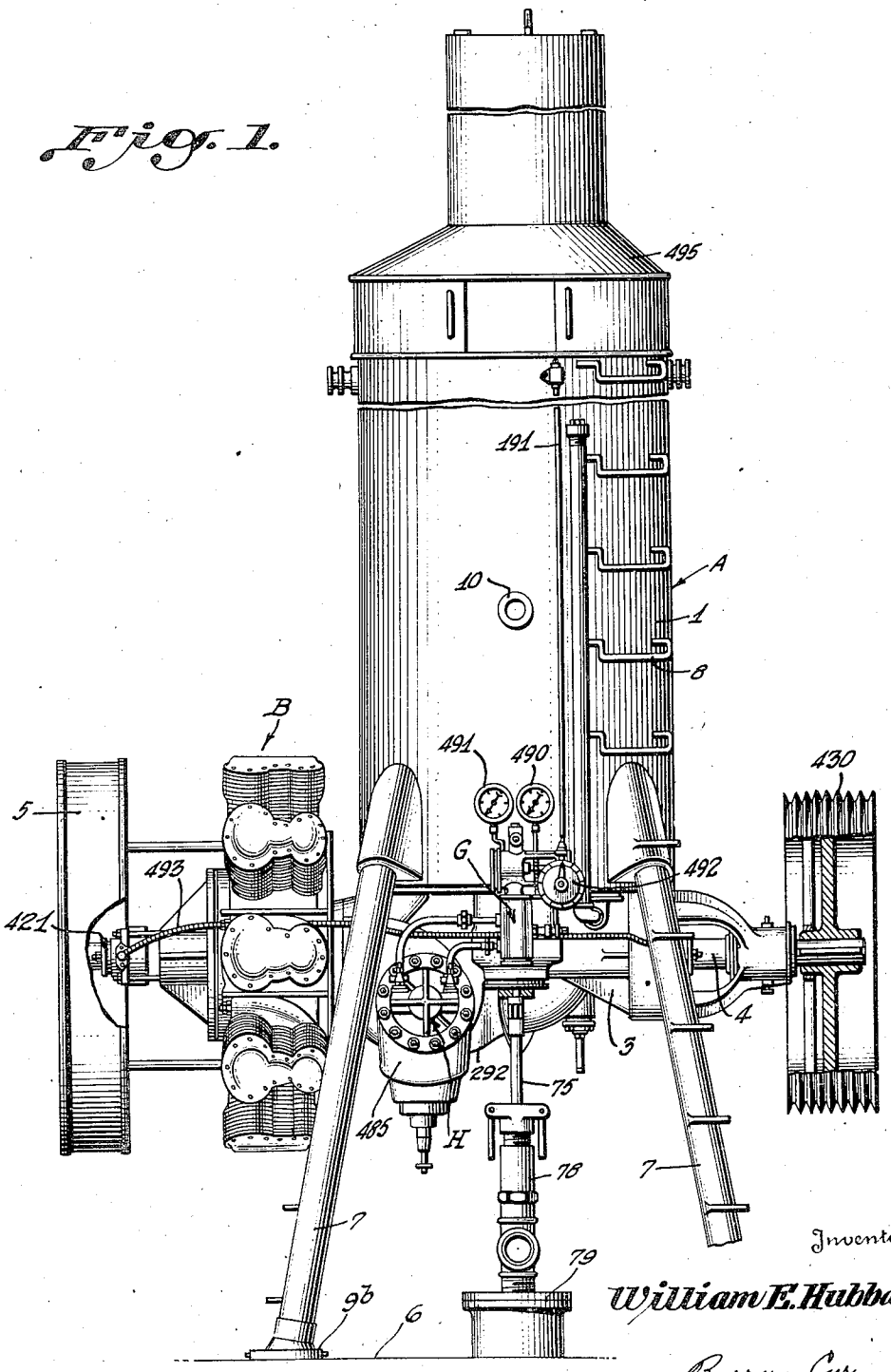
March 31, 1942. W. E. HUBBARD 2,277,761

HYDRAULIC PUMPING APPARATUS

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Fig. 1.



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HYDRAULIC PUMPING APPARATUS

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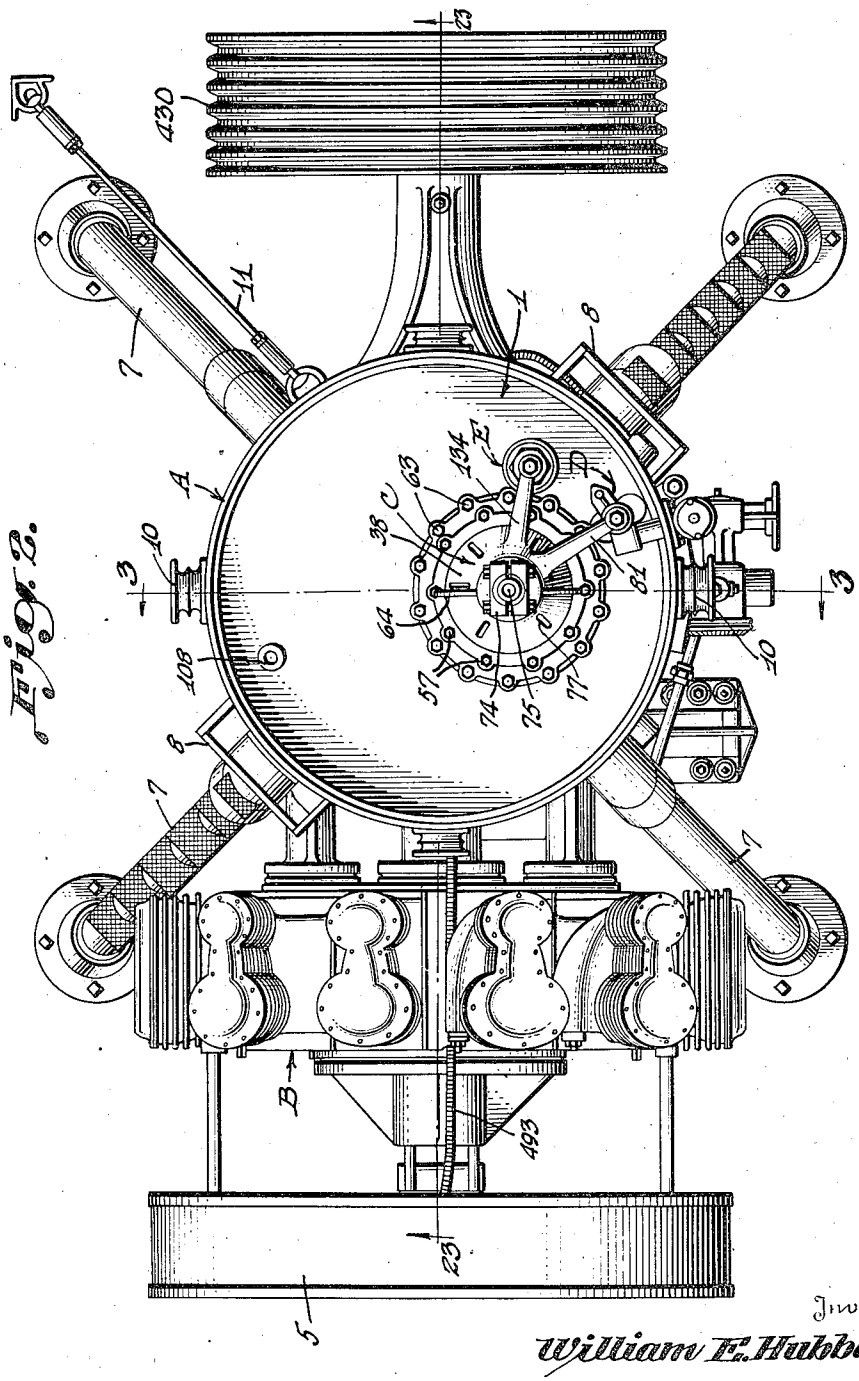


Fig. 2.

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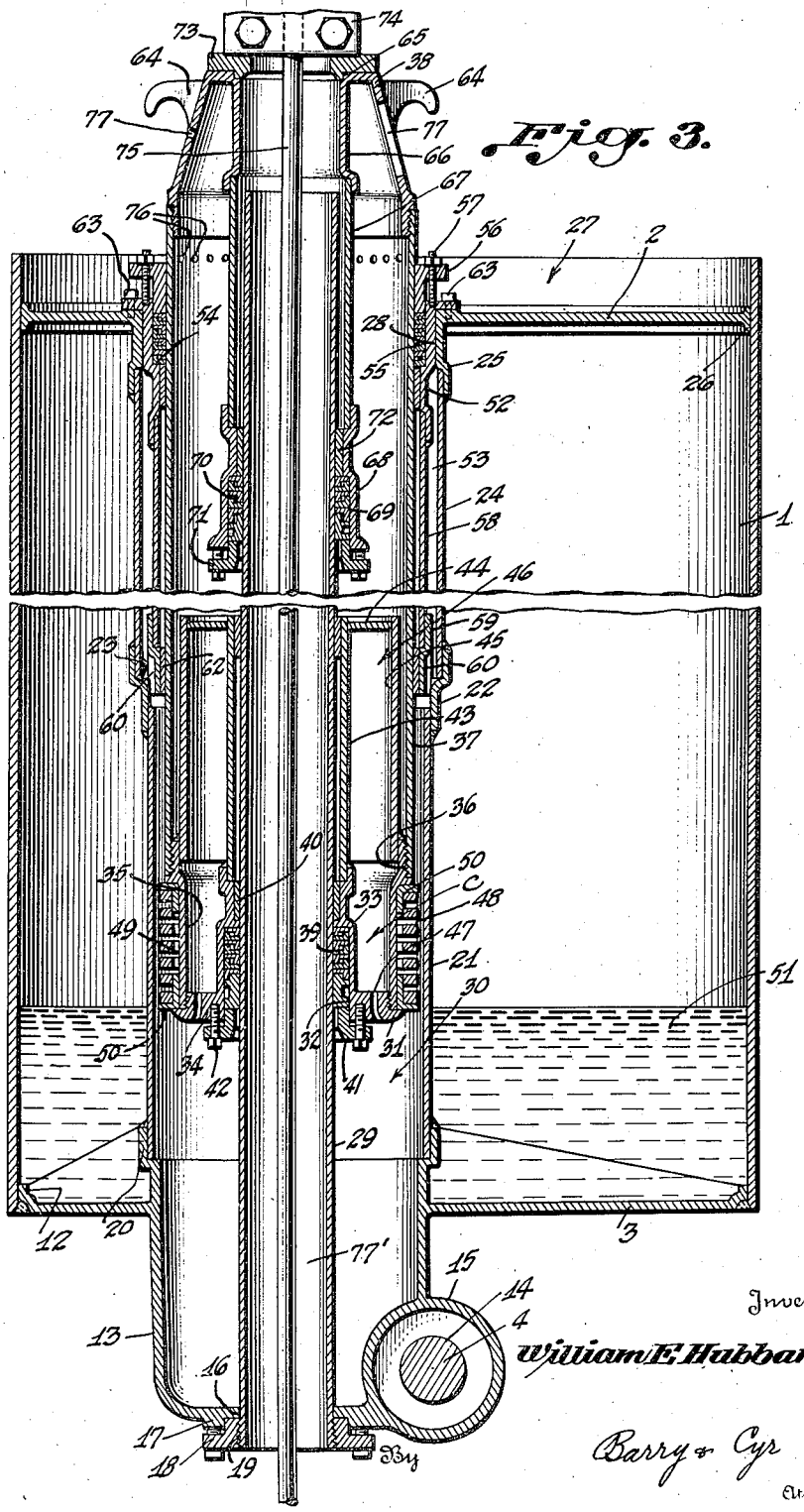
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Fig. 3.



