Oct. 7, 1941. F. E. SCHEIDER 2,258,103

WELL PUMPING APPARATUS

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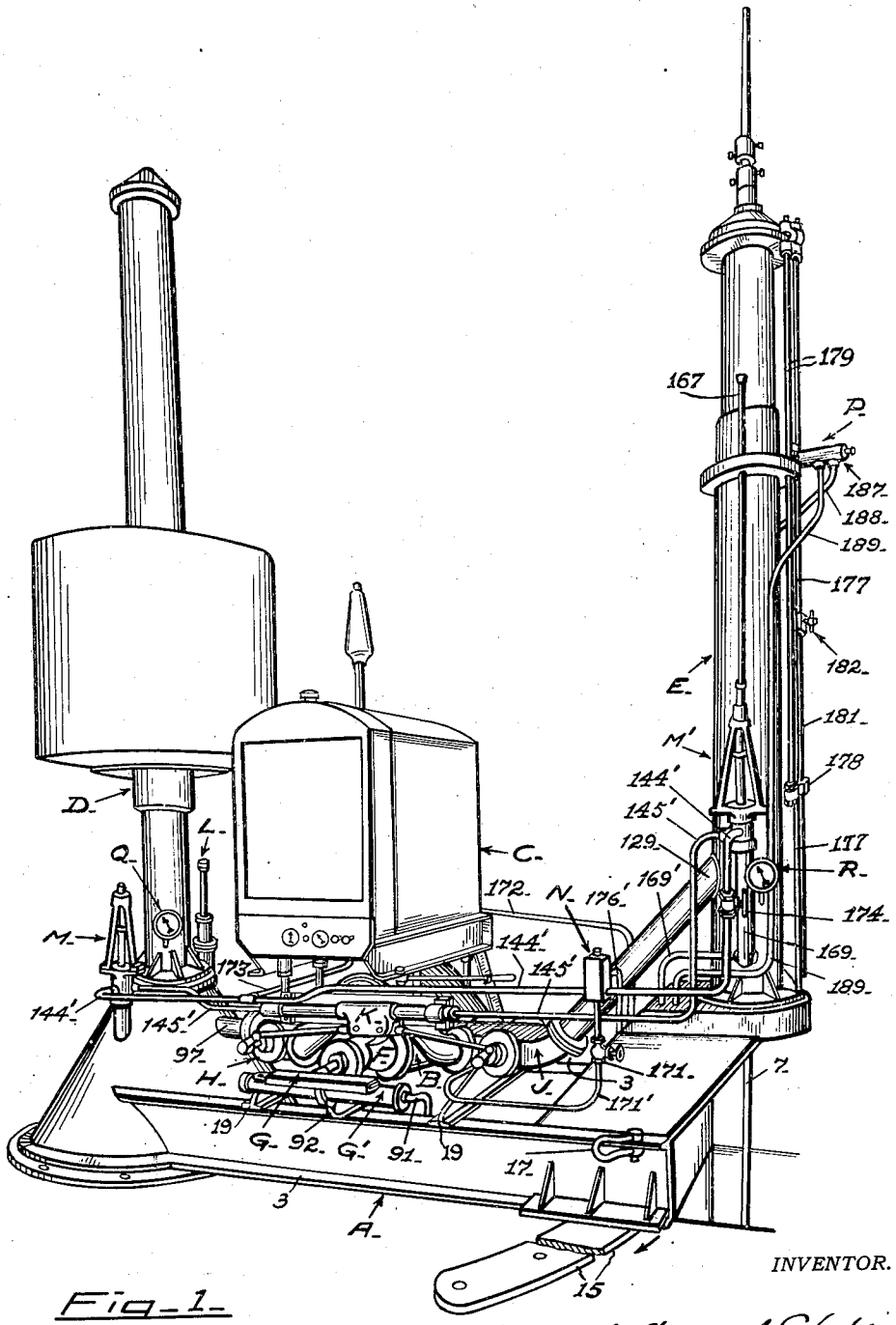


Fig-1-

INVENTOR.

Friedrich Edmund Scheider

Oct. 7, 1941. F. E. SCHEIDER 2,258,103

WELL PUMPING APPARATUS

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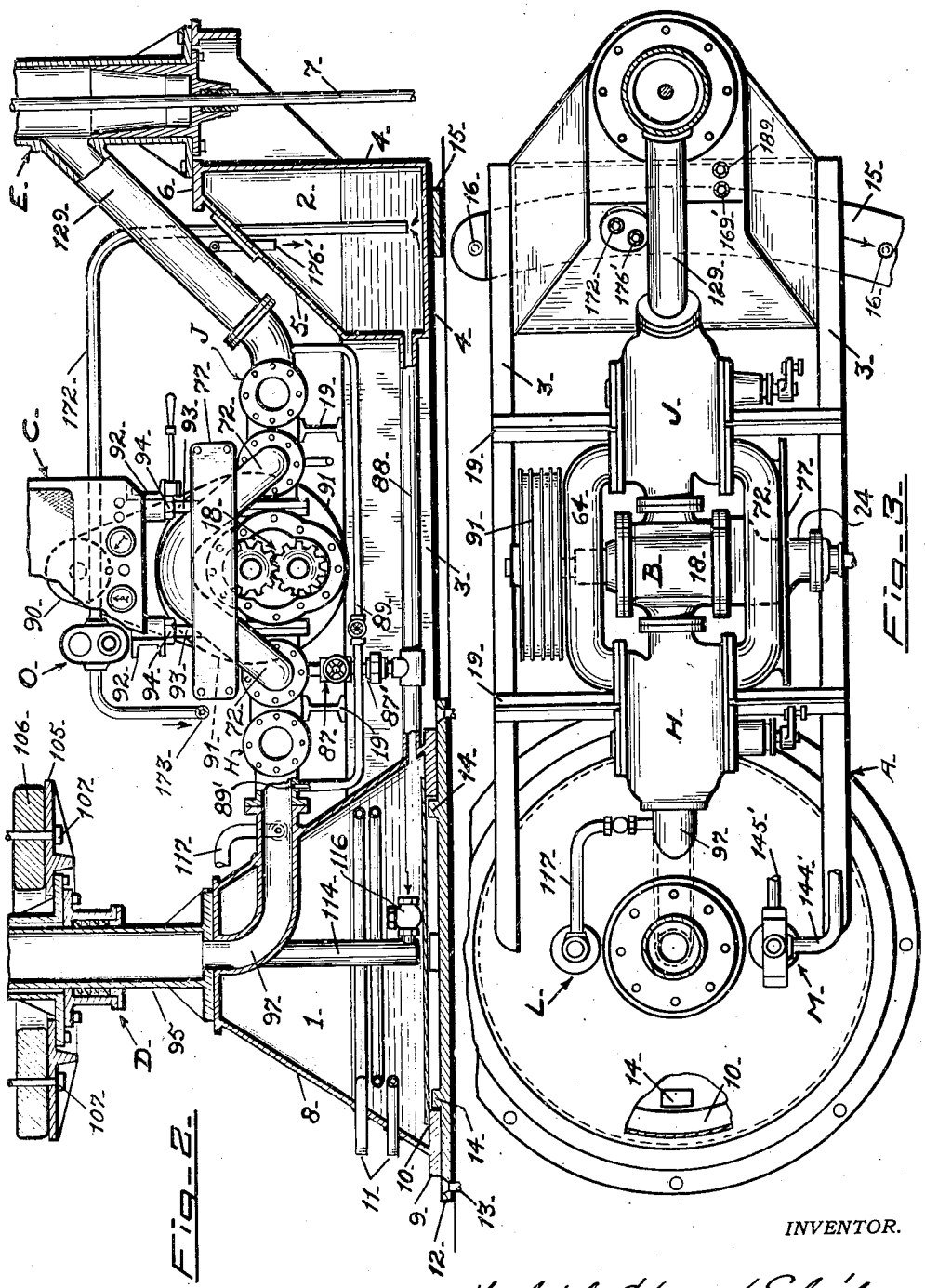


Fig. 2.

Fig. 3.

INVENTOR.

