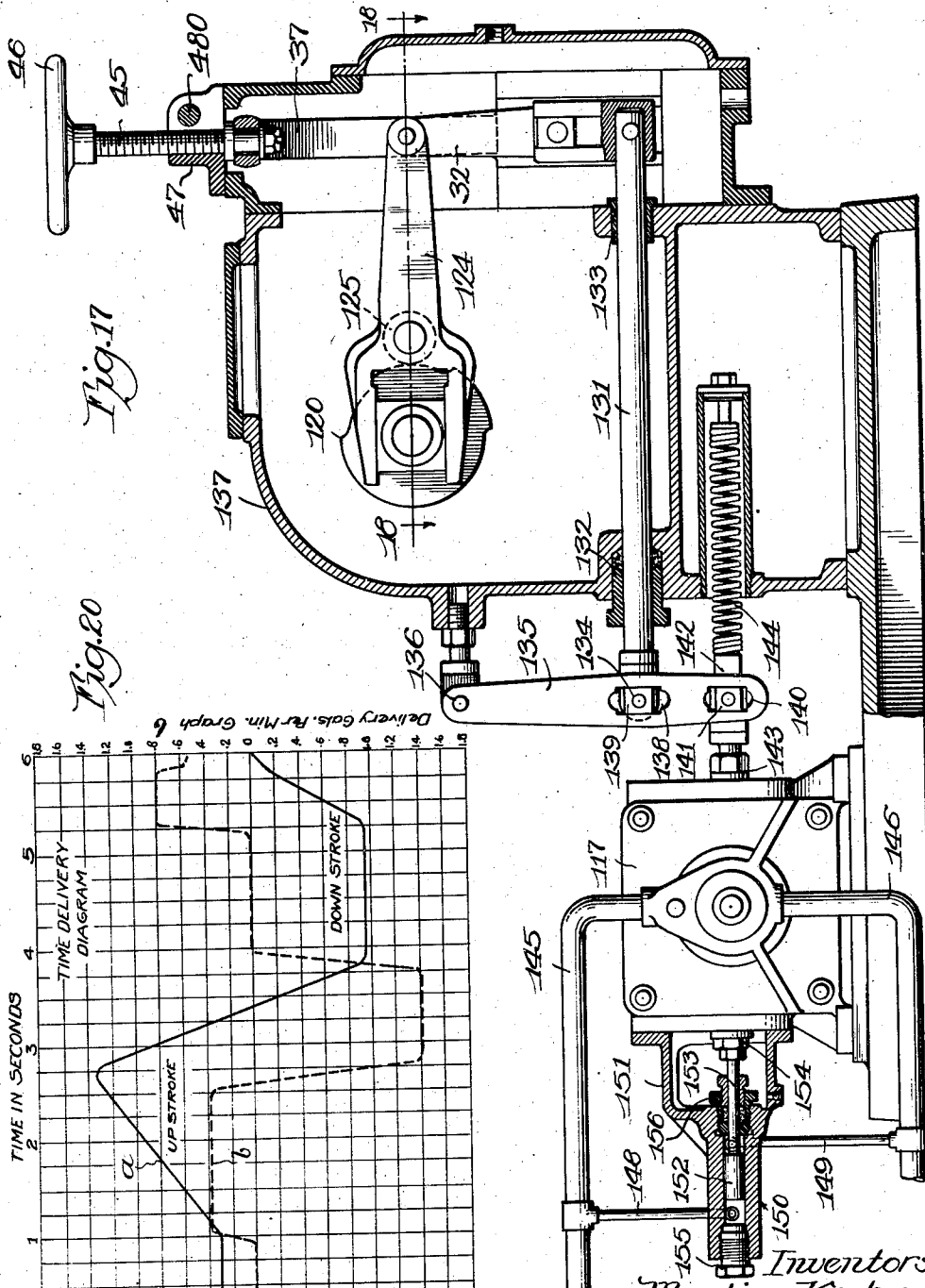
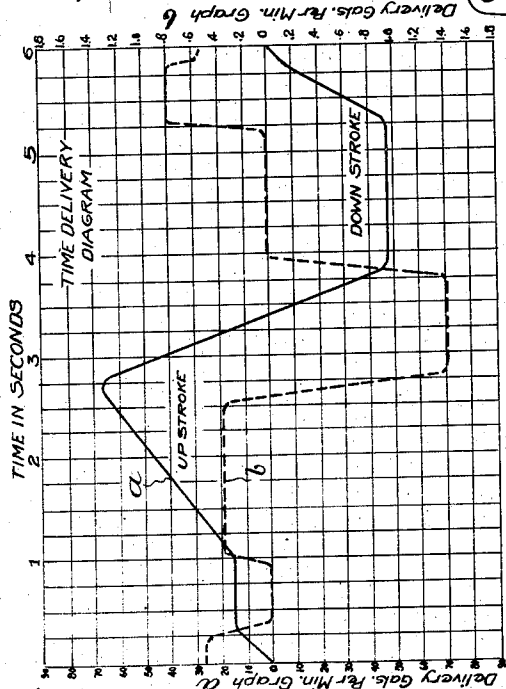


Fig. 17

Fig. 20



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UNITED STATES PATENT OFFICE

2,027,104

HYDRAULIC DEVICE FOR OIL WELL
PUMPINGMartin Kahr and John S. Kahr, Milwaukee, Wis.;
said John S. Kahr assignor to said Martin Kahr

Application June 29, 1931, Serial No. 547,482

37 Claims. (Cl. 60—52)

The present invention relates to oil well pumping devices and more in particular to a hydraulic means and mechanism for pumping oil wells whereby the operation may be accomplished with greater facility and at less expense and the unit is capable of pumping deeper wells than is possible with the devices now in use. These latter devices are mechanically operated and include apparatus using a crank movement in combination with connecting rod and so-called walking beam. In these prior constructions great difficulty is encountered in pumping wells of any considerable depth. The main difficulties encountered are that the load on the pumping rod is so great that the rod frequently breaks, causing shut-downs, repairs, and in most cases, loss of product. Increasing the size of the rod in order to take care of the great load in such wells, would not eliminate this difficulty for the reason that any increased size of the rod would necessarily increase the load.

Three forces combine to cause the enormous strain on the rod, and these items are (1) the weight of the pumping rod itself; (2) the weight of the oil to be lifted; and (3) the force required to accelerate the combined mass of rod and oil from a zero velocity to a certain maximum velocity. The third item is quite high when the common mechanical devices are employed; i. e., apparatus using crank movement in combination with connecting rod and the so-called walking beam. The reason for the great strain imparted to the pump rod is very evident when the elongation of the pump rod is considered. We observe for instance the working of a pumping device employing the crank movement, when the plunger of the pump in the bottom of the well is in its lowest position. The rod has an elongation due to its own weight which is constant during the whole cycle.