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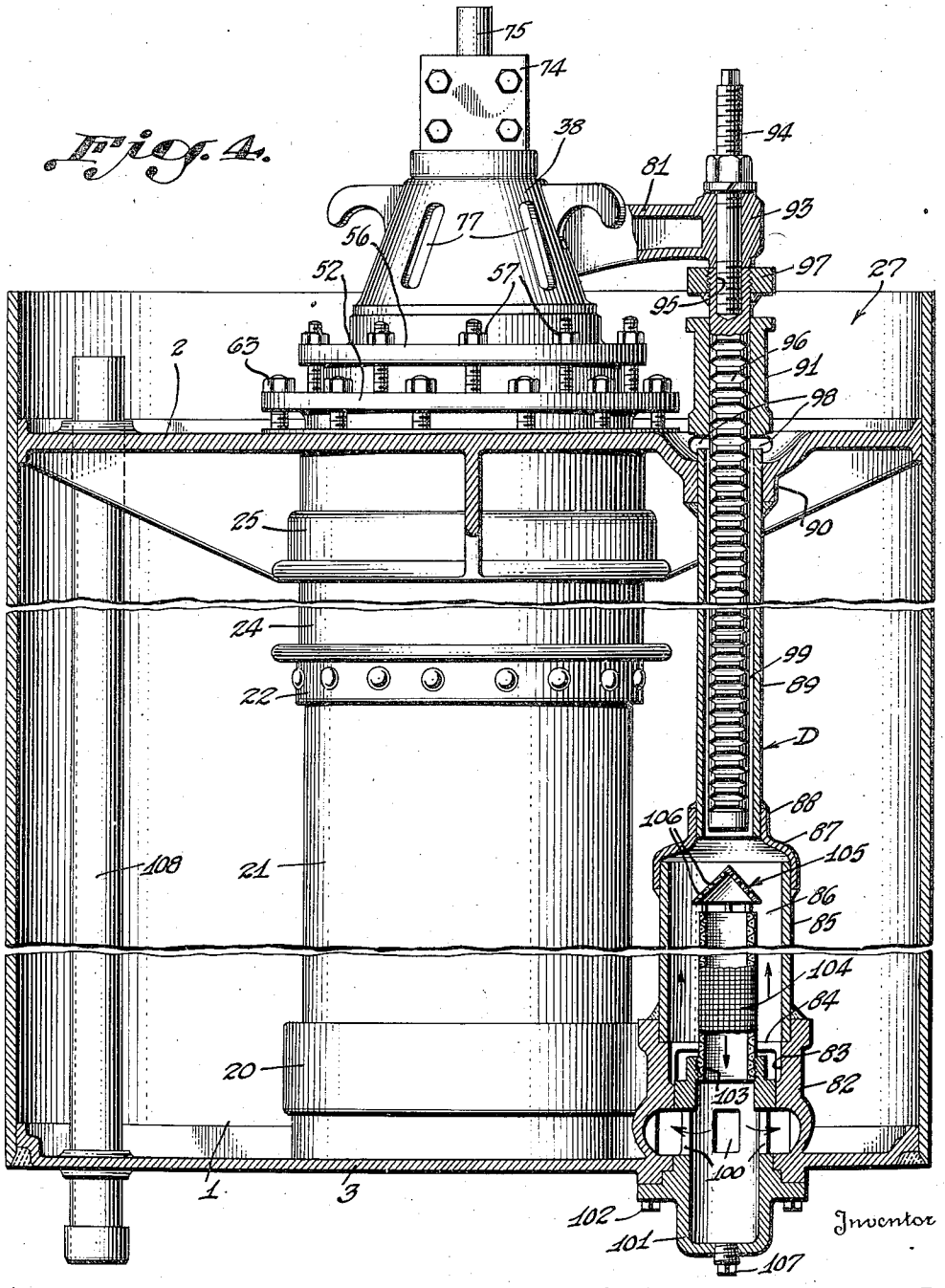
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HYDRAULIC PUMPING APPARATUS

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Fig. 4.



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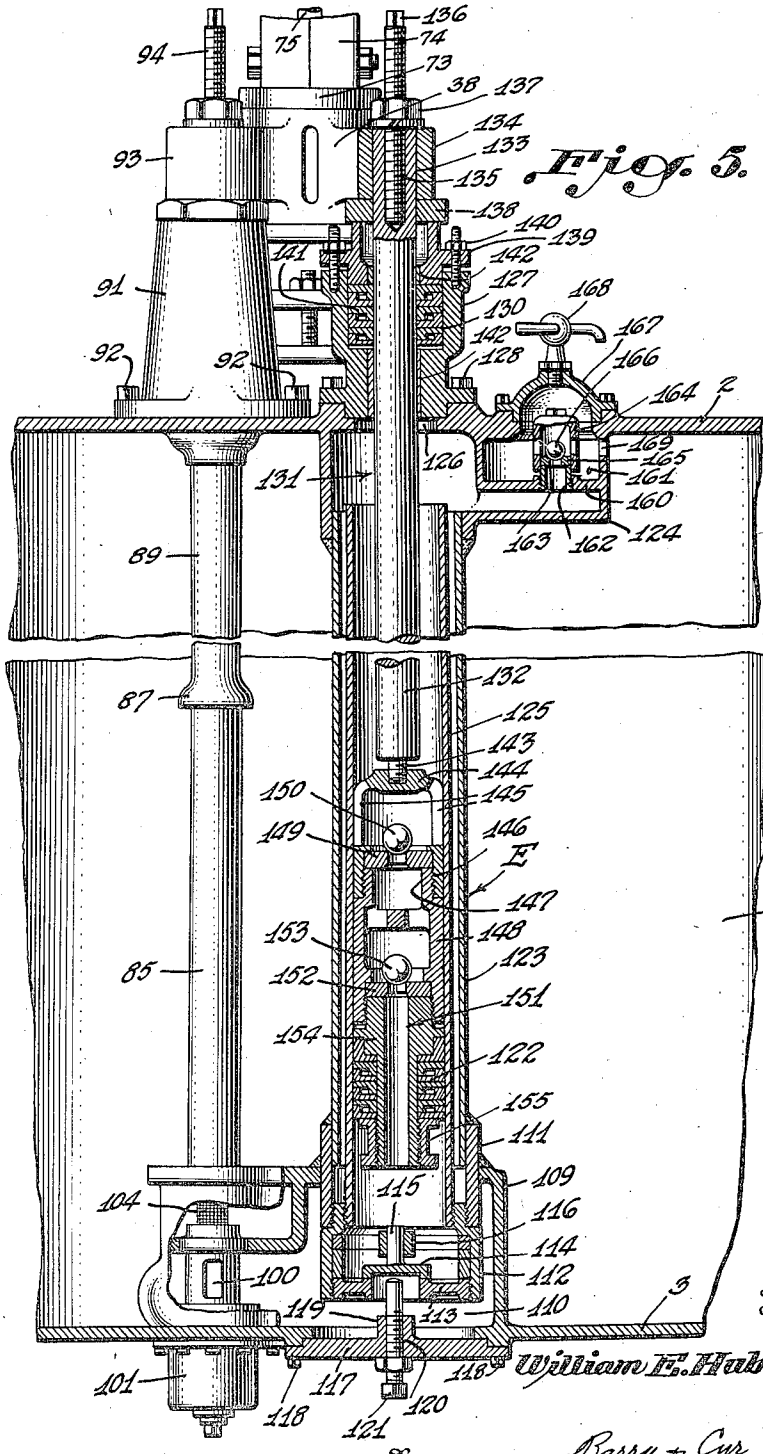


Fig. 5.

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HYDRAULIC PUMPING APPARATUS

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Fig. 6.

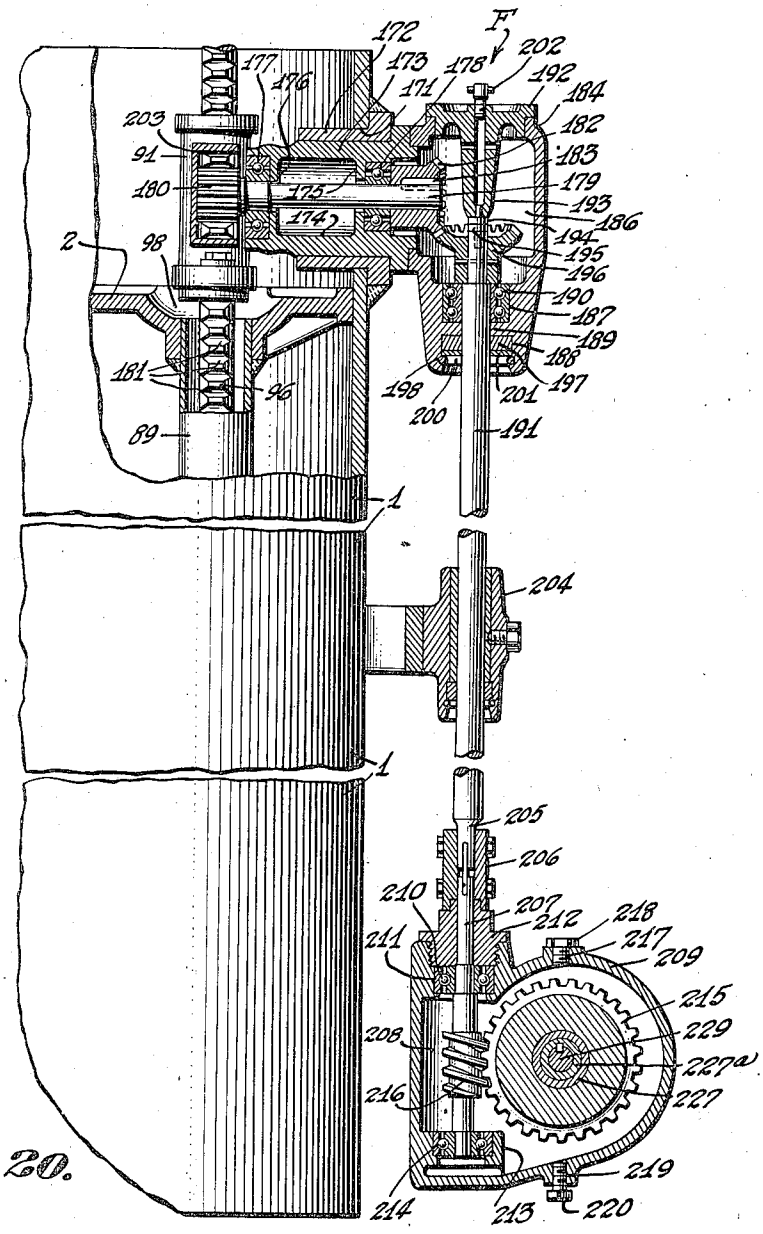
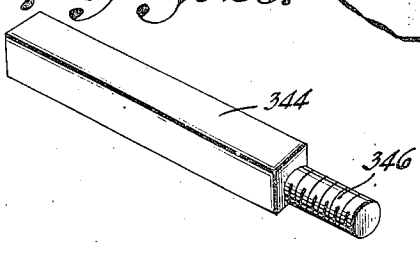


Fig. 20.