Fredrick Edmund Scheider

Oct. 7, 1941. F. E. SCHEIDER 2,258,103

WELL PUMPING APPARATUS

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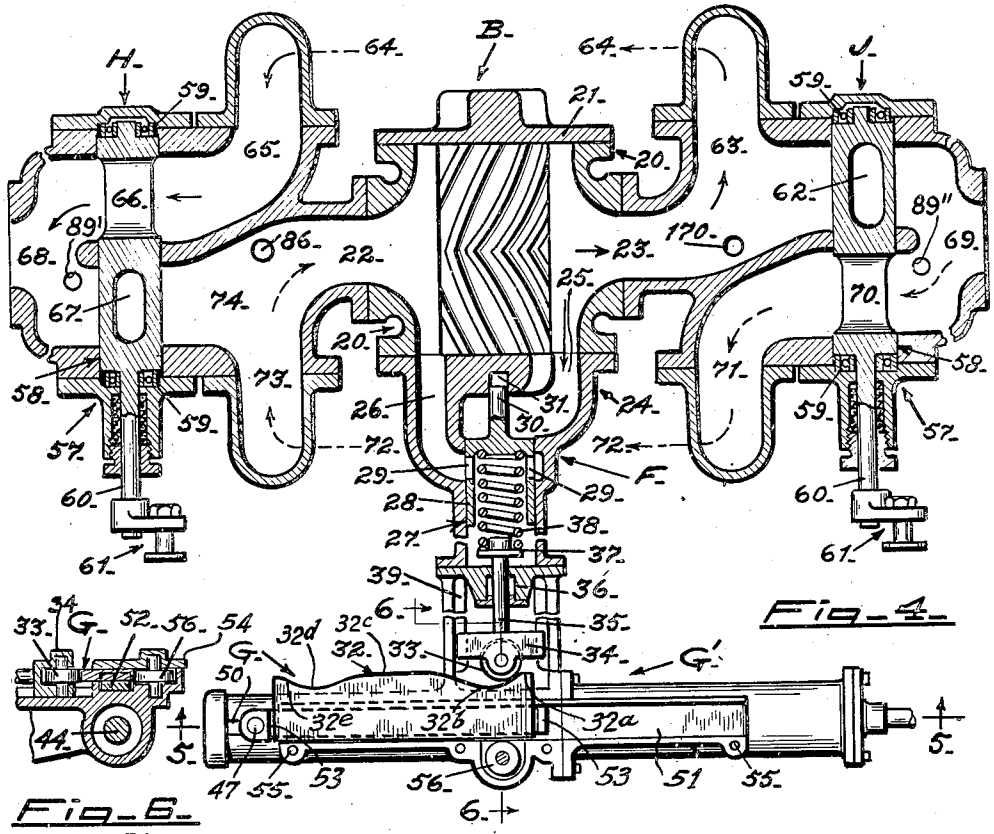


Fig-4-

Fig-6-

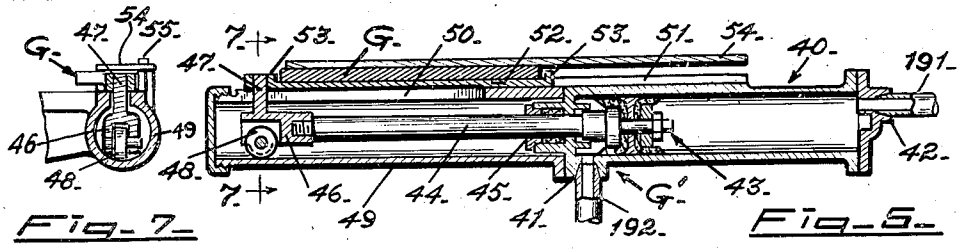


Fig-7-

Fig-5-

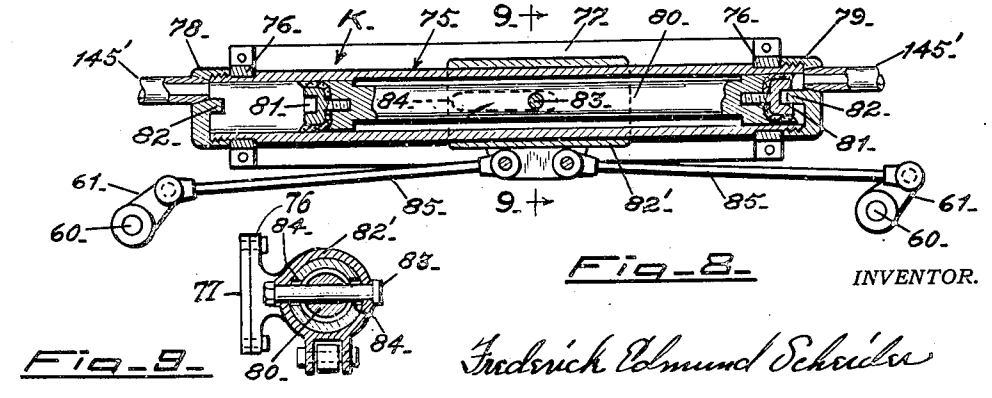


Fig-8-

Fig-9-

INVENTOR.

Frederick Edmund Scheider

Oct. 7, 1941. F. E. SCHEIDER 2,258,103

WELL PUMPING APPARATUS

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Fig. 10.

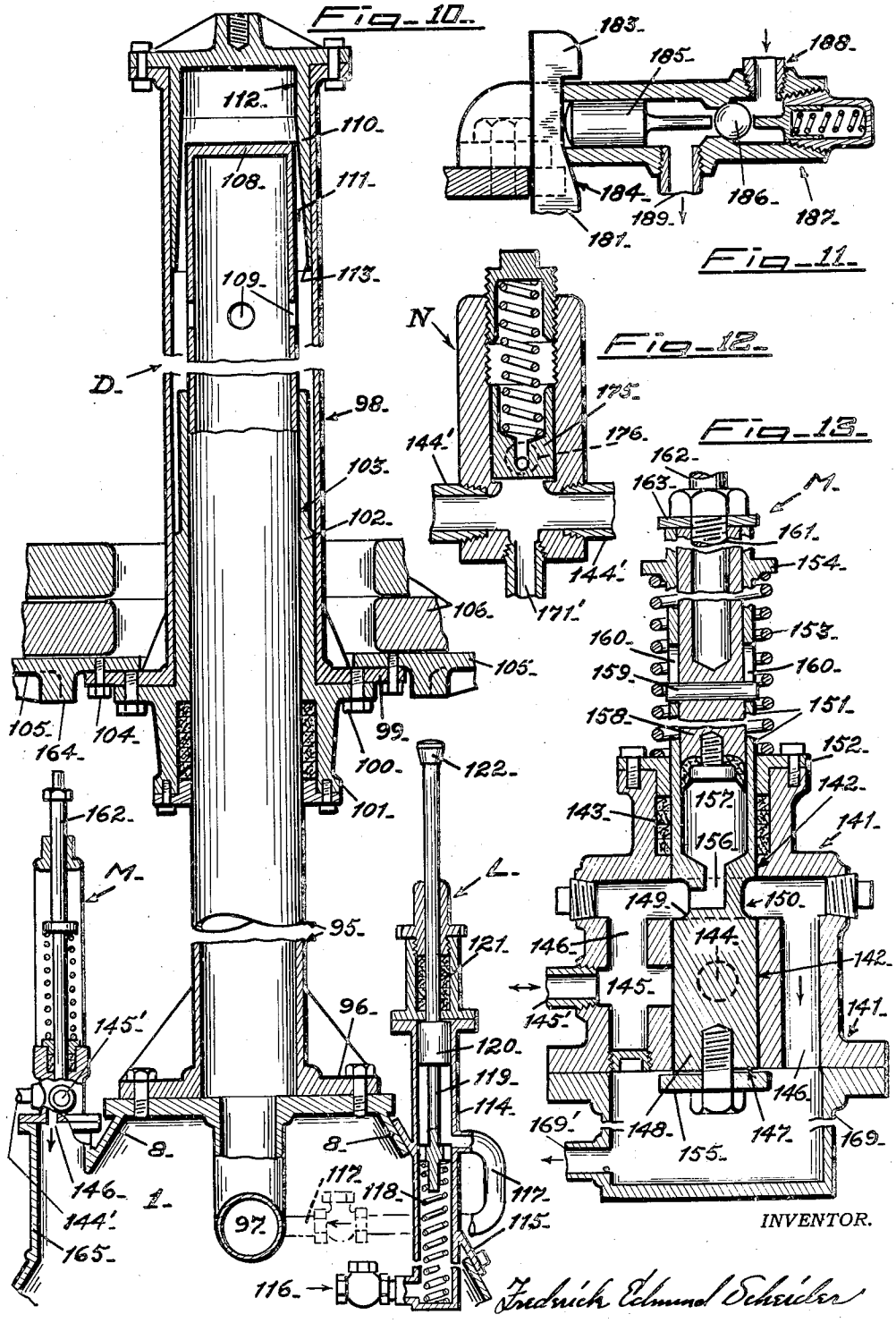


Fig. 11.

Fig. 12.

Fig. 13.

INVENTOR.

Friedrich Edmund Scheider

Oct. 7, 1941. F. E. SCHEIDER 2,258,103

WELL PUMPING APPARATUS

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Fig. 14.