Before the oil starts its upward movement, a force equal to the weight of the oil acting on the plunger is imposed on the pump rod. This force causes a considerable additional elongation in the rod.

Thus before the oil has started to move upwards the crank is very far on its way from the starting position, that is its upper dead center and the velocity of the upper end of the pump rod is very near its maximum. At this point in the cycle the whole volume of oil has to be accelerated from a stand-still. Due to the high velocity of the pump rod at this point in the cycle the force required for the acceleration of the oil

is very high and the rod is subjected to an extremely high tension strain.

The present hydraulic mechanism or unit for oil well pumping and particularly deep well pumping, has the highly important function and feature of decreasing the acceleration forces, and consequently the stress on the pump rod, to a minimum. This is efficiently accomplished by imparting to the pump rod such a motion that in the point of the cycle when the oil shall be lifted the velocity of the rod is very low or zero, and from this point employing a slow and uniform acceleration of the rod up to the maximum velocity and thereafter let the rod rapidly decelerate to a standstill. In combination herewith we employ a much longer duration for the upstroke than for the downstroke, which latter commences with a rapid acceleration up to a maximum velocity and ends with a slow deceleration. The duration of each period within the cycle is dependent on the depth of the well, size and weight of pump rod and weight of oil to be lifted, etc., wherefore it is of utmost importance that the device is of such design that to the pump rod can be imparted any predetermined positive cyclic movement. The most favorable cycle can be calculated for each different case and the contour of the control cam given a corresponding shape.

Among the objects of the present invention is to provide a novel means and method of hydraulic power transmission, and more in particular for pumping oil wells by the employment of hydraulic equipment whereby the upstroke, when the oil is being lifted, has a selective longer duration than the downstroke. The invention contemplates a cam arrangement in combination with a variable capacity pump whereby, on the working stroke, there is provided a very slow and uniform acceleration up to a maximum velocity, after which the piston in the pumping cylinder decelerates rapidly to a stand-still or zero position. Then the suction or return stroke commences with the rapid acceleration and ends with a very slow deceleration, thus causing very little strain on the pump rod. By this means and method the stress in the pump or operating rod is reduced to a minimum.

A further object of the invention is to provide a means and method of oil well pumping whereby the stroke of the operating mechanism may be varied at will during operation so as to give any desired stroke to the pumping rod. By the employment of the present hydraulic system or hydraulic pumping equipment or unit, it is possible to hydraulically operate a piston for pumping oil from an extremely deep sunk well. The piston

pump is so operated as to be given an upstroke of selective longer duration than the downstroke whereby to efficiently pump the oil from the well, and at the same time reduce the danger of breakage of the pump rod.

A further object is to provide an hydraulic power transmission system including a cylinder provided with a reciprocating piston actuated by fluid delivered thereto, with means for controlling the delivered fluid for the purpose of imparting to the piston any desired predetermined cyclic movement. The invention comprehends the employment of a variable capacity and reversible discharge pump. The present construction although disclosed as adapted for use in oil well pumping equipment, is equally well adapted for use on any machine or device where a positive automatic cyclic movement is desired, as in presses, planers, milling machines, rolling mills, or in any machine where useful work is accomplished during a part of the cycle. Another object is the provision of a novel controlling means for an hydraulic or fluid pump whereby fluid delivered by the pump may operate a piston pump in a desired predetermined cyclic movement.

Another object of the invention is the provision of a cylinder and a reciprocating piston in an hydraulic device, and means for operating the piston in synchronism with the flow of fluid delivered from an hydraulic pump. Still another object is the provision of the cylinder with means for preventing the cylinder from being overcharged. The invention comprehends a supply and a by-pass at each end of the cylinder so as to by-pass any excess charge which would overcharge the cylinder with fluid on either side of the piston.

A further object is to provide means in the cylinder for checking the piston so as to prevent too sudden stops in the movement of the piston, or shocks imposed thereon. Still another object is the provision of means for adjusting the position of the piston in relation to the pump rod through which the power from the piston is transmitted. The invention further comprehends the provision of means for locking the piston to the pump rod whereby to prevent relative turning and shifting in relation to one another.

A further object is to provide an hydraulic pumping unit which can conveniently and efficiently be applied to the varied conditions which have to be met in oil well pumping. By reason of the present means and method, and the desired predetermined movement of the pump plunger, production can be increased to a maximum. To attain this desired or required plunger movement, the control cam is given a desired contour or shape.

Still another object is the provision of a novel cam construction in a controlling mechanism for an hydraulic pump whereby a piston operated by the pump may be given any desired predetermined cyclic movement.

A still further object is to provide a novel mechanism for controlling the stroke of the pump. The invention contemplates the provision of a variable capacity and reversible discharge pump adapted to operate a piston for pumping the oil, the stroke being readily altered by a control mechanism.

Another object is the provision of a novel means and method of varying the stroke of the control device whereby the same can be adjusted readily while the pump is operating from a zero position to a position of maximum stroke. By the use

of the controlling mechanism for a variable capacity hydraulic pump, the capacity of the pump may be varied from the maximum to a minimum position without interrupting or in any way interfering with its operation.

Still another object is the provision of the balancing cylinder construction employed in combination with the hydraulic pump to balance such part of the reactive forces inside the pump which increase or decrease with the hydraulic pressure in the system. Another object is the provision of a stroke limiting device preventing accumulation of error in the control cylinder by reason of any inaccuracy in the cam within the stroke controlling device, for controlling the input and output of the variable capacity pump.

This stroke limiting device corrects any error in the control cylinder at each cycle. The stroke limiting device limits the stroke of the control piston in the control cylinder, the control cylinder taking care of or providing the force required to shift the floating ring of the variable capacity pump off center against the high pressure and resistance in the pump.

Another object is the provision of a novel means and method for controlling the stroke and operation of the pump. The present construction provides either mechanical or hydraulic means for performing this function, the hydraulic means including a servo or auxiliary pump or unit rotating in timed and synchronized relation with the main pump.

Further objects are to provide a construction of maximum simplicity, efficiency, economy and ease of assembly, operation, repair and maintenance; and such further objects, advantages and capabilities as will later more fully appear, and as are inherently possessed thereby.

The invention further resides in the combination, construction and arrangements of parts illustrated in the accompanying drawings, and while there is shown therein a preferred embodiment, it is to be understood that the same is susceptible of modification and change, and comprehends other details, arrangements of parts, features and constructions, without departing from the spirit of the invention.

Referring to the drawings:

Fig. 1 is a view in side elevation of the oil well pumping unit.

Fig. 2 is a plan view of the unit disclosed in Fig. 1.