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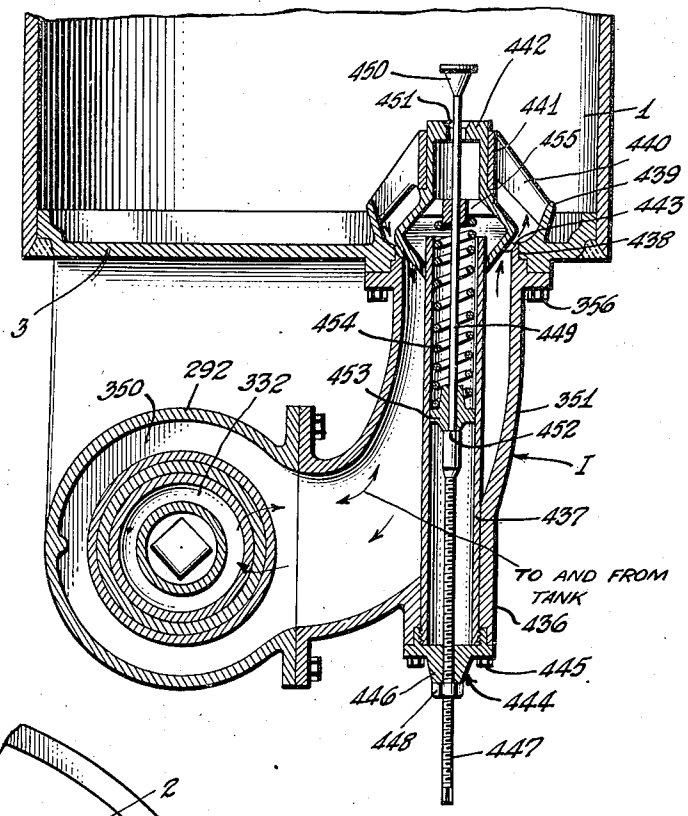
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Fig. 8.



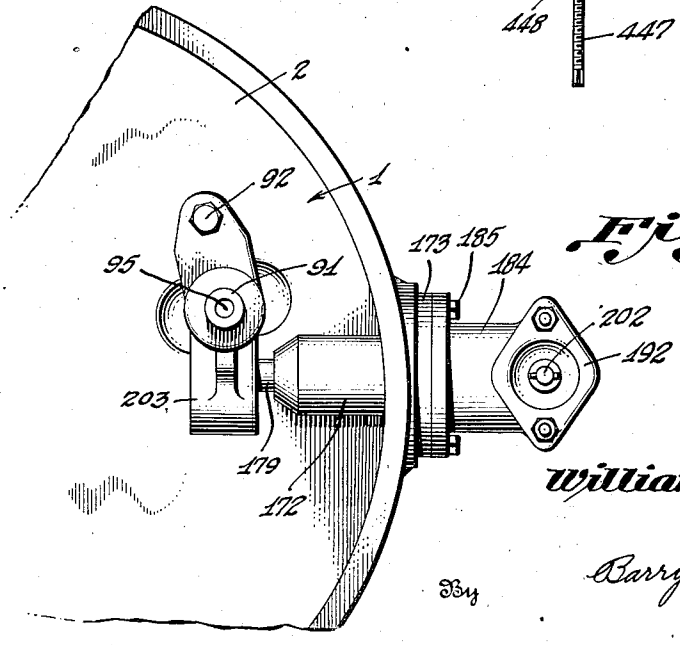


Fig. 7.

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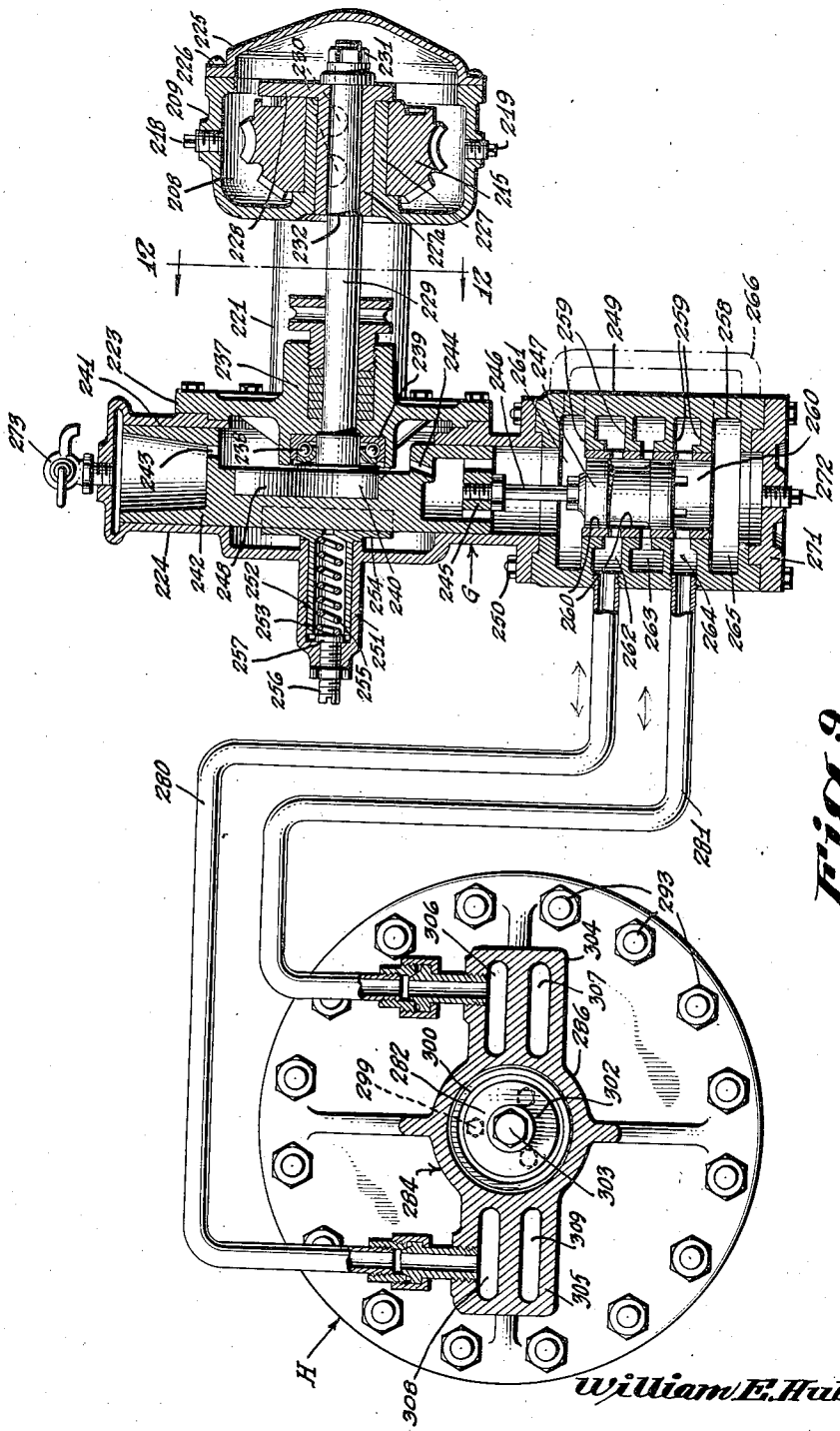


Fig. 9.

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Fig. 10.

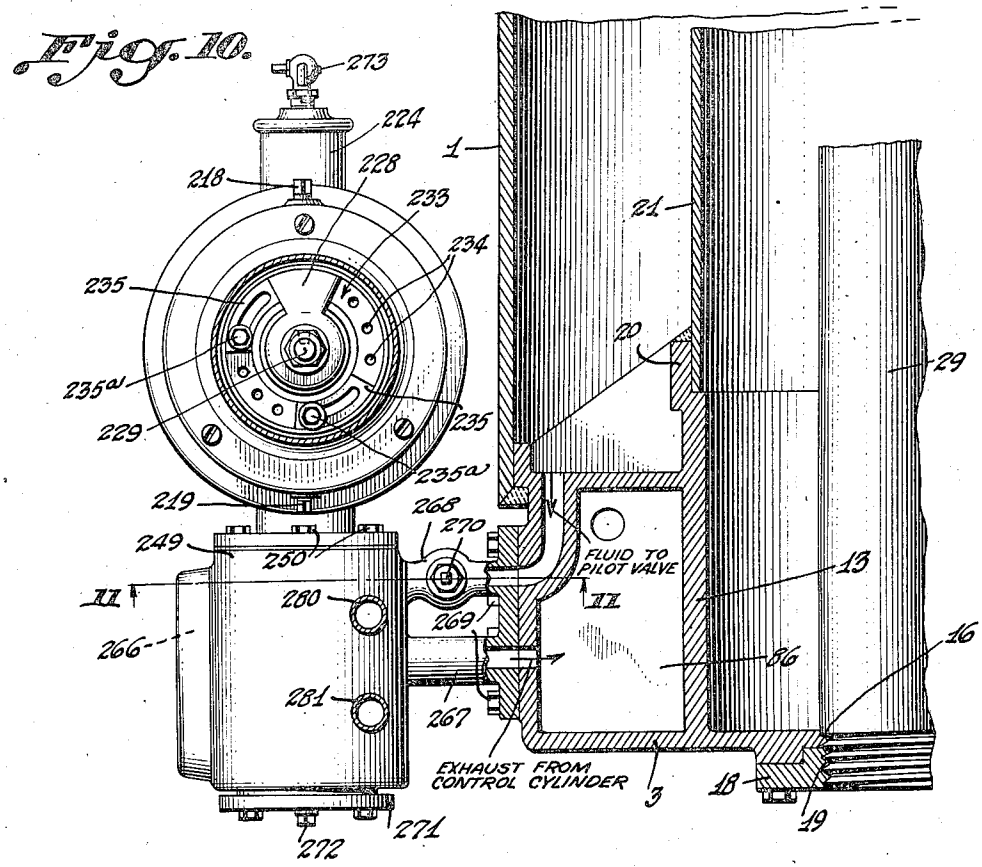
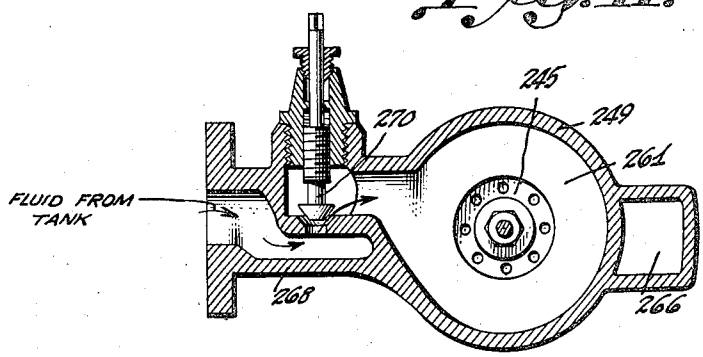


Fig. 11.



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Fig. 13.