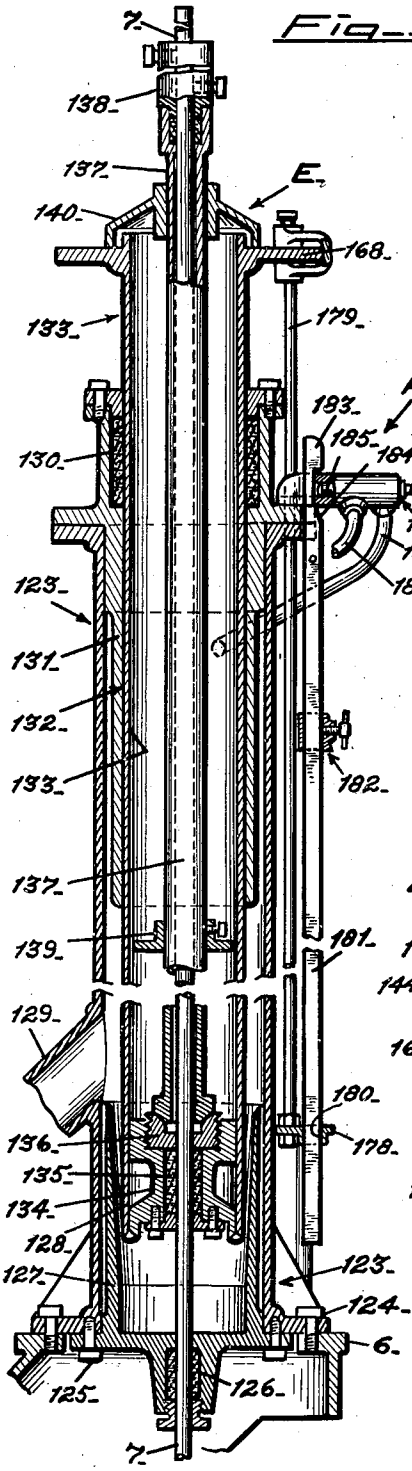


Fig. 15.

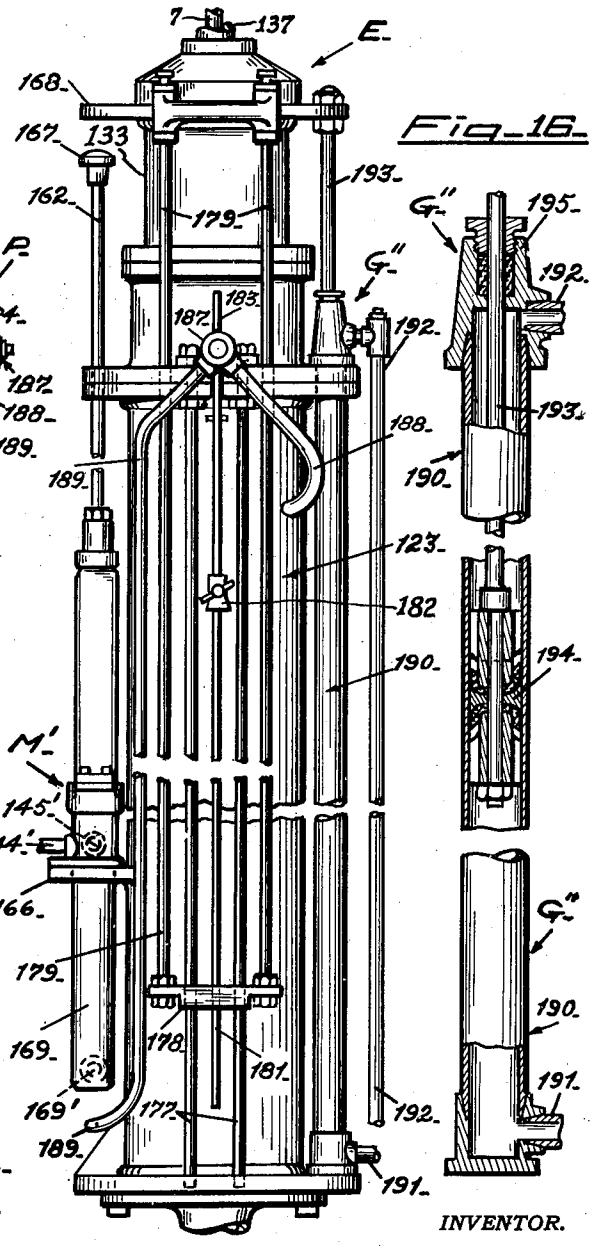


Fig. 16.

INVENTOR.

Frederick Edmund Scheider

Patented Oct. 7, 1941 2,258,103

UNITED STATES PATENT OFFICE

2,258,103

WELL PUMPING APPARATUS

Frederick Edmund Scheider, Los Angeles, Calif.

Application July 9, 1938, Serial No. 218,351

10 Claims. (Cl. 60—52)

The present invention relates to an improved well pumping apparatus of which one embodiment includes a hydraulic engine for operating the sucker rod of a well, an accumulator for assisting in and controlling the operation of said engine, a hydraulic pump unit controlled by and which operates said engine and accumulator, and control valves and devices associated with the aforesaid elements and which together with said engine, accumulator and pump unit are constructed, interrelated and operated to provide for certain advantages and objects as will hereinafter appear.

One of the objects of this invention is to provide for the advantageous use of a comparatively long stroke of the sucker rod, for increasing the output of the well over given pumping periods without entailing appreciably increased production costs.

Another object of this invention is to provide a self-contained pumping unit which may be readily and easily bodily shifted to one side of its operating position to afford full access to the well parts.

Another object is to provide a well pumping jack unit, wherein a novel form of base structure therefor is provided with an air-tight reservoir for an adequate supply of hydraulic operating fluid and includes means for cooling such fluid whereby to prevent aeration and gasing thereof and consequently prevent failure of efficient performance of the several hydraulic units of the system.

Another object is to provide means for automatically injecting cooled fluid from a supply reservoir into the working system and likewise returning to said reservoir from said system, predetermined quantities of operating fluid, during operation of the hydraulic units of the apparatus, whereby to insure the presence in the system of operating fluid in such adequate amount and in such cooled condition as to provide for an efficient operation of the entire unit at all times.

A further object is to provide a fluid injecting means such as described which may be controlled and operated to introduce predetermined amounts of operating fluid into the system for the purpose of varying the length of the stroke of the accumulator and the hydraulic engine which actuates the sucker rod, whereby to vary the length of the stroke of the latter to best suit the particular well or conditions at hand.

A further object is to provide in the apparatus and system hereof a simple and effective means operative at and through the hydraulic pump unit thereof for varying the velocity and timing of the stroke of the sucker rod engine and associated accumulator to provide a lag during the "stretching" action of the sucker rod at the beginning and end of each stroke and for an accelerated stroke between such lag periods, whereby to provide for substantially the same length of stroke at the pump within the well as produced at said engine at the top of the well.

Another object is to provide a stroke velocity or timing control means of the character described which is operative through varying the volume-pressure output of the main hydraulic pump of the unit, and wherein said pump is so constructed as to readily lend itself to such variable pressure output under control of valve means in turn automatically controlled by the sucker rod engine for the purpose of controlling the movement of the sucker rod as aforesaid.

Yet another object is to provide for controlling the velocity of the sucker rod per stroke as aforesaid through the medium of stroke dampening means embodied in the accumulator and sucker rod engine, and wherein said means work in conjunction with the aforesaid valve means to jointly control the timing of the sucker rod stroke.

A further object is to provide a hydraulic sucker rod engine of the character described wherein the sucker rod load is suspended from the lower end of the plunger or piston thereof and provision is made for relative adjustment of the sucker rod at the top of said engine and plunger, whereby to eliminate damaging and objectionable out of line friction producing stresses and distortion in the engine and also provide for an easier and more readily effected attachment, detachment and adjustment of the sucker rod with respect to said plunger.

Yet another object is to provide a self-contained hydraulic pumping system from all parts of which inclusive of the storage reservoir for the operating fluid, air is excluded at all times to prevent aeration of such fluid and thereby insure full operating efficiency of the system.

With the above and other objects in view the invention consists in the novel method and combination of parts hereinafter described, illustrated in the accompanying drawings, and set forth in the claims hereto appended, it being understood that various changes in form, proportion, size and minor details of construction within the scope of the claims may be resorted to without departing from the spirit or sacrificing any advantages of the invention.

Referring to the drawings:

Figure 1 is an elevational perspective view of the apparatus of this invention.

Figure 2 is a longitudinal view of the apparatus showing the base portion in section with directly associated parts such as the prime mover in fragmentary elevation and the pump unit as in elevation with the valve gear operating means thereof removed for clarity of illustration.

Figure 3 is a plan view of Figure 1 with the prime mover omitted for clarity of illustration of the disposition of the pump unit parts.

Figure 4 is a sectional view of the main pump unit taken on a horizontal center line plane showing the disposition of valve controlled pump flow passages and in addition illustrating, partly in elevation, the control means provided for the by-pass valve.

Figure 5 is a sectional view taken on line 5—5 of Figure 4.

Figure 6 is a sectional view taken on line 6—6 of Figure 4.

Figure 7 is a sectional view taken on line 7—7 of Figure 5.

Figure 8 is a longitudinally sectional view of the hydraulically operated valve gear actuative of the main valves controlling the direction of liquid flow to and from the main pump unit as operative of the apparatus.

Figure 9 is a sectional view on line 9—9 of Figure 8.

Figure 10 is a vertically sectional view of the hydraulic accumulator of this invention.

Figure 11 is a sectional detail view of the valve means employed for automatically controlling the process of retention or withdrawal of operating liquid otherwise injected into the hydraulic flow of the apparatus.

Figure 12 is a sectional detail view of one form of relief valve employed.

Figure 13 is a sectional view of the governor valves controlling the operation of the hydraulically operated valve gear which in turn operates the main valves controlling and directing the main pump liquid flow.