Fig. 3 is an enlarged view in side elevation of the pump and controlling mechanism shown in Figs. 1 and 2, but disclosing these constructions in rearranged position.

Fig. 4 is a plan view of the constructions shown in Fig. 3.

Fig. 5 is a view in vertical cross section taken through the stroke controlling device.

Fig. 6 is a view in vertical cross section taken on the line 6-6 of Fig. 5.

Fig. 7 is a view in perspective of the stroke adjusting mechanism disclosed in Figs. 5 and 6.

Fig. 8 is a fragmentary top plan view of a modification of cam arrangement for securing the desired acceleration and deceleration of the piston in the pump cylinder.

Fig. 9 is a view in side elevation of the construction disclosed in Fig. 8.

Fig. 10 is a view in horizontal cross section taken through the variable capacity pump.

Fig. 11 is a view in vertical cross section taken through the variable capacity pump, and discloses

ing the floating ring in the pump in maximum off-center position to the left.

Fig. 12 is a view similar to Fig. 11 but disclosing the floating ring in maximum off-center position to the right.

Figs. 13, 14 and 15 are fragmentary, disconnected views, part in side elevation and part in vertical cross section, of the details of the pumping cylinder, piston and pump rod.

Fig. 16 is a view, part in side elevation and part in vertical cross section disclosing a modification of the hydraulic equipment.

Fig. 17 is a view, part in side elevation and part in vertical cross section disclosing a modification of the hydraulic equipment with the controlling mechanism reversed.

Fig. 18 is a view in horizontal cross section taken on the line 18—18 of Fig. 17.

Fig. 19 is a top plan view of the hydraulic unit for operating the piston in the pumping cylinder.

Fig. 20 is a typical time-delivery and piston acceleration diagram or chart indicating the movement of the piston in the cylinder.

Fig. 21 is a fragmentary view of a relief valve.

Fig. 22 is a fragmentary view of a replenishing valve.

Referring more particularly to the disclosure in the drawings, and more especially to Figs. 1 and 2, the pumping installation, disclosed somewhat diagrammatically, includes an engine or power plant 1 of any well known type adapted to drive, through the medium of a pulley 2, a belt 3, driving a pulley 4 on a shaft 5. The pulleys and shaft 5 in turn rotate a pulley 6 for driving a belt 7. This belt 7 in turn drives a pulley wheel 8, the latter driving the shaft 9 of the variable capacity and reversible discharge pump 10. The means for driving the pump 10 is but illustrative, and it is to be understood that any well known drive mechanism and change speed arrangement such as pulleys, gears direct to the shaft of an electric motor, or the like, may be employed. Conduits 11 and 12 are connected to the pump 10 and from there to the motor cylinder 13, the conduit 11 being connected to the cylinder by means of a manifold 14, while the conduit 12 is connected to the cylinder by means of a manifold 15.

The cylinder 13 is supplied with fluid under pressure by means of the variable capacity, reversible discharge fluid pump 10, which is continuously driven by a gas or oil engine, or other prime mover or power plant 1 through the medium of a belt or chain drive, as explained above, or by electric motor direct connected to the shaft 9. This pump is of the variable stroke type, and it may obviously be of any desired or suitable construction, which permits the reversal of the direction of the fluid circulated by it, while the driving motor or prime mover always operates in the same direction. For altering the stroke of the supply pump 10 and hence the amount and direction of the flow delivered from it, the invention comprehends a control mechanism whereby the stroke of the supply pump may be varied at will. This control mechanism comprises a structure enclosed within the housing 16 for securing the desired acceleration and deceleration on the piston within the cylinder 13, in every instant of the stroke during the cycle, and a control device within the housing 17 for controlling the length of the stroke of the piston in the motor cylinder 13 accomplished by varying the capacity and direction of flow from the pump 10.

In order to control the acceleration and deceleration on the piston within the pumping

cylinder 13, Figs. 3 and 4, a shaft 18 is driven through a speed reducer 18^a by means of a sprocket 19 and chain 20 from the shaft of the pump 10, so that the pump 10 and shaft 18 are rotating in timed and synchronized relation.

Mounted upon the shaft 18 is an eccentrically arranged cam 22, Fig. 5, the cam being mounted intermediate bearing blocks 23 and supporting guides 24. These guides are provided with end plates 25 and 26, the end plates and guides being assembled with bolts or the like 27. Each end plate is provided with a pin or shaft 28, upon which is rotatably mounted a roller 29, adapted to be held in seating engagement with the face or circumference of the cam. The guides 24 are adapted to slide on the bearing blocks 23, so that when the cam rotates the guides 24 and their end plates will shift horizontally, the shaft 18 and bearing blocks 23 of course being prevented from shifting.

Connected to the end plate 26 of the guides 24, is a connecting or lever rod 31 which at its forward end 31^a, Fig. 7, is bifurcated to receive the end of a lever 32. This lever 32 at its lower portion is enlarged to provide an internal guideway 33 and external guides 34, the latter adapted to receive cross heads 35 which are adapted to slide within the guides. The cross heads 35 are pivotally mounted upon pins 36 provided on a fork 37, the fork being provided with side members 38 adapted to span the lever 32 and its enlarged head 32^a. The pins 36 provide a fulcrum about which the lever 32 oscillates, the position of this fulcrum determining the stroke of the pump 10.

Mounted within the internal guideway 33 of the lever 32 is a block 39 pivotally mounted at 40 within the side walls or web 41 of the enlarged head 32^a of the lever. This block 39 may rotate within the lever, but by reason of the pivotal mounting 40, is shiftable therewith so that any oscillation of the lever 32 is transmitted to the block 39, which in turn transmits this motion to the horizontally extending rod 42 which in turn transmits its movement to the floating ring of the pump 10. This rod 42 is mounted within bearings 43 and 44, Fig. 5, in the walls of the housing for the controlling mechanism.

In order to control the length of the stroke of the rod 42, which in turn controls the length of the stroke of the piston in the cylinder 13 and also controls the capacity of the flow of the fluid from the pump 10 in both directions, the fork 37 is provided with an adjusting screw 45 adapted to be operated by means of a hand wheel 46.

When the hand wheel is operated to raise the fork 37 to its uppermost position, the fulcrum 36 is at its uppermost position on the lever 32, and the lever 32 will transmit a maximum reciprocation or stroke to the rod 42. When the fulcrum or pins 36 on the fork 37, Fig. 7, is at its lowermost position, which is adjacent the pivot 40 of the block 39, no reciprocation or longitudinal movement is transmitted to the rod 42 and thus the stroke of the pump is at a minimum or zero. Thus the hand wheel 46 permits adjustment of the fulcrum on the fork 37, which in turn adjusts the stroke of the pump 10 from zero to maximum stroke. When the desired stroke is obtained, the adjusting screw 45 may be locked. This is accomplished by making the cover or closure 47, Fig. 3, split and provided with a lock screw 48. This adjustment of the stroke of the pump may be accomplished dur-

ing the operation of the pump whereby to eliminate any shut-downs or delay. In Figs. 8 and 9 is disclosed an alternate construction of cam mechanism.