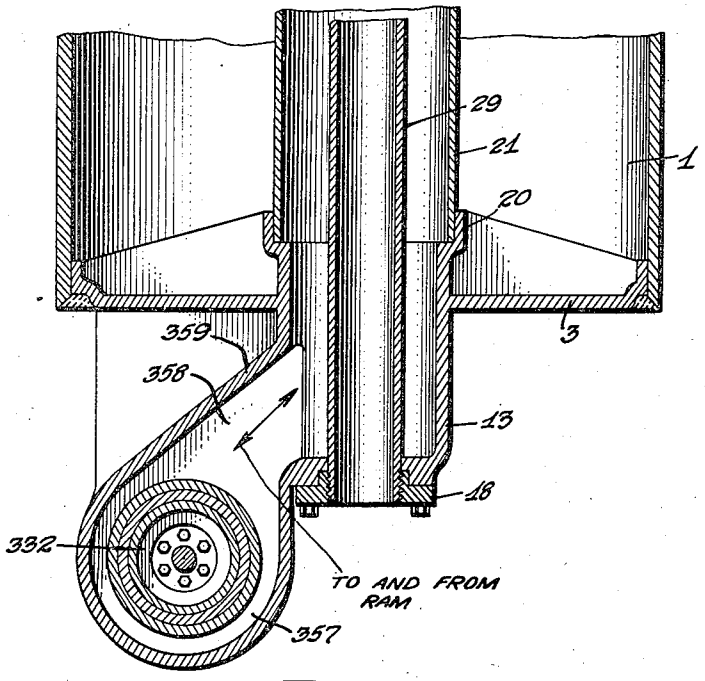
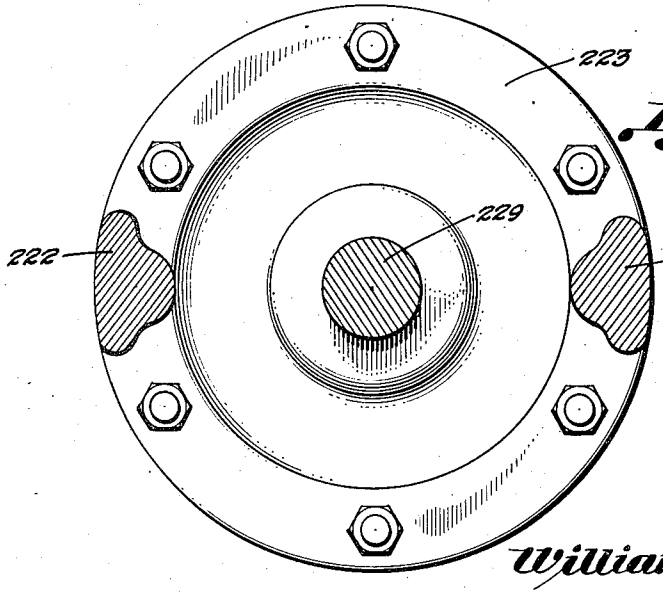


Fig. 12.



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March 31, 1942. W. E. HUBBARD 2,277,761

HYDRAULIC PUMPING APPARATUS

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Fig. 14.

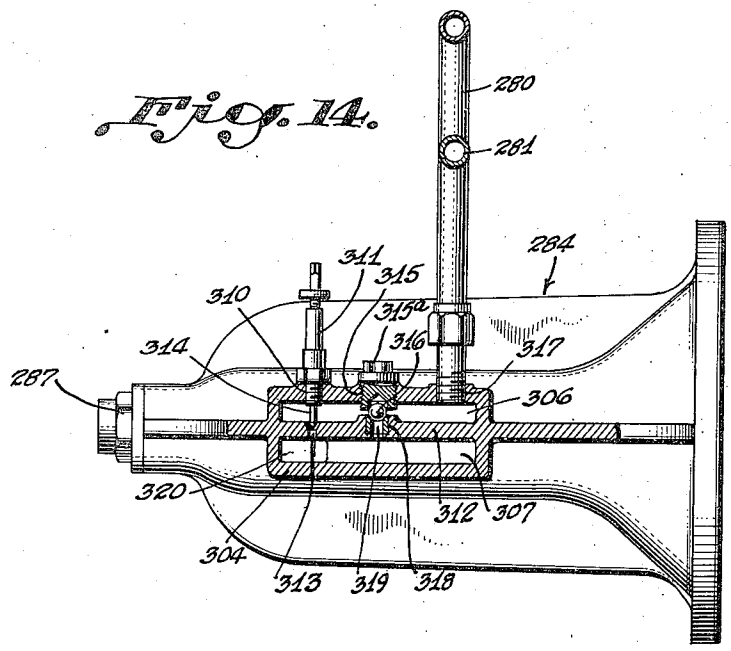
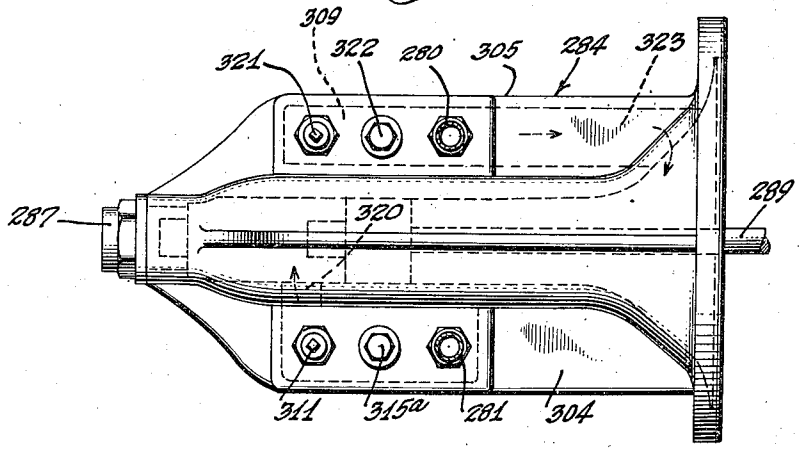


Fig. 15.



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HYDRAULIC PUMPING APPARATUS

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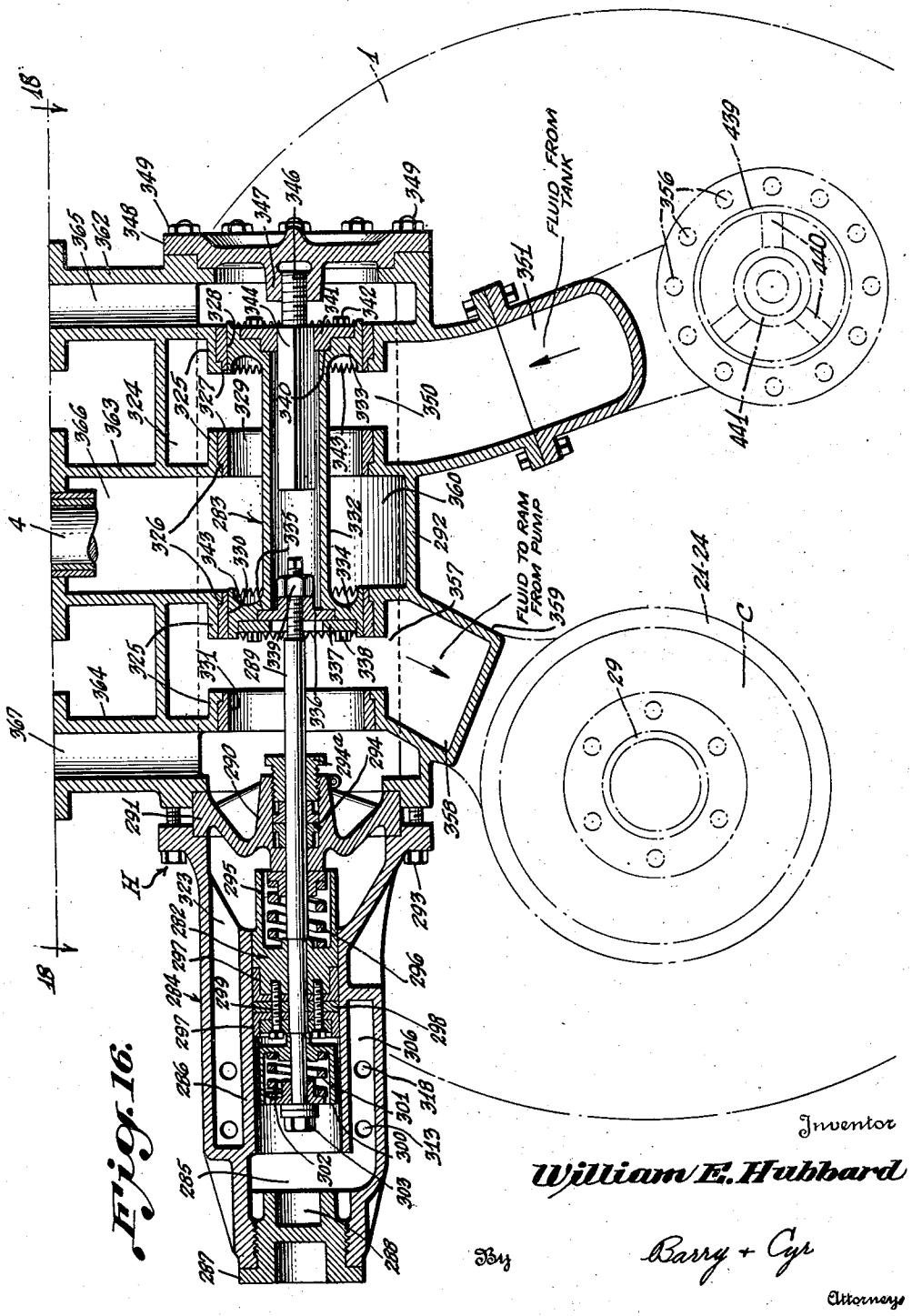


Fig. 16.

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March 31, 1942. W. E. HUBBARD 2,277,761

HYDRAULIC PUMPING APPARATUS

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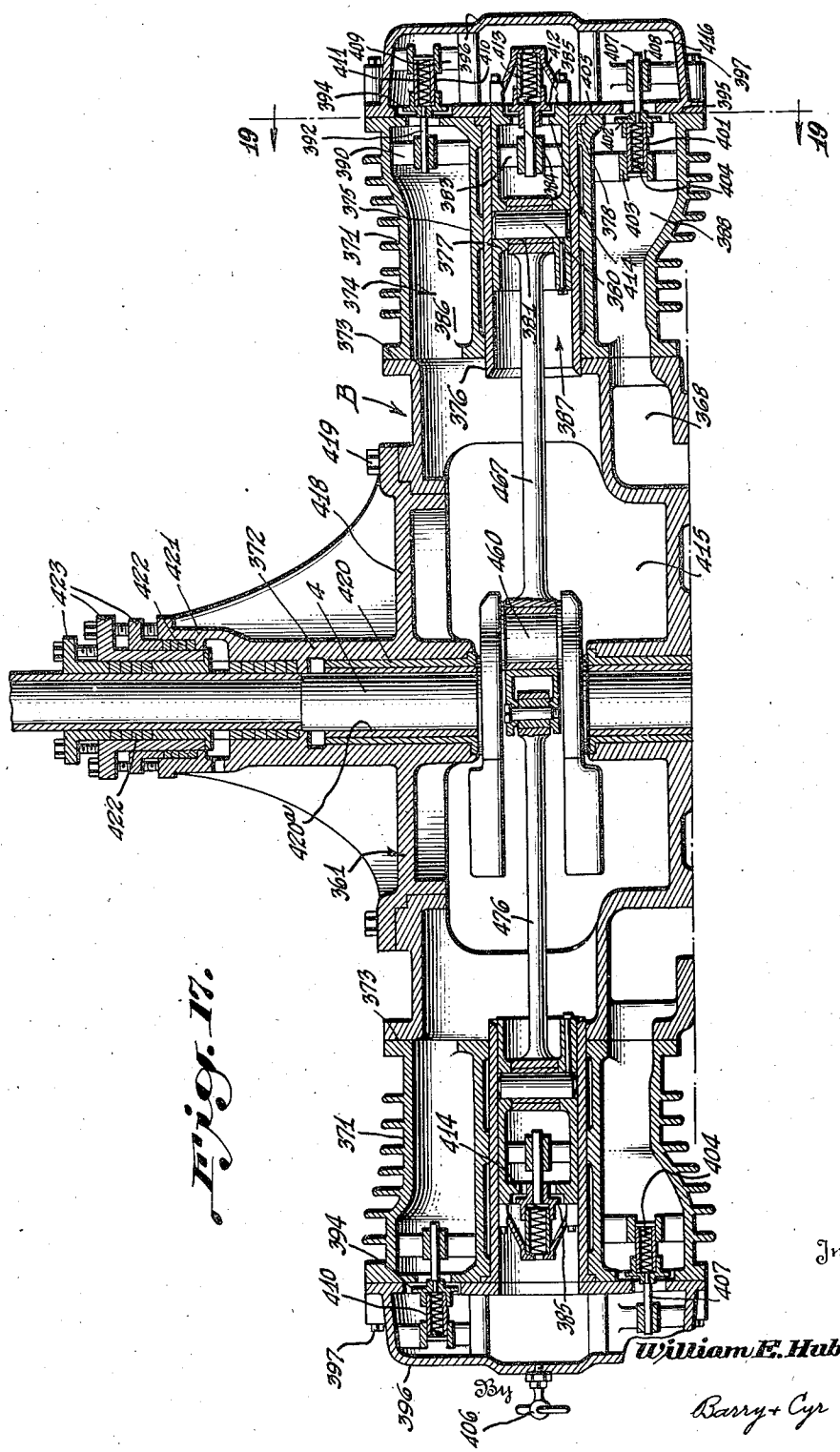


Fig. 17.