Figure 14 is a vertically sectional view of the hydraulic engine of this invention.

Figure 15 is a "head on" elevational view of the hydraulic engine of the apparatus showing the position of parts complementing the main structure thereof.

Figure 16 is an enlarged detail view of the hydraulic impeller actuated by the engine plunger for relatively controlling the operation of the main pump by-pass valve.

One form of well pumping apparatus of this invention generally comprises a base A, a hydraulic pump unit B, a prime mover C for driving said pump, a hydraulic accumulator D controlled by the pump unit and adapted to stand on the fluid column thereof for counterbalancing a certain portion of the well pumping load, and a single acting hydraulic engine E actuated by said accumulator and pump unit and adapted to operate a well pump. These elements and their associated parts are so constructed and arranged as to comprise a hydraulic pumping jack which will operate to raise and lower, in alternating relation, the hydraulic engine plunger (connected to the sucker rod of a well) and the accumulator (with said two units substantially counterbalancing one another) when the volume-pressure flow of a fluid circulated by said pump unit is automatically directed to first one and then the other of said units in accordance with this invention.

The base A is constructed to provide for an air-tight storage and the cooling of a supply of hydraulic fluid to be automatically injected into and automatically withdrawn from the system. It is here noted that the main liquid circulating system of the apparatus is devised to provide for the exclusion of air therefrom and that by further using a liquid from an air-tight cooled supply thereof for hydraulically operating the apparatus hereof aeration and gasing of the liquid that would otherwise occur upon long periods of use thereof is effectively prevented.

In accordance with this invention a regulatable quantity of cooled liquid is constantly and automatically injected into the liquid flow volume utilized in operating the device for the purpose of first, cooling the said liquid volume and from which, in the case of maintaining a "set" length of the pumping stroke, a like volume is automatically withdrawn and returned to storage for cooling, or second, such constantly injected liquid may be utilized, at will, to "build up" the working liquid volume to increase the length of the pumping stroke. Reversely, by the automatically gradual withdrawal of liquid from the operating flow volume in excess of that quantity being constantly injected, the length of the pumping stroke is caused to automatically "settle down" to any desired "set" length thereof, be rendered constant upon stoppage of liquid withdrawal in excess of the injected supply and thus continue as a "set" pumping stroke cycle; into the requisite operating flow volume of which a constant automatically supplied cooled liquid is injected and a like quantity withdrawn.

Base A

The base A as here shown includes air-tight reservoirs 1 and 2, Figure 2, held spaced apart by steel shapes 3. As here shown the reservoir 2 is formed of slide and bottom walls 4 and a sloping upper wall structure 5 terminating in a support 6 for accommodating the mounting of the cylinder of the hydraulic engine E whereby a vertical direct-in-line connection of the engine piston to the sucker rod is effected. As here shown the wall 8 of the reservoir chamber 1 is of truncated conical form and the horizontal upper surface thereof is of sufficient area to accommodate the mounting of the accumulator D. It is here noted that the structure forming the chamber 1 provides for the mounting of an injector pump unit L and a control valve M for the hydraulic pump valve gear F. The conical wall 8 is welded at its lower edge to an annular base 9 to which the bottom 10 of chamber 1 is secured. A pipe coil 11 provides for circulation of water or other medium adapted to cool the fluid stored in the chamber or reservoir 1. A circular sole plate 12 or the like is interposed between the base 9 of the chamber 1 and a suitable foundation (not shown) upon and to which the sole plate is secured by suitable means as the bolts 13. The sole plate 12 is further provided with the lugs 14 adapted to engage the inner annular surface of the base 10 and maintain this end of the base structure pivotally or rotatably supported upon its foundation structure. What may be termed the well end of the base structure A rests upon an arcuate sole plate 15 or the like secured to the foundation as by means of the bolts 16. It is worthy of note that this structure provides a pivotal

or turntable mounting for the device as a unit; whereby the end thereof overhanging the well may be swung or skidded aside, by suitable tackle or winch gear (not shown) attached to the base as by the clevis 17, Figure 1, thus providing for unobstructed access to overhead gear such as derrick equipment used in raising or lowering well structure parts.

Pump unit B

The hydraulic pump unit B as here shown consists of a gear type or other suitable pump 18 disposed between the reservoirs 1 and 2 being held in position by the cross members 19 secured to the base members 3. This pump includes a circumferential housing 20, Figure 4, an end bell 21, inlet port 22 and outlet port 23 of conventional form, but differs from the conventional form of such devices in having one end bell 24 provided with an automatic control valve F interconnecting the pump discharge and inlet; whereby the otherwise constant volume-pressure output of the pump is automatically modulated and applied to produce any desired working or movement cycle of the parts effecting the pumping stroke.

As valve stems and the like are packed in the usual manner to prevent leakage and the various fittings and parts of the unit are secured together by conventional bolted flange connections, specific reference thereto is omitted except where pertinent for clarity of description.

The automatic control valve F comprises the end bell 24 having the passages 25 and 26 respectively communicating with the pump discharge and inlet, and a bore 27 intercommunicating the said passages and provided with a hollow piston 28 having the ports 29 and the dashpot piston 30 adapted to register with the dashpot 31. In closed and open positions the ports 29 of the piston 28 register with the passage 26 to permit the escape of liquid which would otherwise be trapped in the cylinder behind the piston and prevent rapid control movement thereof. In the act of closing, the dashpot action of the piston 30 and dashpot 31 cushion the movement of the valve and act as a limit stop therefor. It is worthy of note that this valve operates rapidly at high pressures without pounding or chattering. It is seen that the pressure of the pump discharge tends to open and that any opposed force acts to close the valve and that when such opposed force is applied as a variable or is maintained constant at any chosen degree of intensity the volume-pressure output of the pump will be either fully maintained or proportionally bypassed to the inlet side of the pump and that in consequence the work output of the pump then applied to produce a pumping stroke will correspondingly vary the action of each stroke cycle relative to dwell or pause periods at each end of the stroke and provide for acceleration, deceleration or constant velocity action of each pumping stroke cycle. Such control of the pump output is effected by means of a cam G adapted to control the "setting" of the valve F, and by means of cam substitution the one for another each having a different cam curve, an infinite number of pump output cycles is attainable, the movement of the cam being synchronized with the pumping stroke and effected by suitable means (as those later described) actuated by that portion of the apparatus acting to produce the desired sucker rod movement.

As here shown the cam G, Figure 4, has a face 32 adapted to engage a roller 33 mounted in a guide 34. This guide is provided with a stem 35 which passes through a stuffing box 36 and terminates in a socket 37 engaging one end of a compression spring 38 the other end of which latter engages the hollow piston 28 of the valve F. The bonnet structure of the valve F is formed to provide guideways 39, for the guide 34, and to support the operating means G' for the cam G. This operating means is actuated by a hydraulic impeller G'', Figures 15 and 16, controlled by the main engine E. The operating means G' comprises a cylinder 40 having the pipe connections 41 and 42 and a piston 43, the rod 44 of which latter passes through a stuffing box 45 and is connected to a block 46. This block has an upwardly projecting pin 47 and supports a guide roller 48. A cylindrical extension 49 of the cylinder 40 surrounds the piston rod and block 46 and is provided with a longitudinal slot 50 through which the pin 47 projects, the inner surface of the cylindrical extension 49 serving as a runway and guide for the roller 48. The cylinders 40 and 49 are provided with a grooved guideway 51 for a cam supporting shoe 52 affixed to the pin 47. The shoe 52 is provided with the abutments 53 adapted to embrace the ends of the cam member G which latter, to simplify cam exchanges, is simply laid therein-between and held in place by the cover plate 54 secured by the bolts 55. A roller 56 is disposed to engage the cam to provide for antifrictional movement thereof.

The pump unit B also includes tri-chambered and ported fittings H and J, Figures 2 and 4, identical in form but set and connected to the pump inlet 22 and outlet 23 with similar lead and ported passages positioned in diagonally symmetrical order with relation to the longitudinal axis of the unit. Each of the said fittings is provided with cylindrical valves 57 adapted to rotate in bores 58 on the ball bearings 59, the valve stems 60 of each valve being provided with crank arms 61. As shown in Figures 2 and 3, certain passages of the fittings H and J are interconnected by crossover ducts illustrated as syphon shaped pipes, later designated. With reference to Figure 4 and considering the respective lead passages and valve ports in the order narrative of liquid flow to and from the pump, and with the valves 57 set in position illustrated as governing one cycle of the two conditions of pump flow, the parts are designated as follows. In the one instance, the port 62 being closed, the continuously one directional pump discharge flows through the passage 63, crossover 64, passage 65, open port 66 and by means of closed port 67 is caused to exit at the opening 68, while simultaneously inlet of liquid to the pump will occur through the opening 69, open port 70, passage 71, crossover 72 and passage 73 to the pump inlet 22. Reversely, by simultaneously throwing the valves 57 (by means later described) to positions wherein port 62 is opened and ports 66 and 70 closed, it is seen that the pump discharge is effected through port 62 to exit at opening 69 while simultaneously liquid inlet to the pump will (as port 66 is now closed) occur through the opening 68, the now open port 67 and passage 74 to the pump inlet 22. It is now seen that the volume-pressure output of the pump 18, automatically controllable by the valve F, is caused to exit at either end of the pump unit and that simultaneous inlet of fluid to the pump will be also caused to occur through either end thereof

in relation alternating with that of the discharge flow.