5 In this construction the shaft 18 is provided with a pair of cams 48 and 49. A sliding guide 50 provided with end plates 51 and 52 held together by means of bolts or the like 53, is connected to the lever or connecting rod 31. Each
10 end plate is provided with a stub shaft or pin 54 having mounted thereon a roller 55 seating between the end plates 51 and 52 and extensions 56 from said plates. Pins 54 are locked in position by means of a nut 57. As in the construction
15 disclosed in Fig. 5, the cam members 48 and 49 are so formed as to give to the sliding guide member 50 a reciprocatory motion to obtain the desired acceleration and deceleration of the piston in the cylinder 13.

20 The cam through its levers and the rod 42 transmits the longitudinal reciprocating motion through a coupling 58 to the control or cross bar 59 on the supply pump 10. The supply pump will then deliver a flow of fluid under pressure
25 first in one direction and then in the other, through the conduits 11 and 12. The pump comprises a body 60, Fig. 11, provided with a series of radial cylinders, the number and size of which vary with the capacity of the pump. The cylinder
30 body 60 is mounted on ball bearings seated in the covers of the pump. Fastened to one end of the body 60 and extending out through the cover 62, Fig. 10, is the spindle or shaft 9 by means of which the pump is rotated by the
35 prime mover. Fixed in the opposite cover 63 is a non-rotatable shaft provided with intake and discharge ports 64, Figs. 11 and 12, communicating with the conduits 11 and 12.

40 It is through these ports 64 that the fluid is drawn into the pump and discharged from it. In each radial cylinder is a plunger 65 with a gudgeon pin 66 fastened to its outer end. This pin engages in slippers 67, one on each side of
45 the plunger, the slippers fitting in circular grooves which encircle the cylindrical body. Around the body 60 is provided a floating ring 68, Fig. 10. This floating ring 68 is mounted on ball bearings
50 69 seated in guide blocks 70 on each end, the ring and guide block assembly being supported on guides on the two end covers. This arrangement allows the floating ring with the circular
55 grooves in which the slippers are engaged to be moved at will so that it is on-center with reference to the cylinder body, or off-center to either side. This arrangement gives the stroke to the
60 pump and controls the amount of stroke and the volume and direction of discharge.

65 In Fig. 11 the floating ring is disclosed as off-center to the left of the cylinder body, the cylinder body being rotated by the prime mover in the direction indicated by the arrow, and continuously and at a constant speed about the shaft
70 which contains the ports 64 and which carries the plungers and slippers around with it. As shown during the upper half of each revolution, the plungers are forced inward by the slippers,
75 following the races in the floating ring and producing the discharge stroke of the pump, while during the lower half they are drawn outward, producing the suction stroke.

When the floating ring is off-center to the right of the cylinder body as disclosed in Fig. 12, the direction of discharge is reversed without changing the speed or direction of rotation of the cylinder body. In this disclosure, the plungers are

forced inward and have their discharge stroke during the lower half of the revolution and are drawn out and have their suction stroke during the upper half. It can readily be seen that the distance the floating ring is eccentric with respect to the cylinder body, determines the amount of the stroke, and hence, the volume of the discharge. This permits any variation from zero to a maximum. When the floating ring is on-center with the cylinder body, which is a position
10 intermediate that disclosed in Figs. 11 and 12, the position of the plungers 65 remains unchanged during the revolution, and although the pump is running, the plungers have no stroke and the fluid remains motionless. As disclosed above, the
15 stroke may be altered by manipulation of the hand wheel 46 so as to change the fulcrum of the fork 37. Although there is disclosed a particular construction of variable capacity and reversible discharge pump, it is to be understood that any
20 form of hydraulic or fluid pump may be used which has a variable capacity and reversible discharge.

Referring more particularly to the disclosure in Figs. 13, 14 and 15, the numeral 71 refers to
25 the oil well casing upon which is mounted the casing head 72, and in which is positioned the oil well tubing 73, which at the bottom of the well is connected to a motor cylinder commonly called the working barrel, which contains the plunger
30 and valves for pumping the oil up through the tubing and permitting its discharge through the pipe T 74. The tubing 73 is suspended on the collar 75 which rests upon an adjustable ring
35 76. The casing head 72 is provided with a packing 77 for sealing the space inside the casing from the atmosphere. The pump rod 78 actuates the plunger in the bottom of the well, this rod passing through the tubing 73 and is connected
40 above the stuffing box 79 to a driving means.

The cylinder 13 of the double acting hydraulic motor is provided with a piston 80 which imparts movement to the pump plunger in the bottom of the well through the medium of the pump
45 rod 78. The motor cylinder 13 is mounted on the casing head 72 in any suitable manner and at its ends is provided with the manifolds 14 and 15. In the embodiment selected to illustrate the invention, standards 82 are provided, extending
50 from the collar 83 on the casing head to the base of the manifold 14. The cylinder 13 is provided with a piston 80 and the piston rod 84 passing through the end covers 85 and 86 of the manifolds and stuffing boxes 87 and 88.

For convenient adjustment of the total active
55 length of the pump rod 78, a portion 89 of this rod adjacent the upper end thereof is threaded and adapted to be received within an internally threaded portion 90 in the piston 80. The upper
60 end of the piston rod 84 is split and provided with tapered threads 91 to receive a lock nut 92, facilitating the piston rod being tightly connected to the pump rod 78 by means of a threaded and split sleeve 93 whereby to prevent the piston 80
65 from turning on the rod 78 after adjustment has been made. To permit convenient application of a wrench or other tool for turning the piston around the rod 78, the piston rod 84 is fitted at
70 its upper end with a split collar 94 which is held by means of a key 95 in addition to the clamping action of a screw 96 adapted to draw the split collar into tight clamping engagement. The threaded end of the pump rod 78 is provided at
75 its upper end with a split nut or collar 97 which is clamped together by means of a bolt 98, the 75

nut or collar providing a connection for a U-bolt 99 which is in turn connected to a chain or cable which suspends a counter-weight 100, Fig. 1.

The upper manifold 15, Fig. 3, is connected to the conduits 12 for supplying fluid thereto, while the lower conduit 11 connects with the manifold 14. These manifolds are designed to serve as a safety and stop mechanism in case the cylinder on any occasion should be overcharged with fluid in one direction or the other.