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March 31, 1942. W. E. HUBBARD 2,277,761

HYDRAULIC PUMPING APPARATUS

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Fig. 18.

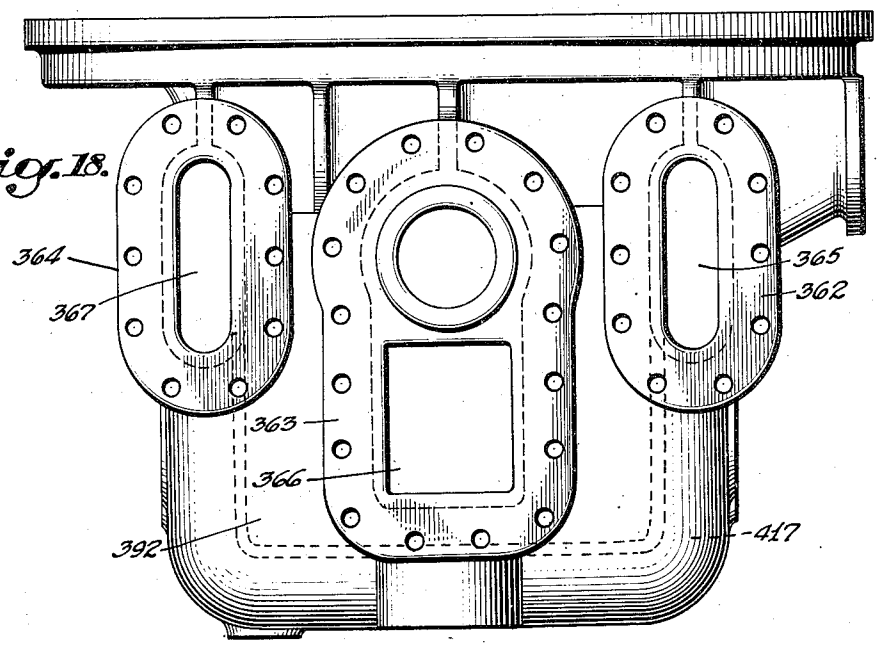
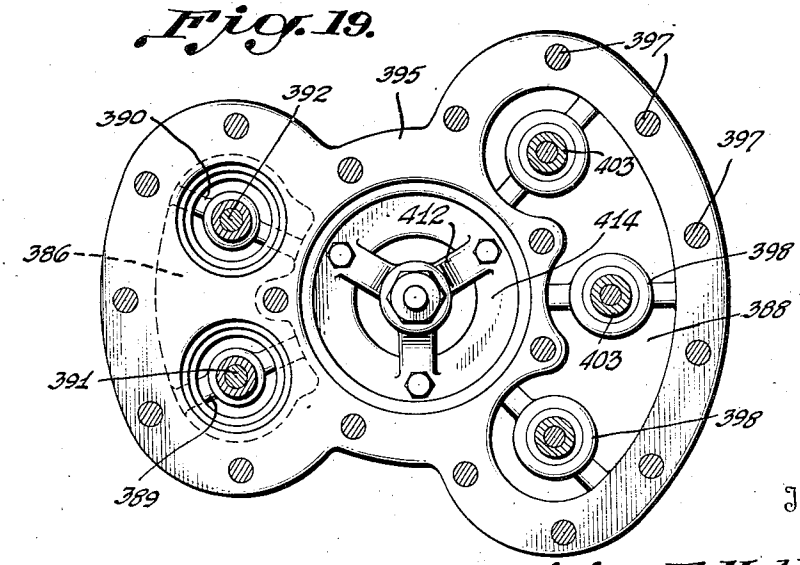


Fig. 19.



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HYDRAULIC PUMPING APPARATUS

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Fig. 21.

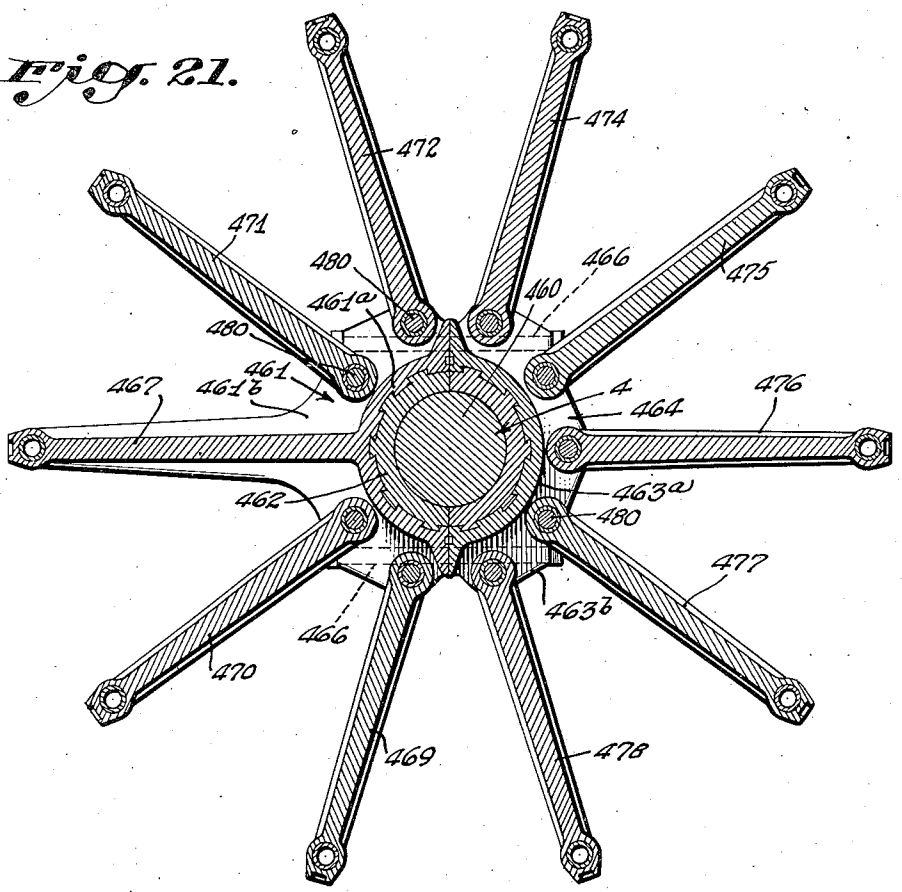
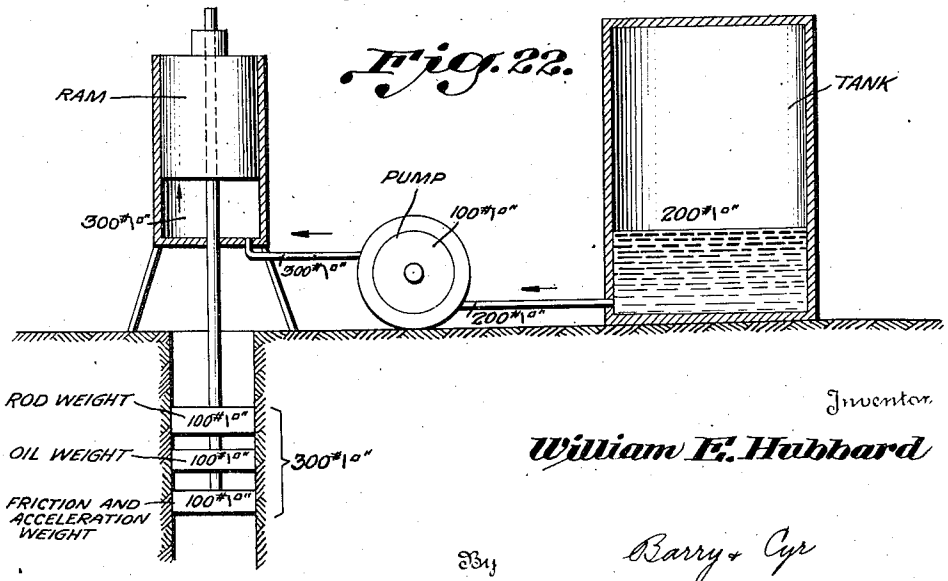


Fig. 22.