Any suitable means may be employed for actuating the valves 57 in unison and as the said ports are positioned therein at right angles to each other respectively, each valve is correspondingly rocked through a ninety degree arc in the act of alternately setting the valves. As here shown, Figure 8, a hydraulically operated valve gear K comprises a barrel 75 fixed by brackets 76 to a plate 77, Figures 2 and 3, secured to the crossover pipe 72. The barrel 75 has capped ends 78 and 79 to which fluid conductors (later designated) are connected. Within the barrel 75 is mounted a floating plunger 80 the cup leathered ends thereof provided with dashpots 81 adapted to register and engage respective dashpot pistons 82 at the end of each one way plunger stroke. Slidable on the exterior of the barrel 75 is a sleeve 82' guided by a bolt 83 sliding in the slots 84 of the barrel 75 and passing through a hole in the plunger 80, whereby said plunger and sleeve are united for reciprocal movement which is changed to and imparted as rocking movement of the valves 57 by means of connecting rods 85 and the respective crank arms 61. It is now seen, that upon the forceful admission and simultaneously free discharge of fluid from opposite ends of the barrel 75 and by alternating such admission and discharge, the said plunger ensemble will be alternately reciprocated in the said barrel and be cushioned and stopped by the said dashpot at each end of a stroke of such length as will, in combination with the radius length of the crank arms 61, simultaneously rock the valves 57 to alternating positions controlling the direction of the liquid flow to and from the pump 18 in the manner above described and for the purposes later set forth.

Further, the pump unit B is provided with a priming inlet 86, Figures 4 and 2, communicating with the pump inlet 22 and connected through a valved pipe 87 to the pipe 88 which interconnects the reservoirs 1 and 2 for free circulation of fluid there-between. The openings 68 and 69 of the pump unit are also interconnected by the valved pipe 89 extending between openings 89' and 89'' Figures 1 and 4. By this means, opening of the valve in the line 89, effects by-passing of the operating liquid from the accumulator to the engine and vice versa. For example, when starting operation of the system, as when raising the accumulator as later described, a sufficient quantity of the operating fluid from the accumulator may be by-passed to the engine to raise the plunger thereof "off the bottom" of the cylinder for the desired clearance of working parts. Further, the by-passing of the operating liquid effects, as desired, relative positioning of the plungers of the accumulator and engine in operation.

The prime mover C for the pump unit B may be of any conventional form and as here shown consists of a suitable automotive engine unit which drives the pump through pulleys 90 and 91, Figures 2 and 3. The engine unit C is mounted on a suitable frame 92 vertically adjustable for belt tightening on the stanchions 93, mounted on the crossover pipes 64 and 72, and provided with the adjustment nuts 94.

Accumulator D

The accumulator D is provided for the purpose of substantially counterbalancing the weight of the well sucker rod plus one half of the well liquid column load, and for counteracting frictional inequalities resulting from movement of mechanical parts of the device together with that of the fluid flow utilized to move these parts, and also for compensating the "drag load" of the sucker rod as variably characterized in each well.

As the mechanical advantage exercised and derived from the use of the accumulator is that of standing on the well sucker rod load as counteractive thereof, it is apparent that by means of the accumulator, loaded to substantially counterbalance three fourths of the well pumping load, the power input of the device exercised in pumping the well is applied as a constant equal to substantially one fourth of the power required to otherwise directly raise the combined well sucker rod and liquid column load. To illustrate; as will appear as this description progresses, the weighted accumulator moves downward on the column of operating fluid between it and the inlet to the pump 18 as the liquid discharge therefrom, simultaneously occurring, raises the well sucker rod-liquid column load. Under conditions, for example, wherein liquid column and sucker rod weights are substantially equal per vertical foot of pumping lift, as roughly common in the art, and assuming the rod weighs one pound, the combined rod-liquid column two pounds, and the counteractive accumulator load one and one half pounds, then a one half pound differential power input is therefore required to raise the sucker rod. Conversely, lowering the one pound sucker rod and raising the one and one half pound accumulator requires a one half pound differential of input effort.

As here shown the hollow plunger 95, Figures 10 and 2, of the accumulator D is secured in upright position on the top of the structure forming the chamber 1, being secured thereto by the bolted flange connection 96 wherefrom a pipe 97 extends through the chamber wall 8 in sealed relation thereto and thereafter is connected to the opening 68 of the pump unit B. In the instance of this invention the plunger barrel is the moving part with the plunger stationary and consists of a barrel 98 having a flange 99 to which is secured, by bolts 100, a stuffing box 101 the skirt 102 of which extends into the barrel and is bored to provide a working fit and guideway 103 for the barrel as reciprocated on the plunger. Otherwise, throughout their length the walls of the barrel and plunger are in spaced relation to each other for the purpose of first, providing an annular space adapted to receive a stroke dampening or retarding device later described and second, obviate the necessity of bore finishing the barrel throughout its length to a working fit on the plunger.

Resting upon the flange 99 and secured thereto by the bolts 104 a circular platform 105 provides a base upon which a plurality of weight members 106 are stacked and held in place by the rod bolts 107, Figure 2. It is here noted that the combined weight of the members 98, 102 and 106 is such as to provide the counterbalancing operation of the device as above described.

The respective lengths of the plunger 95 and barrel 98 being such as to provide the desired length of operating stroke, the top or head of the hollow plunger is closed as at 108 and the plunger wall provided with the ports 109. It is worthy of note that the upper end of the barrel 98 is devised to provide, with relation to the arrangement of the plunger head, a novel form of auto-

matic stroke retarding means operative as controlling both the beginning and ending of stroke travel wherein the plunger head and upper end of the barrel are in conjunction. As illustrated the upper end of the barrel is closed by a bonnet or liner 110 adapted to progressively encircle the plunger head providing the annular clearance space 111 thereof which in ratio thereto decreases toward the end of the barrel and terminates in a bore 112 slightly larger than the diameter of the plunger. In normal stroke operation, controlled as later described, the weighted barrel when standing on the fluid column is stopped "short" of that position wherein the plunger head would enter the bore 112 but in abnormal conditions wherein the weighted barrel would drop; the plunger, coacting with the bore portion 112 constitutes in effect a cushioned or dashpot stoppage of the descent of the weighted barrel. In contradistinction as to the reaction of the respective parts of the bonnet with relation to movement of the plunger head, the bore 113, illustrated as providing a right circular conical surface but in practice devised as a conical surface generated by a curvilinear line segment of desired contour provides a surface which together with the cylindrical exterior surface of the plunger head forms the annular space 111 of novel character constituting an automatically efficient means for dampening or retarding both the beginning and ending of a stroke wherein the respective parts are adjacent one another as described. For, in the one instance as that of beginning the up stroke (with parts related as illustrated) and with a volume-pressure pump discharge (effected as described) flowing through the ports 109 to actuate the up stroke, it is seen that the fluid flow must first "squeeze" through a minimum clearance space (allotted as to area by the stroke stop relation of the barrel to that of the plunger head as more or less telescoped) before becoming effective as volume-pressure input sufficient to begin the stroke, and be followed up by progressively increased volume-pressure admission for the duration of the stroke movement wherein the parts are in telescoped relation. Conversely, during the down stroke the fluid volume utilized to produce the foregoing up stroke is expelled from the barrel under pressure, controlled in intensity by the desirable dead-weight load imposed on the barrel, and occurring as a return flow of fluid through the ports 109 to the inlet of the pump 18 in the manner above described. During termination of the down stroke of the barrel the end of the plunger first enters the largest clearance area provided by the open end of the liner 110 and as it progressively telescopes the plunger head, in continued descent, the clearance area 111 is variably restricted causing directly relative resistance to expulsion of fluid from the barrel liner thereby automatically retarding termination of the down stroke of the barrel, heavily loaded to counterbalance operation of the device as above described.

Influx pump L

As means for automatically causing an influx or injection of cooled fluid into the system for the purposes specified an injector or influx pump L is provided. As here shown a pump of the piston type is employed and consists of the cylinder 114, Figures 10 and 2, passing through and secured, by the bolted flange 115, to the wall 8 of reservoir chamber 1 and provided with the foot valve 116, submerged in the fluid supply to be injected into the system. A non-return check valved pipe 117 connects the pump discharge to the pipe 97 and the main circulating system of the main pump unit B. Within the bottom of the cylinder 114 a compression coil spring 118 reacts to upwardly urge the lower spider formed end of a piston rod 119 having a piston 120 thereon and which thereafter extends through a stuffing box 121 and terminates in a head 122, adapted to be engaged and depressed by the platform 105 on the accumulator barrel 98 during termination of the stroke movement of the latter. It is seen that the spring-urged up stroke of the piston 120 primes the pump with the cooled liquid from storage and that the down stroke injects a quantity thereof, proportional to the piston movement, into the fluid volume operating the system wherefrom a like quantity is either removed or retained for the purposes above set forth and effected by a means later described.