The manifolds likewise automatically aid in starting and controlling the stroke. Fluid entering the manifolds through the port 101, Fig. 14, from the conduit 11, will pass therethrough into the bottom of the cylinder 13 whereby to raise the piston 80 and the piston rod 84, along with the pump rod 78. The piston 80 at the end of this maximum working stroke, uncovers a port 108 which allows the excess incoming fluid to be bypassed through a valve 103. A spring 104 normally holds this valve in seating engagement so as to prevent any incoming fluid through the conduits 11 and port 101 from passing through the by-pass 105, and then through the valve. This construction provides a safety means whereby the cylinder cannot be overcharged. The valve 103 seats within a bushing 106, the valve construction being removable through a threaded closure 107. As the valves in each manifold are identical in construction, the same reference characters are applied thereto.

Each end of the cylinder is provided with a by-pass in connection with inlet and outlet ports, the construction being the same, but the by-passes being reversed. For purpose of draining the system completely of air, drain plugs and air vent 109, 109^a, and 110 are provided.

The stuffing boxes 87 and 88 are each provided with scraper rings 111 each provided with a threaded connection 112 to which may be connected conduits or drain pipes for draining or leading the fluid which might leak through back into a supply storage contained in the housing of the pump 10 or connected therewith. The closure or head 113 for each of the stuffing boxes is connected to the end covers 85 and 86 by means of threaded bolts or the like 114.

The piston is shown as provided with a plurality of rings 115, and in the space between the piston and the cylinder covers is provided a spring 116 which acts as a resilient stop for the piston so as to prevent any shock thereto at the end of the stroke.

In the operation of the constructions which have so far been disclosed, it is advisable before starting the pump 10 to turn the control screw 45 by means of the hand wheel 46 so as to move the fork 37 to its lowest position, corresponding to zero delivery on the pump 10. Thereafter, by turning the hand wheel 46, the stroke of the rod 42 will be gradually increased which in turn increases the stroke of the control or cross bar 59. This in turn adjusts the position of the floating ring 68 so that the same may deliver any capacity of fluid that is desired at every instant during the cycle of its operation. The prime mover which operates the pump 10 also rotates the shaft 18 carrying the single or double cam arrangement, which cam or cams through lever rod 31 and lever 32, reciprocates the rod 42 connected to the pump. The length of the stroke is controlled by means of the fork 37 and its adjusting screw, while the desired acceleration and deceleration on the piston 80 is accomplished by means of the cam construction and contour.

By reason of the above construction and arrangement the supply pump 10 will deliver a flow of fluid under pressure first in one direction and then in the other direction, through the conduits 11 and 12. Now supposing that the piston 80 is in its lowest position resting against the spring 116 and the pump 10 starts to deliver fluid through the conduit 11. The fluid will act on the under side of the piston 80 causing it to move upwardly until the flow is reversed. In the meantime the delivery from pump 10 has increased by the operator turning the screw 45 upward so as to raise the fulcrum 36 in the fork 37. Thus the volume delivered on the downward stroke is greater than it was on the preceding upward stroke. The difference in amount of fluid is by-passed through the valve 103 to the suction line. When flow is again reversed, the piston will move higher up in the cylinder than it did on the previous upward stroke. By turning the hand wheel successively, the piston will come higher up in the cylinder for each stroke until the upper by-pass valve 103 opens. Thereafter the stroke can be shortened to any desired length and the piston will work between the two by-pass valves 103. The rotating cam 22 which actuates the connecting or lever rod 31 and lever 32, causes this rod and lever to continually oscillate or reciprocate in a positive cyclic movement in accordance with the contour of the cam. When the fulcrum 36 is at its uppermost position on the head 32^a of the lever 32, a maximum reciprocation is transmitted by the lever to the rod 42. When the fulcrum 36 is lowered adjacent to or in alignment with the pivot 40 of the block 39, no reciprocation of the connecting or lever rod 31 and lever 32 is transmitted to the rod 42 and the stroke of the pump is at zero.

In Figs. 16 and 17 are disclosed alternate constructions in which the main pump is provided with control and balancing means, as well as with a stroke limiting device. The means for shifting the floating ring of the pump off-center, which in the previous embodiment was done mechanically, in this alternate construction, it is done hydraulically through the medium of a servo or auxiliary pump 117. This servo pump construction is similar to that of the main pump, although it is to be understood that any type of variable capacity pump may be provided as desired.

Referring more particularly to Fig. 16 of the drawings, the casing 118 houses the shaft 119 upon which is mounted a cam 120. On the hub 121 are mounted blocks 122, one on each side of the cam. The bifurcated cam follower 124 is slidably mounted on the blocks 122. A roller 125 is rotatably mounted within the cam follower 124, and is at all times in contact with the face or circumference of the cam 120. The cam follower 124 is in turn connected to a lever 32, similar to the constructions disclosed in Fig. 7, of the drawings. Likewise, the fork 37, adjusting screw 45 and hand wheel 46 are similar to the previously described construction. The rod 42^a is provided with a reduced portion 126 upon which is mounted a spring 127 seating between the shoulder 128 on the rod 42^a and a cross arm 129 for holding the roller 125 in contact with the cam 120. The outer end of the rod 42^a is connected to a cross head 130 similar in construction to the cross head 59 in the main pump. Reciprocation of this cross head will throw the floating ring of the servo pump into off-center or on-center position depending on the stroke desired.

In Fig. 17 is disclosed a somewhat similar con-

struction of controlling device and cam arrangement as shown in Fig. 16, but disclosing the parts in rearranged position so that the controlling device and hand wheel are at the rear of the unit.

In this form, the rod 131 which is reciprocated, is mounted within bearing sleeves 132 and 133, and at its outer end is connected at 134 to a lever arm 135 pivoted at 136 to the casing or housing 137 of the cam device. The lever 135 is bifurcated and the sides thereof provided with slots 138 for receiving a head 139 on the rod 131. Likewise the lever is provided with slots 140 for receiving a head 141 on a rod 142 which is connected to a cross head 143, similar in construction to the cross-head 59 of the pump disclosed in Fig. 10.

This rod 142 is adapted to be reciprocated by the lever 135 and in order to return the rod after it has reached the end of its stroke, the invention comprehends the provision of a tension spring 144 for accomplishing this result, the function being the same as the compression spring 127 in Fig. 16.