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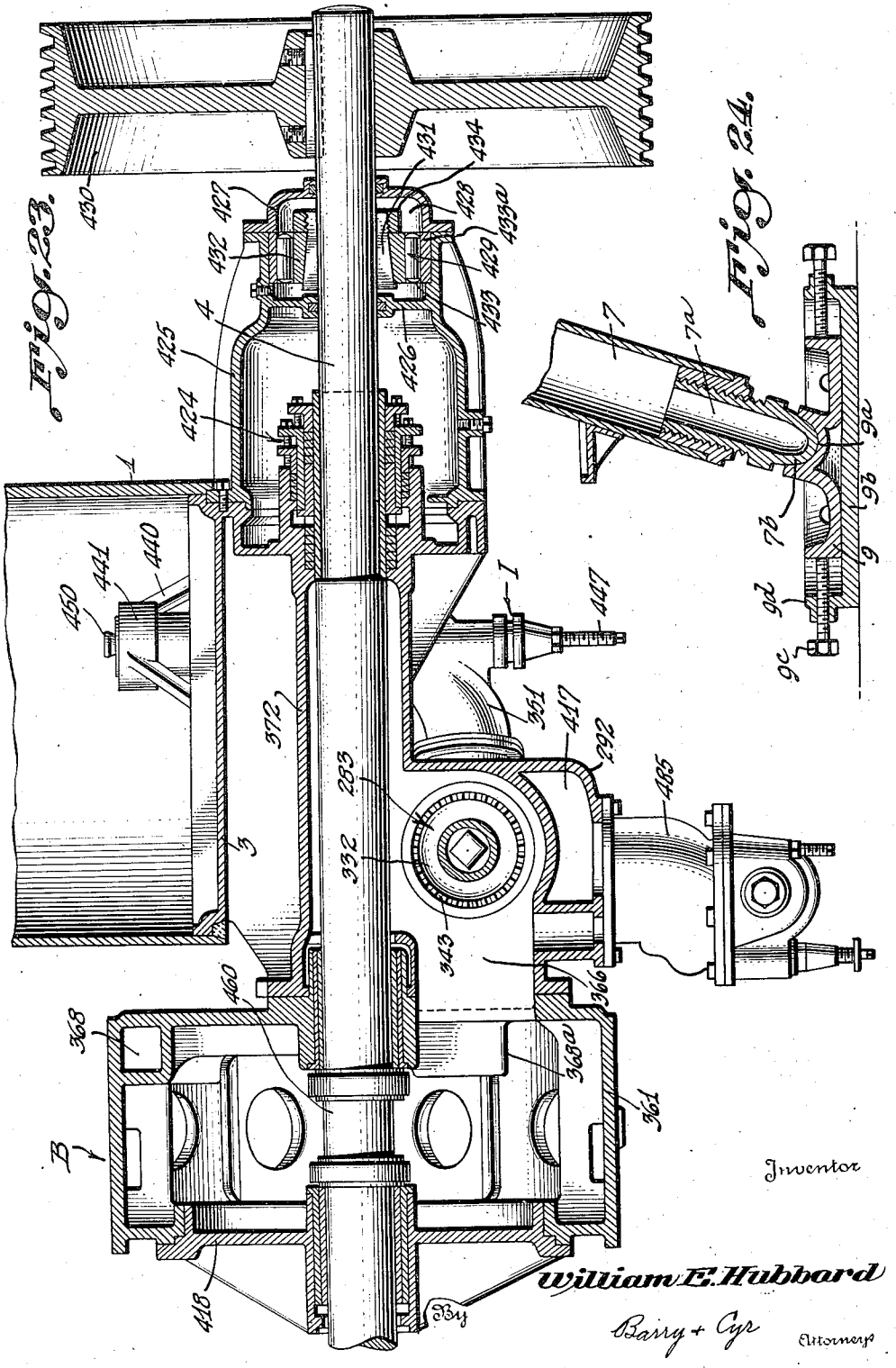
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HYDRAULIC PUMPING APPARATUS

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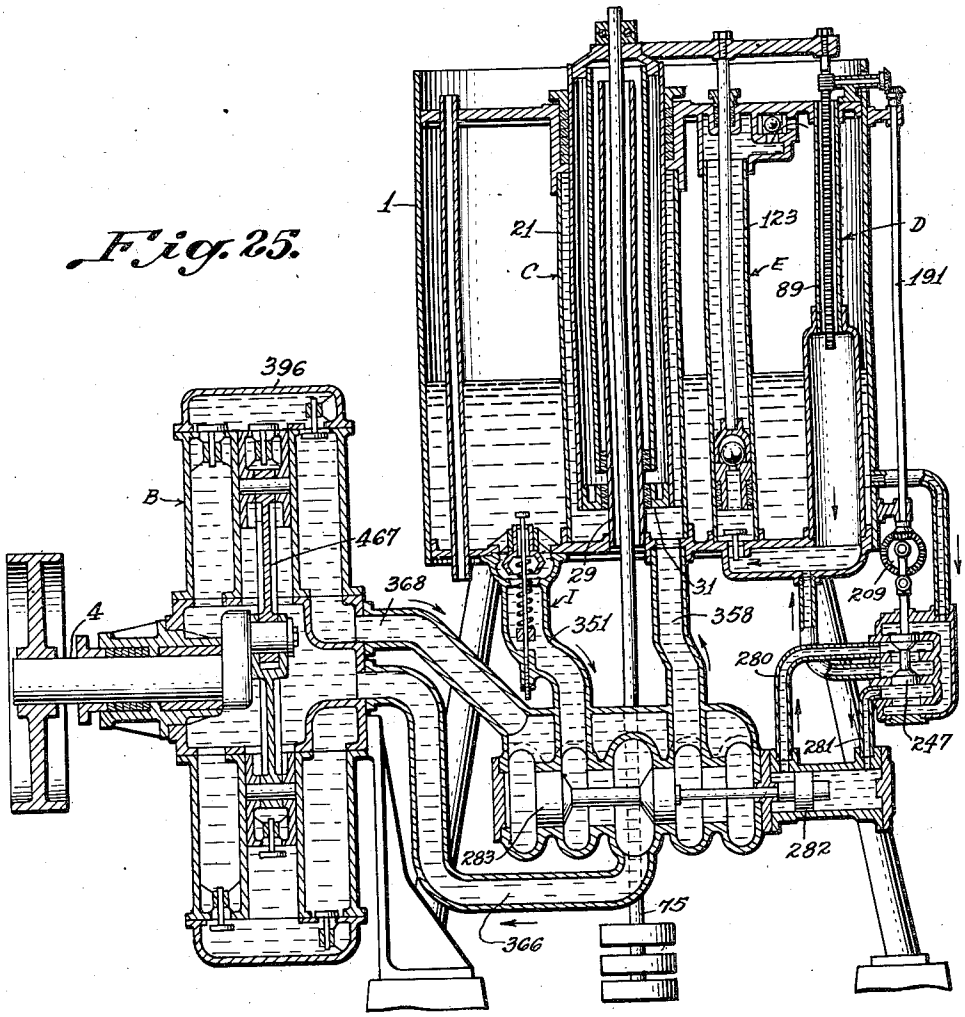


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Fig. 25.



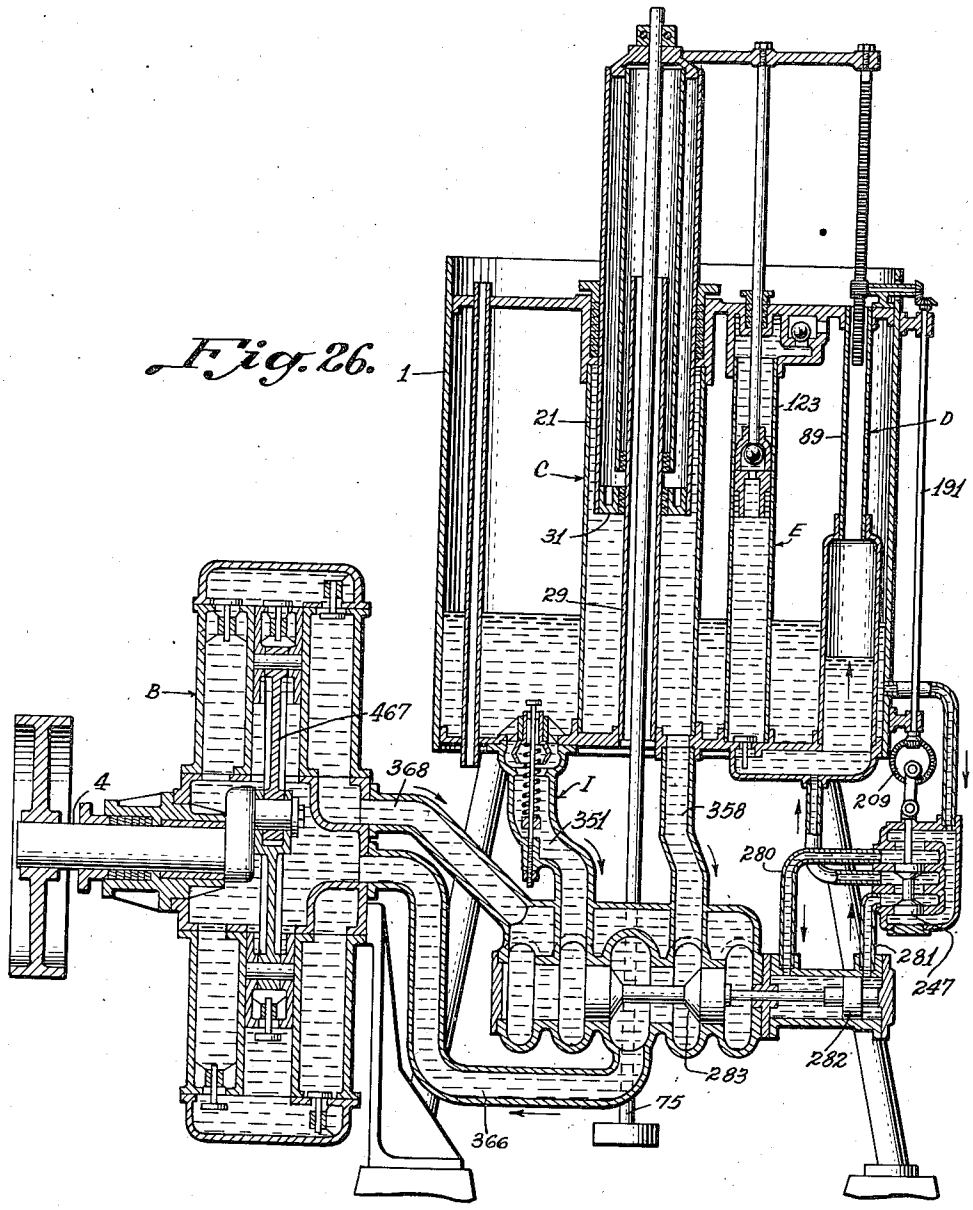
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HYDRAULIC PUMPING APPARATUS

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Fig. 26.



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Patented Mar. 31, 1942

2,277,761

UNITED STATES PATENT OFFICE

2,277,761

HYDRAULIC PUMPING APPARATUS

William E. Hubbard, Tulsa, Okla., assignor to Hydraulic Pumper Incorporated, Tulsa, Okla., a corporation of Oklahoma

Application January 20, 1939, Serial No. 252,032

8 Claims. (Cl. 60—52)

This invention relates to a balanced hydraulic pump, and more particularly, but not by way of limitation, to a long stroke hydraulic pump for the pumping of oil wells and the like. The present application represents improvements evolved from my prior patent numbered 1,879,262, dated September 27, 1932.

In conventional pumping jack and crank disc apparatus used today throughout the oil well pumping industry, all of the revolving weight necessary for its operation must necessarily operate without any consideration for the slender sucker rods used to actuate the plunger in the working barrel at the bottom of the hole. Furthermore, such apparatus does not harmonize with the load carried by the plunger at the bottom of the well, and a conflict between the two is prevalent. It is now generally recognized that sucker rod trouble, such as breakage and the like, is not due to crooked holes, but is a direct result of conflict between pumping jack apparatus and the working barrel plunger. The plunger driven rapidly upward by the fluid in the well, would continue to go upward because of the kinetic forces produced, while the jack crank, after it has reversed, would be starting downward. Since the distance is shortened between the plunger and the crank, the rods would buckle and have a tendency to break.

Furthermore, it has been found that for any given load in pumping apparatus cooperating with sub-surface rods, the static stretch of the rods would be the same for any type of apparatus. With the use of a long stroke in the pumping apparatus, it has been found that a great saving in power and up-keep can be effected. For example, if it took 30 revolutions with a short stroke pump, and the same work could be done with a long stroke pump at 6 revolutions, there would be a saving of twenty-four stretch, friction, and accelerating movements in addition to considerably less movement of the valves.

In the evolvement of the hydraulic balancing system wherein the long stroke principle can be successfully operated, I have provided a system in which a volume of air and fluid is compressed into a tank at such a pressure that it will equal all of the weight of the sucker rods, one-half of the oil weight to be pumped, one-half of the friction of the oil in the tubing and one-half of the acceleration load necessary to start the plunger and attendant parts on their upward stroke. From this it would be obvious that all the work to be done by the system is balanced with the exception of one-half the oil weight, one-half the friction load and one-half the acceleration load. In order to take care of these unbalanced loads, and to raise the main plunger, additional energy must be produced by an outside source.