Hydraulic engine E

For the purpose of directly operating the well sucker rod by the means of this invention, first, to automatically cushion the action of peak load stresses on the rod, secondly to provide means for suspending the rod load from the lowermost portion of the means connected to and serving to operate the pumping stroke thereof, thereby eliminating lateral load friction and strains, thirdly to provide means automatically effecting, at will, either the withdrawal or retention of surplus operating fluid injected into the system as and for the purpose specified; and lastly to provide means for automatically diminishing or increasing the sucker rod stroke, control its stroke limits and exercise variable control of progressive stages of sucker rod stroke movement; the hydraulic engine E here employed is constructed and operated as will now be described.

As here shown the single acting hydraulic engine E consists of the cylinder or barrel 123, Figures 14 and 15, secured on the top 6 of the structure forming the chamber or reservoir 2, by means of the bolted flange connection 124. By means of the bolts 125, a stuffing box 126 is secured to the connection 124 and the skirt or liner 127 of this box extends into the barrel 123 and is bored to form with the plunger head 128 a combination of elements functioning in the same manner and for the same purpose as previously described in connection with the liner 110 and plunger head of the accumulator D. By thus controlling the initial velocity of the up stroke movement of the sucker rod to, in this instance, cause the well mouth end thereof to dwell or pause for an appreciable and regulatable period of time allowing the well bottom end to have reached the limit of elongation occurring upon reversal of rod stroke movement; peak rod-loads are proportionally diminished and the pumping stroke volume output of the well pump increased. In other words by the act of synchronizing the relative movement of the upper and lower ends of the sucker rod, unnecessary rod elongating strains are eliminated and pumping output increased inasmuch as the rod then becomes an element of more constant length whereby the well pump stroke substantially equals the well mouth apparatus stroke.

From the engine cylinder 123, at a point just above the rim of the liner 127, Figure 14, a pipe 129 connects with the opening 69, Figure 4, of the pump unit B. The upper end of the engine cyl-

inder 123 is provided with a stuffing box 130, the skirt 131 of which extends into the cylinder and is bored to provide a working fit and guideway 132 for the plunger 133. The exterior wall of plunger 133 operates, throughout the stroke length, in spaced relation to the inner wall of the cylinder for the same purposes as hereinbefore described for the accumulator. The lower end of the hollow plunger 133 is closed by a plug member 134 providing for the polish rod stuffing box 135 and a screw threaded valve-like seat member 136. This seat is adapted to receive and support the lower end of a hollow column 137 through which the sucker or polish rod 7 extends and by and upon the top of which the sucker rod load is borne as by set collars 138. It is here noted that by the means thus provided the sucker rod load is suspended from the lower end of the engine plunger 133; thus eliminating lateral stresses tending to cant the plunger with relation to the barrel, a feature of importance when considering the device as characterized by a pumping stroke of twenty feet or more. Further, the means as devised provides ready accessibility to the parts effecting; adjustment, removal or fastening of the sucker rod with respect to the engine plunger, for the column 137 having the guide disk or disks 139 and cap member 140 loosely engaging the plunger, may be readily withdrawn from the plunger barrel as a unit. Further, it is apparent that upon alternate admission and withdrawal of fluid from the engine cylinder 123 the plunger thereof is caused to reciprocate and cause a pumping stroke movement of the well sucker rod connected thereto.

Governor Valve M

The openings 68 and 69 of the pump unit B are respectively connected by the pipes 97 and 129 to the accumulator D and hydraulic engine E, and the direction of flow of the fluid in the pump unit described is controlled by the valves 57 when and as actuated by the valve gear K. For synchronizing the operation of the valve gear K as controlled by and in turn controlling the alternating stroke movements of the accumulator and engine; the governor valves M and M' are provided. As both are identical in structure and operation, a description of the one will serve for the other.

As here shown the governor valve M comprises a body portion 141, Figure 13, having the centrally located bore 142 provided with the stuffing box 143. Conduit connecting ports 144 and 145 communicate with the central bore 142, the former serving as an inlet and the latter as an outlet and inlet to the central bore 142. A port 146 serves port 145 in by-passing or closed relation as will appear. Slidable in the bore 142, a plunger 147 provides a lower portion 148 for controlling the ports 144 and 145. A neck portion 149 provides an annular space or ring port 150 which in one position of the plunger (see Figure 13) serves as an open passageway in the port 146 and which, upon downward movement of the plunger whereby to align the said space with the ports 144 and 145 serves as an intercommunicating passageway between them. Above the neck 149 the plunger 147 is extended as a hollow cylinder portion 151 passing through and extending beyond the stuffing box gland 152 a sufficient distance to accommodate a suitably resilient compression coil spring 153. This spring is interposed between the stuffing box bland and the collared end 154 and urges the plunger upwardly an extent as permitted by the stop 155. A port 156 interconnects the ring port 150 with the chamber 157 of the plunger barrel 151 wherein the cup leather fitted piston 158 is free to move between limits set by the ends of the stop pin 159 (transversely fixed in the piston) extending into and respectively engaging the ends of slots 160 in the plunger 147. With the stop pin 159 engaging the bottoms of the slots 160 the upper end of the piston 158 is flush with the upper end of the plunger 147 and is adapted, as by the threaded bore 161, to mount a push rod 162 in turn adapted, as by use of the collar 163, to simultaneously engage and depress the plungers and piston. In operation of the valve the conduit port 145 serves as an outlet and inlet for the fluid flow and with the parts in the relative position illustrated the port 145 and the now open by-pass port 146 accommodate a return flow to discharge through said ports as the fluid inlet port 144 is closed. With reference to the preceding up stroke of the plunger ensemble, fluid pressure in the chamber 157 has forced the piston 158 upward until the stop pin engages the upper end of the slots 160 whereupon relative movement of the piston in the plunger barrel ceases and both are held against further upward movement, urged by the spring 153, by the stop-collar 155 on the bottom of the plunger. It is now seen that initial downward movement of the push rod 162, first lowers the piston to the position illustrated as that of contact of the push rod collar 163 with the now flush top ends of the piston and plunger and with the stop pin 159 at the lower ends of the slots 160. As continued descent of the rod-piston-plunger ensemble occurs, the full size portion of the plunger just above the port 146 supplants the ring port 150 thereby closing port 146. Upon continued travel whereby the confines of the ring port are wholly enclosed by the plunger bore 142 the lower limit of the ring port passes or opens relative to the upper limit of the port 144 whereupon fluid (under pressure) rushes through the now wholly enclosed ring port and communicating port 156 to the chamber 157 and by reaction between opposed ends of the "downheld" piston 158 and chamber 157 "snaps" the plunger downward against the action of the spring 153 to the limit stop effected by the pin 159 engaging the upper ends of the slots 160. As the travel of the plunger effected by depressing the push rod occurs until such time as the ring and inlet ports register in slightly open position and as the working length of the stop pin slots substantially equals the width of the ring port, the "snap" travel of the plunger aligns the inlet, ring and outlet ports whereupon a full-open flow of fluid is attained and maintained by the valve.

It is here submitted that the valve motion described presents a novel and highly efficient means for completion of the otherwise "dead-stop" movement of valve mechanism controlling and in turn operated by parts actuated by a liquid wherein such liquid moved parts, and in consequence the valve mechanism operated thereby, cease moving upon only "cracking" or partial opening or closing of valve parts.

With reference to Figures 10, 1 and 15, a governor valve M (above described) is mounted on the base of the accumulator D in upright position such that termination of the down stroke of the accumulator barrel 98 is effected by means thereon as the lug portion 164 of the platform engaging and depressing the push-rod 162 of the

valve M for the purpose of reversing the stroke travel of the accumulator barrel as effecting the up stroke thereof later described. As shown the valve M is mounted on a pipe connection 165 communicating with the reservoir chamber 1 whereinto the fluid flow, controlled by the valve M and utilized to operate the valve gear K, is discharged through the port 146 of the valve M. Likewise a governor valve M' is mounted in upright position on the side of the hydraulic engine E being supported on the bracket 166, Figure 15, and provided with an elongated push rod 162. The position of the top 167 of this push rod is such that termination of the down stroke of the engine plunger 133 is effected by means thereon as the flange 168 engaging and depressing the push rod 162 of the valve M' for the purpose of reversing the stroke travel of the engine plunger as effecting the up stroke thereof later described. A sump 169 and pipe 169' connects the discharge port 146 of the valve M' to reservoir chamber 2 whereinto the fluid flow, controlled by the valve M' and utilized to operate the valve gear K, is discharged.