By proper adjustment of the hand wheel 46 and screw 45 so as to shift the fulcrum of the fork 37, any desired stroke may be secured on the servo or auxiliary pump 117. Connected to the auxiliary pump 117 are provided conduits 145 and 146 through which is discharged the fluid from the pump in opposite directions during each cycle of operation. The conduits 145 and 146 are connected to the opposite ends of a control cylinder 147, Fig. 16, at one side of the main pump 10. Connected to the conduits 145 and 146 are pipes or lines 148 and 149, Fig. 17, leading to opposite ends of a balancing cylinder 150 for the purpose of counteracting such forces inside the pump which can practically be balanced with the pressure in the fluid lines. This balancing structure comprises a housing or casing 151 adapted to be attached to a side of the auxiliary pump 117, the cylinder being provided with a piston 152 having a rod 153 attached to a cross head 154, also similar in construction to the cross head 59 of the pump shown in Fig. 10. At each end of the cylinder are provided threaded closures 155 and 156 so as to make an air and liquid tight joint. Fluid passing through the pipes or lines 148 and 149 flows in alternate directions in each cycle, so that the fluid passing down through the pipe 148 from the conduit 145, will force the piston 142 into the position shown in Fig. 17, while at the next instance when the flow is reversed, the fluid will flow through the conduit 149 while the fluid to the left of the piston 152 will flow outwardly through the pipe 148 into the conduit or line 145.

Again referring more particularly to the disclosure in Fig. 16 in which is shown the complete main and auxiliary pump unit, fluid flowing into the control cylinder 147 through the pipe or conduit 145, will force the piston 157 to the left. The piston rod 158 being connected to the cross head 59, will shift the floating ring of the main pump 10 so as to throw the same off-center. The greater or longer the path of the piston 157, the longer will be the stroke of the pump. During the next instant of the cycle when the fluid is flowing upwardly through the conduit or pipe 146 and draining outwardly through the conduit or pipe 145, the fluid at the left end of the piston 157 will force this piston outwardly, and if in the previously described operation, the pump was discharging, then during this part of the cycle, will be the suction stroke of the pump. In this construction, the control cylinder performs hydraulically the function of shifting the floating

ring of the pump 10 off-center, whereby to provide the length of stroke of this pump, which operation was performed in the construction disclosed in Figs. 1 to 4 inclusive, by mechanical means. Should it be found that there is a greater flow of fluid on one side of the piston than on the other, this excess fluid is by-passed through spring-pressed valves 159 as shown in Fig. 21, which permit the flow of fluid in but one direction. Any fluid so by-passed is drained through a pipe 160 to a supply reservoir 161. In order to replenish the supply of fluid, pipes 162 and 163 are provided, each pipe being furnished with a replenishing valve x as shown in Fig. 22, so as to prevent drainage of fluid from the supply line during the normal operation of the unit. The replenishing valves are plain check valves similar to those shown in pipes 162^a and 163^a, which permit a flow of oil from the reservoir 161 to the pump, but preventing any oil going back to the reservoir from the pressure line.

The conduits 11 and 12 of the main pump 10 may likewise be provided with replenishing pipes 162^a and 163^a having replenishing valves to permit a flow from the reservoir to the main conduits.

Connected to the side of the main pump 10 opposite the control cylinder 147, is a balancing cylinder 164 and a stroke limiting device 165. This balancing cylinder is provided with a piston 166, the opposite ends of the cylinder being provided with supply pipes or lines 167 and 168 connecting with the main supply conduits 11 and 12 of the pump 10. It is to be understood that the flow of fluid and the pressure in the conduits 167 and 168 is similar to that in the main conduit so that during each cycle, fluid is flowing in alternate directions through the pipes.

As disclosed more fully in Figs. 16 and 19, the piston rod 169 is connected to a cross head 170, the outer ends of which are connected to rods 171 which are associated with the floating ring in the pump 10. Thus, any movement of the piston 166 is transmitted through these rods to the floating ring in the cylinder of the pump for the purpose of counteracting or balancing forces inside of the pump, and to help in the shifting of the floating ring. In order to limit the stroke of the piston 157 in the control cylinder, the invention comprehends a stroke limiting mechanism which may be shifted by the operator so as to adjust the stroke. This stroke limiting device comprises a threaded member 172 adapted to be rotated by a hand wheel 172^a. The member 172 is provided with threaded sections 173 and 174, one provided with left hand and the other with right hand threads, the function of which is to draw the cross arms 175 and 176 toward one another, or when the hand wheel is operated in the other direction to shift the position of the cross arms so that they are threaded away from one another, whereby to increase the gap between them. The gap or distance between these cross arms 175 and 176 determines the stroke of the piston 157 as well as the piston 166 for the reason that the cross head 170 operates therebetween and is thus limited in its movement. It is to be understood that both the control piston 157 and the balancing piston 166 are connected by the cross heads 59 and 170, and the tie rods 171 so that the same movement is imparted to both pistons. The cross arms 175 and 176 along with the cross arm 177 are mounted on rods 178 which are connected to the balancing cylinder, the cross arm 177 being fixedly mounted thereon, while the

cross arms 175 and 176 must necessarily be loose thereon so as to permit their relative adjustment. The valves 159 are spring loaded relief valves set for a pressure higher than the ordinary working pressure in cylinder 147. When the cross head 170 is stopped against the cross arms 175 or 176, the pressure in cylinder 147 increases and valve 159 opens until the flow is reversed and this side of the cylinder 147 becomes the suction side.

The stroke limiting device is to prevent accumulation of error in the control cylinder where there is any inaccuracy in delivery of fluid by reason of inaccuracy in the cam. For instance should a greater volume of fluid be delivered through conduit 145, Fig. 16 than through conduit 146, the piston 157 can only move until the crosshead 170 stops against cross arm 175. The still incoming fluid through conduit 145 is then bypassed to the oil supply 161, through relief valve 159 and pipe 160. In the same way is corrected any error in the volume of fluid delivered through conduit 146.

In Fig. 19 is shown a plan or lay-out of the unit or assembly when the servo or auxiliary pump as well as the control and balancing cylinder and stroke limiting device, are employed. An electric motor or other prime mover 178^a drives through a flexible coupling 179, the shaft 9 of the main pump 10. This motor likewise through sprockets or other driving means 180 and 181, drives a speed reduction mechanism 182 which in turn drives the cam shaft in the cam housing 137. The servo or auxiliary pump 117 is likewise driven through suitable drive mechanism including a flexible coupling 183. By this construction, the various rotating parts are driven in timed relation so as to provide a properly synchronized working relationship between the various parts making up the unit or equipment.

Referring again to the complete oil well pumping unit disclosed in Figs. 1 and 2, the supporting structure is made shiftable so as to permit ready access to the various parts. In this arrangement, the rest or support 184 carrying the beam 185 supporting the pulleys 186, cable 187 and counterweight 100, is shiftable upon the pivotal support 188. All that is necessary to shift this structure is to disconnect the support 184 and its brace members 189 and 190.