In the development of a hydraulic deep well pump of the type disclosed in my prior patent above mentioned, it was found that the conventional reciprocating line pumps for producing the energy for the unbalanced load would not produce the speed necessary to obtain the proper fluid velocity to reciprocate the main plunger unit with the required rate of piston displacement. Furthermore, there were frictional losses due to the separation of the balancing tank and its cooperating units. The separation of the balanced tank, the line pump and attendant units obviously necessitated connecting pipes, which created friction and reduced the efficiency of the whole unit. Furthermore, in case of repairs, it was necessary to break the pipes and dissipate the hydraulic fluid contained in the unit.

It is therefore an important object of this invention to embody a long stroke pumping movement with a hydraulic apparatus for producing the stroke in order that a uniform motion free of any irregularities can be obtained.

A further important object of this invention is to provide a self-contained hydraulic pumping unit grouped around the center of a well hole having its cooperating units so constructed that lifting of the complete unit from the well can be done without disconnecting any pipes or dissipating any hydraulic pressure.

Another important object of this invention is to provide a balanced hydraulic pumping apparatus having a radial pump for allowing an increased fluid flow therethrough whereby an increased piston displacement per minute is provided.

And still another important object of this invention is to provide a balanced hydraulic pumping apparatus having a radial pump structure cooperating with a balancing tank containing the main plunger, said radial pump allowing fluid to flow radially from a central position within the radial pump, whereby the connecting rods of the radial pump in their motion will add impetus to increase the velocity of the fluid flowing thereby to displace the fluid through the radial pistons at such an increased velocity as to reciprocate the main piston plunger through greater feet of piston travel.

And still another important object of this in-

vention is to provide a self-contained balanced hydraulic pumping apparatus having its cooperating structures so disposed centrally around a well hole that frictional losses through connecting mediums are eliminated, thus producing an increased efficiency in the cooperating parts.

And still another important object of this invention is to provide a hydraulic pumping apparatus having a main piston unit of such construction that it substantially prevents all leakage losses of the fluid under pressure during the actuation of the piston unit. However, the construction provides that in case of any fluid leakage, it is returned to the system immediately as it occurs.

And still another important object of this invention is to provide a balanced hydraulic pumping apparatus having a main piston unit of such construction that all shocks and vibrations are compensated for during the reciprocation of the piston unit.

An additional object of this invention is to provide a hydraulic pumping apparatus having a main piston unit so constructed as to provide for a flexible alignment of a cooperating polish rod to compensate for any distortion or variations in alignment of the polish rod due to any reason whatsoever, whereby an efficient operation of the moving parts of the pumping apparatus will prevail.

And still a further object of this invention is to provide a hydraulic pumping apparatus having a main piston unit of such arrangement that a spaced relation is provided between the piston unit and its cooperating polish rod to allow for great variations in alignment as well as eliminating a polish rod stuffing box in the pumping unit, thus preventing corrosive action upon the polish rod, which would tend to cause leakage in the hydraulic apparatus.

And still another object of this invention is to provide a hydraulic pumping apparatus having a main piston unit of such construction that it permits the pulling of all cooperating sub-surface rods through the pumping unit without necessarily removing the unit from its position over the well.

Other objects and advantages of my invention will be evident from the following detailed description read in conjunction with the accompanying drawings which illustrate one form of my new invention.

In the drawings,

Fig. 1 is an elevational view of the balanced hydraulic unit, partly broken away and in section, and shown disposed in relation to the casing of a well hole.

Fig. 2 is a top plan view of the unit, with the main or tank cover removed.

Fig. 3 is a broken vertical sectional view, taken on the line 3—3 of Fig. 2, and showing in detail the inner construction of the main piston unit.

Fig. 4 is a fragmentary sectional elevational view, taken vertically through the main or balancing tank, and showing in detail the rack unit disposed within the tank.

Fig. 5 is a view similar to Fig. 4, and showing in detail the auxiliary pump unit which is disposed in the main tank, adjacent the rack unit, the latter being shown mainly in elevation.

Fig. 6 is a fragmentary sectional elevational view of the balancing tank with the reversing mechanism arranged mainly exteriorly of the wall thereof, and illustrating the manner in which it is operatively connected to the rack unit.

Fig. 7 is a fragmentary top plan view of the balancing tank, showing the disposition of the reversing mechanism relative to the tank.

Fig. 8 is a vertical sectional view of the speed valve and main valve shown arranged at the bottom of the balancing tank.

Fig. 9 is a sectional elevational view of the pilot valve structure, and the main control piston structure, with the pipes which connect the same.

Fig. 10 is an elevational view of the pilot valve and a portion of the reversing mechanism with a cover of a housing of the latter removed, and showing these parts connected to the main balancing tank which is illustrated in vertical section.

Fig. 11 is a horizontal sectional view of a detail taken on the line 11—11 of Fig. 10.

Fig. 12 is a vertical sectional view of a detail, taken on the line 12—12 of Fig. 9.

Fig. 13 is a vertical section, taken through the bottom of the tank, and showing the passageway from the main control valve to the bottom of the main ram or plunger unit.

Fig. 14 is a side elevation, partly in vertical section, of the main control piston structure, and illustrating the housing thereof, and some of the control ports.

Fig. 15 is a top plan view of the control piston housing, and showing the piston in dotted lines.

Fig. 16 is a horizontal section through the main control valve and its piston shown connected by dot and dash lines with the lower portion of the balancing tank and the main plunger unit.

Fig. 17 is a horizontal section taken diametrically through the radial pump unit. By alignment of Figs. 16 and 17, a complete showing of the connection between the radial pump and the main valve may be obtained.

Fig. 18 is a side elevation of the main valve housing, taken on the line 18—18 of Fig. 16.

Fig. 19 is a sectional view taken on the line 19—19 of Fig. 17.

Fig. 20 is a perspective view of a stem employed in guiding the main valve and preventing the latter from turning.

Fig. 21 is a vertical sectional view of the connecting rod assembly of the radial pump.

Fig. 22 is a schematic view of the hydraulic pumping system.

Fig. 23 is a vertical sectional view taken through the lower portion of the balancing tank, on the line 23—23 of Fig. 2, and showing the disposition of the crankshaft with respect to the main valve and the radial pump unit; the crank case only of the latter being shown in order to facilitate illustration.

Fig. 24 is a vertical sectional view of the adjustable supporting means arranged at the bottom of one of the legs on which the apparatus is mounted.

Fig. 25 is a vertical sectional view of a schematic layout of applicant's hydraulic unit shown in up stroke position, with certain parts out of proper position for better illustration.

Fig. 26 is a view similar to Fig. 25 of the unit shown in down stroke position.

Referring to the drawings in detail, and more particularly to Fig. 1, the hydraulic unit A comprises a vertically disposed cylindrical tank 1 having a head 2 (Fig. 3), and a bottom or lower casting 3. A radial pump unit B is disposed adjacent the lower end of the tank and supported

on a crank shaft 4 which in turn is supported by the bottom casting 3. A fly-wheel 5 is arranged on the end of the crank shaft adjacent the radial pump unit. The complete hydraulic unit is adapted to be disposed centrally above the well hole on a derrick floor 6. With the exception of the radial pump unit B, the cooperating elements for the complete unit A, such as the main piston, main valve, auxiliary pump, rack mechanism and control piston, are self-contained within the tank 1 or in the lower casting 3 in order to provide a compact unit disposed directly above the well hole.

The hydraulic unit A is supported on a plurality of legs 7, preferably four in number, and spaced 90 degrees apart. The unit A has a plurality of ladders 8 affording access to the top of the unit. As best shown in Fig. 24, the lower end of each leg is provided with an upwardly and downwardly adjustable extension 7a having a substantially dome-shaped lower end 7b which fits in a socket or cup 9a provided on a plate 9, the latter resting slidably on a stationary plate 9b secured to the derrick floor. Adjusting screws 9c threadedly engage an upstanding rim 9d of the plate 9b and impinge against the plate 9 for use in adjusting the same. This construction permits me to compensate for any dis-alignment due to settling of the derrick floor foundation, or to any shifting of the derrick. It will be understood that the pump unit A by this particular anchoring means merely rides on the plates 9, and the weight of the unit A holds the pump unit without any possibility of capsizing. This anchoring means has a particular purpose, in that it allows lifting of the complete pump unit A through the medium of the lugs 10 provided on the exterior of the tank 1, and upon being replaced, allows the unit to properly fit or set on the plates 9 without removing them from the floor. As clearly shown in Fig. 2, further anchoring for the unit is provided by extending tie or suspension rods 11 (only one of which is shown) from the upper portion of the tank to the legs of the derrick (not shown). Such rods assist in aligning and holding the unit A in a central position relative to the derrick.

In reference to the novel self-contained feature of the unit A, the bottom 3 is cast so as to provide housings for the main valve, the speed valve, the control piston, the main crank shaft, and the lower portions of the rack unit, and the auxiliary pump mechanism to be hereinafter described. In the following description, each of these units, with its particular function relatively to the complete unit A, will be treated separately.

Main ram or piston

As clearly shown in Fig. 3, and as heretofore mentioned, the tank 1 is closed at the top and bottom by the cast steel plates or manifolds 2 and 3, respectively. The lower plate or casting 3 is provided with a peripheral flange 12 that is welded to the inner surface of the tank 1. This casting has an integral depending housing 13 with its axis offset approximately six inches from the center line of the tank, in order to allow the main crank shaft 4 to pass through a bore 14 formed in a housing 15 cast integrally with the housing 13. The crankshaft 4 is longitudinally disposed in such manner as to substantially intersect the center line of the tank (see Fig. 2). The housing 13 has a bottom aperture 16 surrounded by an annular shoulder 17, and it receives an annular plate 18 bolted to the lower end of the housing 13. The plate is provided with internal threads 19 for a purpose to be hereinafter set forth. At the place where the upper end of the housing 13 is joined to the plate 3, the latter is provided with an upstanding annular flange 20 which embraces the lower end of a tubular cylinder 21 for the main ram piston unit C. The cylinder 21 extends vertically upward into engagement with an annular collar 22, and is secured thereto by welding or the like. The upper portion of the collar 22 is of greater diameter than its lower portion, thereby providing an annular shoulder 23 to which a second or upper cylinder 24 is secured. The latter extends vertically upward, and its upper end is secured to a depending flange 25 integral with the head 2.

The head 2 is provided with a peripheral flange 26 that is secured to the annular wall of the tank 1 by welding or the like. At this point it will be observed that the head 2 is disposed below the upper edge of the tank, so as to provide a reservoir 27 which functions to catch any oil leaking from the upper end portion of the plunger unit C, as will hereinafter be explained. The flange 25 provides an aperture 28 at the upper end of the tank.

The outer cylinder cooperates with an inner cylinder 29 which has its lower end in threaded connection with the plate 18, and extends upwardly through the central portion of the outer cylinder to a point above the upper edge of the tank 1. As the inner and outer cylinders are spaced from one another, they provide a chamber 30 for a purpose hereinafter explained. An annular plunger base 31 is apertured at 32 and adapted to surround the cylinder 29, and it is provided with an upwardly extending flange or sleeve 33. The peripheral portion of the base 31 is provided with threads which connect it to an annular sleeve 35 having its upper end provided with a threaded portion 36 for connecting the same to an intermediate cylinder 37. The latter extends from the sleeve 35 vertically upward through the head 2 to a position substantially above the tank 1, where the topmost portion thereof is threadedly secured to a plunger head 38.