With reference directed to Figures 4 and 1, an opening 170, on the volume-pressure discharge side of the pump unit B, is connected by the pipe 171' having a valve 171 therein, to a relief valve N, Figure 12. From valve N, conduits 144' lead to the conduit inlet ports 144 respectively of the valves M and M'. It is now seen that upon opening of the valve 171 a volume-pressure flow from the pump unit B will freely occur through the conduit 171' and each of the conduits 144' to the valves M and M'. However, an auxiliary volume-pressure fluid flow through the conduits 144' is derived, at will, from an auxiliary pump O. Referring to Figures 2 and 1, the pump O of conventional form is mounted on the prime mover C and driven thereby with any conventional form of drive means not shown. A suction pipe 172 connects the fluid supply of chamber 2 to the pump O and a pipe 173 connects the discharge therefrom to the conduit 144', Figure 1, of the valves M and M'. From the conduit inlet-outlet ports 145 of the valves M and M' respective conduits 145' lead to the respective ends of the cylinder 75, Figure 8, of the hydraulically operated valve gear K.

Operation

Coordinated operation of the parts of the apparatus thus far described is as follows; with specific description of adjunctive means employed; such as those controlling sucker rod stroke length and variable stroke velocity, appearing in sequence descriptive of desirable utility of the device. To prepare the apparatus for operation the accumulator and engine plungers are disposed at rest in their down positions and together with the entire system are primed with the operating liquid. The valves 57 of the pump unit are manually set in the position shown in Figure 4 and the piston 80 of the valve operating gear K is therefore disposed in the position shown in Figure 8. Owing to the accumulator and engine being in down position, the valves M and M' are held by the push rods 162 in position below that shown in Figure 13, and such that the ring port 150 is in "cracked" communication with the ports 144. To now raise the accumulator the valve 171, Figure 1, is opened, valve 174 in line 144' between valve N and valve M', Figure 1, is closed, and the prime mover C is started. The operating liquid is now drawn by pump O from reservoir 2 through pipe 172 and discharged into pipe 173, conduit 144', through relief valve N, valved pipe 171', opening 170, see Figure 4, to the discharge side of pump unit B. As port 62 is now closed, pressure is established in the cross-over pipe 64, port 66, now open, opening 68, see left end of Figure 4, and pipe 97, Figures 1, 2 and 3, and in the fixed hollow plunger 95. It should be noted that as soon as pump O commences its operation the operating liquid is also forced through pipe line 144' towards valve M and M' but does not reach valve M' due to valve 174 being closed, see Figure 1. However, the liquid does enter valve M through the slightly "cracked" port 144 and then enters the chamber 157 through port 156 whereupon to "snap" the plunger barrel 151 downwardly to fully register the ring port 150 with ports 144 and 145. At this time pressure exists in pipe line 145' which is in communication with the left end of cylinder 75, Figure 8, but is ineffectual other than to hold the piston 80 in the position in which it was disposed in initially setting the valves 57 as aforesaid. After barrel plunger 151 has been snapped downward pressure will build up to raise accumulator D.

This action takes place upon the initiation of the upward movement of the accumulator but as the accumulator ascends and 164 tends to move away from the push rod 162 the liquid pressure in chamber 157 becomes effective to move the plunger 158 upwardly to follow the accumulator, while barrel 151 remains stationary because of pressure in the chamber 157. The upward movement of 158 continues until pin 159 engages the upper ends of slots 160 when the fluid pressure ceases to be effective to move either 158 upwardly or 148 downwardly. After pin 159 engages the ends of slots 160, spring 153 will move barrel 151 upwardly and pressure in 157 will cause 158 to move upwardly until the ring port 150 moves completely above port 144. When however, the port 150 is blocked by the bore 142 the liquid pressure has no further raising effect on plunger 158, but the spring 153 will continue to act to further raise parts 151 and 158, as fluid is trapped in chamber 157 at this time. As soon as the port 150 begins to register with port 146 the liquid in chamber 157 is relieved through 146 and 169' so that the plunger 158 will remain stationary while spring 153 continues to move barrel 151 upwardly until member 155 abuts the lower end of the member in which bore 142 is formed and pin 159 contacts the lower ends of slots 160, as seen in Figure 13. The height to which the accumulator is raised results in a corresponding stroke length of the engine upon operation of the apparatus, thus any desired length of pumping stroke required to "feel out" pumping conditions in the well is available, with progressive stages of stroke length increase, "up" to that of the maximum of the apparatus, automatically attainable as later described. This provides for any stroke variation without changing or adjusting the "set" of the well pump plunger with respect to the "bottom" of the well. It is here noted that a second means is provided for starting the apparatus which consists of the non-operation of the pump O, closing of the valves 171 and 174, starting the main pump 18 and opening valve 87, Figure 2. Liquid is now drawn from the reservoirs 1 and 2 through pipes 88 and 87' and opening 86, Figure 4, to the inlet side of the main pump and as the valves 57 are "set," as before described, the liquid is pumped

into and raises the accumulator D to the initial stroke height desired, whereupon valve 87 is closed. Valves M and M' are not effected in any manner by the operating liquid when raising the accumulator by means of the pump 18 exclusive of pump O since at this time valves 171 and 174 are both closed and the operating fluid from the pump 18 is therefore shut off from said valves. However, valve M will be raised solely by its spring 153 as the accumulator is raised, while valve M' will, as is the case when the raising of the accumulator is effected by pump O, remain in position such that the ring port 150 thereof is in partial registration with port 144. I will now describe operation of the engine E by means of pump 18. With the accumulator now raised valve 87 is closed and valves 171 and 174 are opened and the pumping operation begins. For, as described, the engine E (plunger 133) being in the down stroke position, the push rod 162 thereof is depressed thereby opening the valve M' to the flow of liquid from the main pump 18 through the now open valved pipes 171' and 174, valve M' and conduit 145' to the respective end 79, Figure 8, of the valve gear K. Herein the volume-pressure liquid flow "snaps" the plunger 80 to the dashpot stroke stop position effected at the end 78 of the plunger barrel 75. As the "accumulator" (barrel 98 raised as described) is now in the up stroke position, the push rod of valve M has been raised, actuated by the spring 153, whereby the liquid simultaneously expelled from the barrel end 78 by the plunger stroke, just actuated by valve M', is bypassed through the valve M to the reservoir 1. Thus operated, the valve gear K throws the valves 57 to the alternative position described as causing the operating liquid to flow into and discharge from the pump, effecting a down stroke of accumulator D and an up stroke of engine E. As the accumulator D descends the collar 163 on push rod 162 contacts the upper ends of barrel 151 and plunger 158 and moves the latter downwardly until the port 150 starts to register with port 144, at which time the operating fluid enters chamber 157 through port 150 and 156 and reacting therein between plunger 158 and barrel 151 moves the latter downwardly with a snap action into position fully registering ports 144 and 150 wherefore a full flow of operating liquid will travel through port 145 and line 145' to the left end 78 of cylinder 75 and move the piston 80 to the position shown in Figure 8. This will operate the links 85 and crank arms 61 so as to move the valves 57 to the position shown in Figure 4 whereby the pump 18 will draw liquid from the engine to effect the down stroke thereof and force the liquid into the accumulator to effect the up stroke of the latter. Pump flow cycles, controlled as described, in alternating continuance, constitutes the pumping stroke operation of the device.

It is here noted that a secondary and independent liquid source is provided for operating the valve gear K through the valves M and M' as effected by continuous operation of the pump O, whereby liquid flow is caused in the system in the manner described as that of primarily raising the accumulator D. However in this instance the valve 171 is closed and therefore, the continuous flow from pump O, excepting that volume periodically utilized to operate the valve gear K (in the manner described) is by-passed to the reservoir 2 through the relief valve N, the adjustable spring urged plunger 175, Figure 12, of which is set for the desired pressure of the liquid flow, which upon lifting of the plunger, escapes through the outlet port 176 and pipe 176' (Figure 1) to reservoir 2 for return flow to and from the pump O.

As described, each down stroke of the accumulator D will cause the influx pump L to inject, into the operating volume flow, an allotted volume of liquid governed in effects and disposition by the means P, for varying the length of the pumping stroke, mounted on and operated by the engine E. With reference to Figures 14 and 15, the control means P includes guides 177 extending between and fixed to the flanged ends of the engine cylinder 123 and serving to slidably guide the crosshead 178 connected and reciprocally moved by the connecting rods 179 affixed to the engine plunger head 168. The crosshead 178 is provided with a bore 180 freely slidable on a reach-bar 181 provided with the longitudinally adjustable clamp stop 182 and having its upper end formed to provide a hook portion 183, Figures 14 and 11, for suspending the reach-rod for free movement thereof productive of engagement of the cam face 184 with the piston push pin 185 engaging a ball check 186 of the valve 187. This valve consists of the spring-urged ball check 186 to the checked side of which a pipe 188 connects with the engine cylinder for discharge of liquid therefrom when unchecked and discharged through the pipe 189 to the reservoir 2. It is worthy of note that the means provided and just above described performs a threefold function in operation of the apparatus. For by raising (from preoccupied position) and securing the stop clamp 182, the liquid injected by the influx pump L boosts successive engine strokes until the crosshead 178 engages the stop clamp and lifts the reach-rod 181 thereby opening valve 187 whereby the liquid, successively injected, is successively vented from the system and the engine stroke length becomes an automatically maintained constant. Conversely, by lowering the stop clamp, early opening of the valve 187 vents more liquid than pump L injects, wherefor the engine stroke automatically "settles" down to the new-set limits. Further, both instances of stroke length control envolving retention or withdrawal of liquid from the system, is followed by an automatic cycle of operations injecting cooled liquid into the main operating liquid flow and venting therefrom an equal quantity for the purpose hereinbefore set forth.