In Fig. 20 is disclosed an illustrative chart plotting the time and delivery during each cycle which includes the up and down stroke, it being understood that the pump is of the reversible type having a discharge and a suction stroke so as to reverse the flow of fluid through the cylinder 13. The chart discloses curves *a* and *b* plotted on coordinate axes, the vertical divisions denoting the delivery in gallons per minute on each of the up and down strokes, while the horizontal divisions denote the time consumed in each cycle of the working and suction or returning stroke. The curve *a* denotes the volume of fluid delivered in every moment of the cycle from the main pump 10, and curve *b* denotes the quantity of fluid delivered from the servo pump in every moment during the cycle when the main pump performs in accordance with curve *a*. The curves *a* and *b* are in vertical different scale, the delivery from the servo pump being only a few per cent of delivery from the main pump. Between the curves *a* and *b* exists also the relation that when curve *a* in a certain scale denotes the velocity of piston 80 in cylinder 13, curve *b* indicates the corresponding acceleration and deceleration of the piston 80.

It is of course to be understood that these curves are but illustrative and velocity and acceleration within the stroke may be readily altered by varying the contour or face of the cam to give the desired upstroke and downstroke, or discharge and suction stroke. Likewise, the capacity may be varied at will.

From the above description and the disclosure in the drawings, it will be readily seen that the invention comprehends, and that the unit and equipment is suitably adapted for use in other fields than in the oil industry. The same is admirably adapted for use in milling machines or planers, punch presses, screw machines, and various other machines and devices where it is desired to operate some mechanism or tool in a positive cyclic movement.

In the oil industry, the invention serves a long felt need and eliminates to a great extent the frequent shutdowns and delays caused by breakage of the pumping rod due to the enormous stresses and strains under which the same has to operate in combination with the pumping device used up to the present time.

Having thus disclosed the invention, we claim:

1. In an hydraulic power transmission system, a cylinder provided with a reciprocating piston, a pump for delivering fluid to the piston, means synchronized with the pump for operating the piston in a positive cyclic movement, said means including a system of levers associated with the pump for controlling the length of stroke of the piston, and means for shifting the fulcrum of said levers whereby to vary the capacity and flow from the pump and the stroke of the piston between zero and maximum position.

2. In an hydraulic transmission system including a variable capacity pump provided with stroke controlling means, a cylinder provided with a reciprocating piston, automatic means for imparting to the piston a positive cyclic movement and including a cam and a system of levers for imparting movement of the cam to the controlling means of the pump, and means for shifting the position of the fulcrum of said levers whereby to increase or decrease the stroke of the pump.

3. In an hydraulic power transmission system, a motor, a variable capacity pump for delivering fluid to said motor, cam actuated means operated in synchronism with the pump for controlling the rate and direction of discharge of said pump and imparting to the motor any desired positive cyclic movement, and means for controlling the stroke of said pump.

4. In an hydraulic power transmission system, a motor, a variable capacity pump for delivering fluid to said motor, cam actuated means operated in synchronism with the pump for controlling the discharge therefrom and imparting to the motor any desired positive cyclic movement, means for controlling the stroke of said pump, and hydraulic means applied to said stroke controlling means for reducing the force required to operate the same.

5. In an hydraulic power transmission system, a cylinder provided with a reciprocating piston, a pump for delivering fluid to the piston, means rotated in timed relation with the pump for controlling the capacity and direction of flow from the pump and thereby controlling the movement of the piston in its cycle of operation, and means associated with the pump for controlling the length of the stroke of said piston.

6. In an hydraulic power transmission system, a cylinder provided with a reciprocating piston, a

variable capacity pump for supplying fluid to said cylinder, means synchronized with the pump for controlling the stroke of the pump and thereby operating the piston in a positive cyclic movement, and a by-pass at each end of the cylinder adapted to be uncovered by the piston to exhaust any overcharge of fluid to the cylinder.

7. In an hydraulic device for oil well pumping, a cylinder provided with a reciprocating piston, a variable capacity pump for supplying fluid to said cylinder, means operating in timed relation with the pump for controlling the capacity and discharge of the pump and operating the piston in a positive cyclic movement, and means for exhausting any overcharge of fluid in the cylinder.

8. In an hydraulic power transmission system, a cylinder provided with a reciprocating piston, a variable capacity pump for supplying fluid to said cylinder for operating the piston, and means operating in timed relation with the pump for controlling the capacity and flow from the pump, said means including a second variable capacity and reversible discharge pump for hydraulically actuating the first mentioned pump, and a cam mechanism imparting to the stroke controlling means of the second pump any desired cyclic movement.

9. In an hydraulic power transmission system, a cylinder provided with a reciprocating piston, a variable capacity pump for supplying fluid to said cylinder, means operating in timed relation with the pump for controlling the discharge of the pump and operating the piston in a desired positive cyclic movement, and means including a cylinder and piston operable therein for balancing the frictional resistances caused by the hydraulic forces in said pump.

10. In an hydraulic power transmission system, a cylinder provided with a reciprocating piston, a variable capacity pump for supplying fluid to said cylinder for operating the piston, means operating in synchronism with the pump for operating and controlling the stroke of the pump whereby to operate said piston in a positive cyclic movement, and means for limiting the movement of said controlling means.

11. In an hydraulic power transmission system, a cylinder provided with a reciprocating piston, a variable capacity pump for supplying fluid to said cylinder for operating the piston, and hydraulic means synchronized with the pump for controlling the discharge of the pump and for balancing the frictional resistances caused by the hydraulic forces in said pump.

12. In an hydraulic power transmission system, a control cylinder provided with a reciprocating piston, a variable capacity pump for supplying fluid to said cylinder for operating the piston, and means including a driven cam synchronized with the pump for controlling the capacity and direction of flow from the pump for imparting to the piston any desired positive cyclic movement.

13. In an hydraulic device for oil well pumping, a cylinder provided with a reciprocating piston, a variable capacity pump for delivering fluid to the cylinder to actuate the piston, and cam actuated means operated in synchronism with the pump for controlling the capacity and direction of flow from the pump for imparting to the piston a desired positive cyclic movement.

14. In an hydraulic power transmission system, a cylinder provided with a reciprocating piston, a variable capacity pump for delivering fluid to the cylinder to actuate the piston, and means synchronized with the pump for continuously

imparting to the piston any desired positive cyclic movement.

15. In an hydraulic device for oil well pumping, a cylinder provided with a reciprocating piston, a variable capacity pump for delivering fluid to the cylinder to actuate the piston, and means synchronized with the pump for controlling the discharge therefrom and for imparting to the piston a working stroke of variable velocity and of longer duration than the return stroke.