The variable pumping stroke velocity of the apparatus is attained by varying the volume-pressure output of the main circulating pump 18, as controlled by the valve F which latter is controlled by cam G in turn operated by hydraulic means G' actuated by the hydraulic impeller G''. The impeller G'' consists of the barrel 190 affixed to the engine cylinder 123 having the conductors 191 and 192 respectively connected to the pipe connections 42 and 41, Figure 5, of the cylinder 40 of the cam operating means G'. A piston rod 193 provided with the two-way cup leathered piston 194, passes through the stuffing box 195, and the end thereof is affixed to the engine plunger head 168. The system being primed with operating liquid it is seen that this liquid acts and reacts as synchronizing the movement of the two pistons.

It should be noted that the spring 38 of valve F is arranged and controlled to permit said valve to by-pass the fluid in the pump whereby to

stop the pumping operation, when the fluid pressure in the system exceeds that necessary for the ordinary operation thereof, as would occur in case of sanding-up or other overload action of the well pump. At the start of operation of engine E the cam G is in position shown in Figure 4 due to the fact that the piston 194, Figure 16, is in its lowermost position and will have forced fluid beneath it into cylinder 40, Figure 5, through lines 191 and 42 thus shifting piston 43 and cam G to position shown in Figures 4 and 5. At this time the high point 32a at the right end of the cam is beneath the roller 33 whereby to place the spring 38 under such tension as to hold the valve 28 closed against the operating pressure of the pump as necessary to start the up stroke of the engine. As soon as the engine moves on its up stroke the piston 194 moves correspondingly and forces fluid through pipe lines 192 and 41 into cylinder 40, Figure 5, whereby to shift the piston 43 and cam G to the right, proportionately to the movement of piston 194 and to such extent that the roller 33 will ride off the high point 32a of the cam into the low point 32b and thereby reduce the tension of the spring 38. This reduction of spring tension as will be apparent, will take place as soon as the engine has gotten started on its up stroke and the valve member 28 of valve F will then be subject to opening under the pressure developed by the pump, whereupon the fluid will by-pass into the intake side of the pump and the up stroke is decelerated. It must be borne in mind that the pump at all times operates to produce greater power than required for lifting the load on the engine. At the start of the engine the valve F as above explained is prevented from allowing a by-passing action due to the tension of the spring 38 holding valve F closed. However, after the start and as the cam G moves to relieve the spring tension, the valve F may open and by-pass fluid as aforesaid to decelerate the stroke of the engine. This deceleration is caused by a diminution of the volume flow of operating fluid and the fact that the pumping of this lesser quantity of fluid into the engine than initially, requires a greater length of time for the pump to build up volume therein and therefore slows down the engine stroke. Having once started the engine as aforesaid and then decelerated its stroke immediately thereafter it is now desirable to continue the stroke at a faster and uniform speed and to this end the cam G is provided with a relatively long and high surface 32c which again increases the tension of spring 38 and prevents a by-passing operation of valve F such that maximum volume pressure from the pump is available for operating the engine. As the engine nears the end of its up stroke the cam G will have been advanced to the right sufficiently to bring the second low point 32d near the left end of the cam into contact with roller 33 whereby to again lessen the tension of spring 38 and decelerate the stroke of the engine in the same manner as previously described. At the extreme left end of the cam G is another high point 32e for increasing the tension of spring 38 and holding valve F closed when the accumulator is started on its up stroke.

Pressure gages Q and R are connected with the accumulator and sucker rod engine for indicating the respective working pressures thereof whereby the desired counterbalancing action of the accumulator with respect to the engine may be determined.

I claim:

1. In well pumping apparatus, a hydraulic engine for operating the sucker rod of a well, a hydraulic accumulator including a reciprocable plunger hydraulically interconnected with said engine, a hydraulic pump unit, valve means associated with said unit and responsive to the strokes of the engine and accumulator, for alternately directing the pump flow to and from said engine and accumulator, and means for varying the volume-pressure flow of the pump for varying the velocity of the stroke of said engine.

2. In well pumping apparatus, an engine, a reciprocable hydraulic accumulator hydraulically interconnected with said engine, a hydraulic pump unit, valve means responsive to strokes of the engine and accumulator for alternately directing the pump flow to and from said engine and accumulator, means controlled by said engine for varying the fluid pressure flow from the pump unit during the working stroke of the engine to create lag and acceleration periods in said stroke.

3. In well pumping apparatus, a hydraulic engine for operating the sucker rod of a well, a hydraulic accumulator hydraulically interconnected with said engine, a hydraulic pump unit, valve means operated by the engine and accumulator for alternately directing the pump flow to and from said engine and accumulator, means controlled by said engine for varying the fluid pressure flow from the pump unit during the working stroke of the engine to create lag and acceleration periods in the stroke of the sucker rod, including valve means for by-passing fluid around the pump, a cam means for controlling said valve means and means controlled by the engine for operating said cam means.

4. In well pumping apparatus, a hydraulic reciprocable engine for operating the sucker rod of a well, a hydraulic accumulator hydraulically interconnected with said engine, a hydraulic pump unit, valve means controlled by the engine and accumulator for alternately directing the pump flow to and from said engine and accumulator, means controlled by said engine for varying the fluid pressure flow from the pump unit during the working stroke of the engine including valve means responsive to fluid pressure of the pump for by-passing fluid around the pump, a cam means for controlling said valve means and means controlled by the engine for operating said cam means, and means embodied in the upper end of the accumulator and in the lower end of the engine and operative for creating lag periods.

5. In well pumping apparatus, a hydraulic engine including a cylinder, a plunger therein adapted to be connected with the sucker rod of a well, a hydraulic pump unit, valve means for directing a hydraulic operating fluid to and from said cylinder, valve means responsive to said fluid for varying the velocity of the stroke of said plunger and means controlled by said plunger for controlling said valve means.

6. In well pumping apparatus, a hydraulic reciprocal engine for operating the sucker rod of a well, a hydraulic reciprocal accumulator hydraulically connected with the engine, a hydraulic pump connected with said engine and accumulator, valve means for controlling the application of operating fluid from the accumulator to the engine and vice versa via the pump, and separate operating devices which are responsive

to the strokes of the engine and accumulator respectively for controlling said valve means.

7. In well pumping apparatus, a hydraulic pump, a hydraulic reciprocal accumulator hydraulically connected with the pump, a hydraulic reciprocable engine adapted to have the stroke thereof reversed by the stroke of the accumulator and being hydraulically connected with said pump, valve means associated with the pump for directing the hydraulic fluid from the pump to the accumulator and from thence through the pump into the engine and vice versa and separate operating devices for said valve means respectively operating responsive to and at ends of the strokes of the accumulator and engine for reversing the cycle of operation.

8. In well pumping apparatus, a hydraulic pump, a hydraulic reciprocal accumulator hydraulically connected with the pump, a hydraulic reciprocable engine adapted to have the stroke thereof reversed by the stroke of the accumulator and being hydraulically connected with said pump, valve means associated with the pump for directing the hydraulic fluid from the pump to the accumulator and from thence through the pump into the engine and vice versa and separate operating devices for said valve means respectively operating responsive to and at ends of the strokes of the accumulator and engine for reversing the cycle of operation, and means associated with the engine and accumulator and operating responsive to a stroke of at least one of them for varying the fluid content of the system for varying the length of the the strokes of the engine and accumulator.

9. In well pumping apparatus, a hydraulic pump, a hydraulic reciprocal accumulator hydraulically connected with the pump, a hydraulic reciprocable engine adapted to have the stroke thereof substantially counterbalanced by the stroke of the accumulator and being hydraulically connected with said pump, valve means associated with the pump for directing the hydraulic fluid from the pump to the accumulator and from thence through the pump into the engine and vice versa, a hydraulic operating device for said valve means, separate valves for controlling said device associated with said accumulator and engine and respectively operating responsive to and at ends of the strokes of at least one of them for reversing the cycle of operation, and means associated with the accumulator and engine and operating responsive to a stroke of one thereof for injecting fluid into the system, and other means associated with the engine and accumulator and operating responsive to a stroke of one thereof for ejecting fluid from the system.

10. In well pumping apparatus, a reciprocable hydraulic accumulator, a hydraulic pump connected therewith, a reciprocable hydraulic engine connected with the pump, valves associated with the pump and operable for directing fluid from the pump into the accumulator to raise the accumulator and for directing the fluid from the accumulator through the pump to the engine for lowering the accumulator and effecting the working stroke of the engine, then directing fluid from the engine through the pump back into the accumulator and so on, a reciprocable hydraulic valve operating device connected in the system, means of operative connection between said device and said valves, and separate reciprocable valve means responsive to ends of strokes of the accumulator and engine respectively for directing operating fluid to and actuating the valve operating device for controlling the first named valves as aforesaid.

FREDERICK EDMUND SCHEIDER.