16. In an hydraulic power transmission system, a cylinder provided with a reciprocating piston, a pump for delivering fluid to the piston, and cam mechanism operated in synchronism with the pump for controlling the discharge of said pump and continuously imparting to the piston a desired positive cyclic movement.

17. In an hydraulic power transmission system, a cylinder provided with a reciprocating piston, a pump for delivering fluid to the piston, and cam actuated mechanism synchronized with the pump for varying and controlling the stroke of the pump and piston, the cam being so constructed and arranged that the working and return strokes of the piston are of unequal duration and variable velocity.

18. In an hydraulic device for oil well pumping, a cylinder provided with a reciprocating piston, a pump for delivering fluid to the piston, and automatic working mechanism synchronized with the pump for varying the stroke of said pump between a positive maximum and a negative maximum output whereby to operate the piston in a positive cyclic movement.

19. In an hydraulic device for oil well pumping, a cylinder provided with a reciprocating piston, a pump for delivering fluid to the piston, and means operated in synchronism with the pump for actuating and controlling the length of the stroke and capacity of the pump whereby to impart to the piston a desired positive cyclic movement.

20. In an hydraulic device for oil well pumping, a cylinder provided with a reciprocating piston, a pump for delivering fluid to the piston, means associated with the pump for controlling the length of the stroke of the piston, and means operated in timed relation with the pump for controlling the stroke and capacity of the pump and the continuous cyclic operation of the piston.

21. In an hydraulic device for oil well pumping, a cylinder provided with a reciprocating piston, a variable capacity pump for supplying fluid to said cylinder for operating the piston, and cam actuated means operated in timed relation with the pump for determining the stroke of the pump whereby to operate the piston in a positive cyclic movement.

22. In an hydraulic power transmission system, a cylinder provided with a reciprocating piston, a variable capacity pump for supplying fluid to said cylinder for operating the piston, and cam actuated mechanism operated in synchronism with the pump for controlling and determining the stroke of the pump whereby to operate the piston in a positive cyclic movement.

23. In an hydraulic power transmission system, a cylinder provided with a reciprocating piston, a variable capacity pump for supplying fluid to said cylinder for operating the piston, means operated in timed relation with the pump for actuating the pump and determining the stroke thereof, and means associated with said first named

means for adjusting and controlling the length of stroke of said piston.

24. In an hydraulic power transmission system, a cylinder provided with a reciprocating piston, a variable capacity pump for supplying fluid to said cylinder for operating the piston, cam actuated means operated in synchronism with the pump for controlling the discharge from the pump and actuating the piston in any positive cyclic movement, and means for changing the stroke of said piston.

25. In an hydraulic power transmission system, a cylinder provided with a reciprocating piston, a variable capacity pump for supplying fluid to said cylinder for operating the piston, automatic means synchronized with the pump for controlling the stroke of the pump and imparting to the piston a desired positive cyclic movement, and means associated with the cylinder for operating the piston in synchronism with the flow of fluid from the pump.

26. In an hydraulic power transmission system, a cylinder provided with a reciprocating piston, a variable capacity pump for supplying fluid to said cylinder for operating the piston, cam actuated means synchronized with said pump for controlling the discharge of the pump and operating the piston in a positive cyclic movement, and means associated with the cylinder for preventing the cylinder at either end of the piston from being overcharged with fluid from the pump.

27. In an hydraulic power transmission system, a cylinder provided with a reciprocating piston, a variable capacity pump for supplying fluid to said cylinder for operating the piston, means rotated in timed relation with the pump for controlling the discharge and direction of flow from the pump and operating the piston in a positive cyclic movement, and a spring seating within said cylinder for intercepting the piston so as to prevent sudden stops in the movement of the piston or shocks imposed thereon.

28. In an hydraulic power transmission system, a cylinder provided with a reciprocating piston, a pump for delivering fluid to the piston, a cam rotated in timed relation with the pump for controlling the discharge of the pump and imparting to the piston a desired cyclic movement, and mechanism for controlling the length of stroke of the piston.

29. In an hydraulic power transmission system, a cylinder provided with a reciprocating piston, a variable capacity pump for supplying fluid to said cylinder, a cam rotating in synchronism with the pump for controlling the rate and direction of discharge of the pump and operating the piston in a positive cyclic movement, and means in the system for exhausting any overcharge of fluid in the system.

30. In an hydraulic power transmission system, a cylinder provided with a reciprocating piston, a variable capacity pump for supplying fluid to said cylinder for operating the piston, and means for controlling the capacity and flow from the pump, said means including a second variable capacity and reversible discharge pump and cam

mechanism operated in timed relation with the first mentioned pump for actuating said second pump.

31. In an hydraulic power transmission system, a variable capacity pump for supplying fluid under pressure, hydraulic means for controlling the stroke of said pump, said means including a cylinder and piston operable therein, and means also including a cylinder and piston operable therein and actuated by fluid under pressure from said system for balancing the reaction forces on the pump controlling means.

32. In an hydraulic transmission system, a cylinder provided with a reciprocating piston, a variable capacity pump for supplying fluid to said cylinder, means associated with the pump for operating the piston in a positive cyclic movement, a control cylinder for controlling the stroke of the pump and provided with an hydraulically operated piston, mechanism for limiting the stroke of the pump, means for supplying fluid under pressure to said control cylinder in a determined quantity for each time element during the cycle, and a by-pass for any surplus fluid supplied to said control cylinder.

33. In an hydraulic transmission system, a variable capacity pump for supplying fluid under pressure, hydraulic means for automatically changing the stroke of said pump in any repeated cyclic movement, means for limiting said stroke, and means for by-passing any surplus fluid supplied to said controlling means.

34. In an hydraulic power transmission system, a control cylinder provided with a reciprocating piston, a variable capacity pump for supplying fluid to said cylinder for operating the piston, means including a cam rotated in synchronism with the pump for controlling the capacity and direction of flow from the pump for imparting to the piston any desired positive cyclic movement, and means for limiting the stroke of said piston.

35. In an hydraulic device for oil well pumping, a cylinder provided with a reciprocating piston, a variable capacity pump delivering fluid to the cylinder to actuate the piston, and means including a cam rotated in timed relation with the pump for controlling the discharge from the pump and imparting to the piston any desired positive cyclic movement.

36. In an hydraulic power transmission system, a motor, a variable capacity pump for delivering fluid to said motor, and cam actuated means operated in synchronism with the pump for controlling the capacity and discharge of the pump and imparting to the motor any desired positive cyclic movement.

37. In an hydraulic power transmission system, a motor, a variable capacity pump for delivering fluid to said motor, cam actuated means operated in synchronism with the pump for controlling the discharge of the pump and imparting to the motor any desired positive cyclic movement, hydraulic means for controlling the stroke of said pump, and means for limiting said stroke.

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