The plunger base sleeve 33 is constructed with a varying inner diameter in order to provide a space between the same and the inner cylinder 29 for the reception of leather or fabric packing rings 39, and an annular bushing 40. The rings 39 are firmly anchored between the sleeve 33 and the cylinder 29 by an annular gland 41 (of L-shaped cross section), secured by bolts 42 to the plunger base 31. Such packing serves to prevent any fluid from escaping from the chamber 30 upwardly along the inner guide cylinder 29. Of course, the packing also serves to guide the plunger on such cylinder. An annular cylinder 43 is secured to the upper end of the sleeve 33, and extends vertically upward to a place where an annular horizontally disposed plate 44 is welded thereto. A cylinder 45 is secured to the upper end of sleeve 35 and extends upward to a point where it is secured to the horizontal plate 44. In this manner, an air chamber 46, closed at its upper end by the plate 44 and at its lower end by the base 31, is formed. Ports 47 in the base 31 allow liquid from the chamber 30 to enter the chamber 46 so as to compress air within the latter.

The sleeve 35 is reduced in diameter relatively to the outer cylinder 21, so as to form an annular space 48 to receive a helical shock absorbing spring 49 which is confined between annular

glands 50 which are L-shaped in cross section and are slidably arranged on the sleeve 35. Movement of these glands is limited by shoulders formed on the parts 31 and 35.

It is to be understood that under working conditions, the fluid 51, consisting of air and light oil or water, is placed in the balancing tank 1 under pressure, and as such, acts as a solid, but it will be apparent that with the fluid being forced against the lower face of the plunger base 31, the motivation of the actuating fluid will have a tendency to cause bubbling, wherein occasional air bubbles from the air in the tank will intermix with the other fluid. The intermixed air and liquid will pass through the ports 47 into the chamber 46, and air being lighter than other oil or water will be compressed in the upper portion of chamber 46 to such an extent that the initially low air pressure is increased until it is equal to the pressure of the fluid used for actuating the mechanism. In this condition, the chamber 46, with its combined compressible and non-compressible fluid pressure acts as a cushioning medium to assist in the absorption of shocks due to the reciprocation of the plunger unit C. This shock absorption achieved by the chamber 46 is particularly prevalent when the plunger stroke is reversed either on the up-stroke or the down-stroke, and is also effective to absorb any shocks that may occur in the vertical travel of the plunger unit.

A flanged upper guide sleeve 52 is disposed in the bore 28 of the flange 25, and extends downward into a chamber 53 positioned between the cylinders 24 and 37. The sleeve is formed with a shoulder 54 to support packing rings 55 interposed between the sleeve and the cylinder 37. The packing rings are held firmly by a packing gland 56 secured to the sleeve by screws 57. The lower part of the plunger guide 52 has a cylinder 58 secured thereto, which extends vertically downward to a point where it is secured to an annular plunger guide 59 provided with a plurality (preferably six) of vertical ports 60 which are spaced peripherally about said guide. The space between the cylinders 24 and 58 forms the air chamber 53 which is complementary to the air chamber 46 and functions in a manner similar to that chamber, in that air under pressure that has been intermixed in the tank 1 with the non-compressible fluid passes by the helical spring 49, through the space 48 and upward through the ports 60 into the chamber 53. The latter becomes filled with air and other fluid under pressure similar to chamber 46, and consequently acts as an additional cushioning medium for the complete plunger unit to absorb shocks upon the vertical travel of the plunger unit. A cylindrical bushing 62 is interposed between the plunger guide 59 and cylinder 37.

It will be apparent that the combined construction of the guide sleeve 52, cylinder 58, packing 55, bushing 62 and plunger guide 59 form a complete outer guide unit for the main ram or plunger unit C; it being understood that the cylinder 37 forms substantially the outer portion of said unit. This particular construction has a special purpose, in that the topmost portion of the plunger guide sleeve 52 can be released from the head 2 by removing bolts 63, so that any conventional hoisting means, when attached to hooks 64 on the plunger head 38, may be employed to hoist the complete ram unit C out of the cylinder 21—24. It is to be noted that as the plunger unit comprising mainly cylinder 37 and base 31 is being removed from the tank, the upper spring gland 50 contacts the lower end of the guide 59 to force said guide and its cooperating guiding structure, above mentioned, upward and out of the cylinder. A complete removal of the main plunger as a unit has a particular advantage, in that it facilitates repairs, replacing of packing, bushings, or any worn parts in a minimum of time.

The plunger head 38 has a top aperture 65, and adjacent thereto, the head is provided with a depending extension formed by an inner sleeve 66 which has welded thereto a downwardly extending cylinder 67. The latter is disposed between the cylinders 29 and 37, and has its lower end secured to an inner guide sleeve 68. Such sleeve is of varying inner diameter in order to provide a space 69 to receive packing rings 70 held therein by a gland 71 bolted to the sleeve 68. An annular bushing 72 is interposed between the cylinder 29 and the sleeve 68. The top of the plunger head is closed by a cover plate 73 upon which rests a polish rod clamp 74 secured to a polish rod 75 that extends into the well hole for connection with the sucker rods (not shown). The packing 70 and the bushing 72 prevent leakage of fluid which might occur through packing 39. If it were not for the packing 70, the fluid might leak past the guide sleeve 68, over the top of cylinder 29 and pass therethrough to the derrick floor 6. The cylinder 37 has a plurality of spaced apertures or ports 76 through which any liquid leaking past packing 39 may pass through the chamber within cylinder 37, ports 76 and into the reservoir 27. Any excess leaking liquid which does not pass through the ports 76 can pass through ports 77 provided in the plunger head 38 and thence into the reservoir.

It is to be noted that the diameter of cylinder 29 is slightly less than the diameter of the aperture 65, and this permits a polish rod, sucker rod and working barrel (not shown) to be pulled out of the well hole through the passageway 77' in cylinder 29 without removing the complete pump unit A or the plunger C. This space also allows for any desired adjustment of the polish rod and cooperating sucker rods in various positions in the well hole. In deep well pumps, using a sucker rod connection with a working barrel in the hole, it is advantageous to provide for a flexible alignment of the polish rod and its complementary sucker rods in order to eliminate the possibility of rod breakage. The passageway 77' being of greater diameter than the polish rod, allows for this flexibility in alignment of the rods. If, for any reason, the derrick (not shown), should shift or move from its foundation by wind or the like, this flexible alignment will allow for adjustment of the rods. It can readily be seen that with a fixed alignment, any movement of the derrick would distort the rods out of a true alignment, and thus cause an inefficient operation of the moving parts of the unit A. In this invention, the polish rod is secured to the topmost portion of the plunger unit C by the polish rod clamp 74. This arrangement allows for a distance of several feet between the securing position of the polish rod and the polish rod stuffing box 78 (Fig. 1) disposed at the top of the well hole, immediately above the casing 79. Consequently, the spaced relation between the polish rod and the cylinder 29 allows for greater variations in alignment.

This feature of the invention has another purpose distinguishing it from standard structures, in that it eliminates a stuffing box in the bottom of the pump unit A through which the polish rod would ordinarily be reciprocated. Since all oil wells contain more or less water highly corrosive in action, the actuation of a polish rod through such a stuffing box would cause the water to corrode the outer surface of the polish rod, whereby it would be practically impossible to keep the packing intact in the box. Under such conditions, the packing would allow fluid leakage from the pump unit which would necessarily distort the pressure balance conditions in the tank 1 which are necessary for the proper function of the plunger unit C.

In the present invention, all leakage through the packing 39 or the like is returned to the tank A, as it occurs, that is, liquid leakage that passes by the packing or stuffing box 39 is deposited in the reservoir 27 where it can be returned to the tank 1 by an auxiliary pump, as will be hereinafter set forth. Stuffing box 78 or packing 70 surrounding the inner cylinder 29 has an additional purpose, in that a small quantity of the fluid leakage provides lubrication for the main plunger unit C.

The rack unit

In Fig. 4, a rack unit D is shown arranged adjacent the outer cylinders 21 and 24, and within the tank 1. The plunger head 38 has an outwardly extending arm 81 inter-connected with the rack unit D for a purpose as will be hereinafter explained. The bottom 3 of the tank has cast integrally therewith an upwardly extending rack base housing 82 having a bore 83 of varying diameters. The upper part of the bore is formed with an annular shoulder 84 which engages the lower end of a cylinder or pipe 85 forming a lower rack chamber 86. The upper end of the cylinder is connected to a bell collar 87 having a reduced neck portion 88 secured to an upper rack cylinder 89. The latter extends vertically upward to a point where it is secured to an apertured boss 90 provided in the head 2. A tubular rack plunger guide 91 is disposed above the head 2 in alignment with the cylinder 89, and is secured to the head by bolts 92 (see Figs. 5 and 7).

The bracket arm 81 projecting from the plunger head is provided with an apertured outer portion 93 for the reception of a stud bolt 94 in alignment with a threaded recess 95 provided in the upper end of the rack 96. A safety collar 97 is threaded to the upper end of the rack and disposed immediately above the guide 91. The rack extends downwardly through the guide 91 and the boss 90 into the cylinder 89 to a position where the lower end of the rack is substantially adjacent the upper end of the bell collar 87 when the rack is in its lowermost position. As will be hereinafter set forth, it is to be understood at this time that the length of stroke of the rack 96 is equal to the length of stroke of the main ram C. At a point adjacent the boss 90, the head 2 is provided with diametrically opposite ports 98 which permit any liquid leaking from the reservoir 27 to flow into the passageway 99 formed by the cylinder 89 and through the collar 87 into the space 86. Such flow provides lubrication for the rack. From the chamber 86, the liquid passes through ports 100 into the auxiliary pump unit E shown in Fig. 5, as will be hereinafter set forth.

The lower part of the base 82 is closed by an apertured plug 101 bolted at 102 to the bottom 3. The cylindrical upper portion of the plug is constructed with the ports 100. The upper end of the plug is provided with internal threads 103 which threadedly connect the same to an upwardly extending vertically disposed cylindrical screen 104 closed at the top by a cap 105. The leakage liquid coming from the reservoir 27 into the space 86 is filtered by the screen before it passes through the ports 100. The cap is provided with vents 106 so that the fluid will continue to flow into the screen even if the screen, for any reason, becomes clogged due to sediment or the like. If the screen stopped the flow of liquid, this would affect the reciprocation of the unit C by a dissipation of the hydraulic pressure, since the excess liquid could not be returned to the tank 1, as it accumulates in the reservoir.

The plug 101 is provided with an auxiliary plug 107 to allow for replenishment of the liquid supply in case it becomes dissipated for any reason. The construction of the upper portion of the rack unit D is such that when it is found necessary to remove the main ram plunger unit C, it is not necessary to remove the rack from the tube 89. For this purpose, the stud 94 is merely unscrewed from the rack, and the latter is allowed to rest on the guide 91 supported by the collar 97. This separation of the rack from the arm 81 prevents any possibility of the arm being distorted or mutilated by dis-alignment of the rack upon reinsertion of the main plunger unit C. With the latter unit re-assembled, it is only necessary to screw the stud 94 into the recess 95 to properly connect the rack with the main plunger unit.

An overflow pipe 108 is secured in the tank 1 and extends from a point slightly above the head 2 downwardly through the tank to allow any excess liquid accumulating in the reservoir 27 to flow to any conventional depository (not shown).

The auxiliary pump unit

From an inspection of Fig. 5 it may be seen that the auxiliary pump unit E comprises a base 109 cast integrally with the bottom 3, and forming a chamber 110 in communication with the rack chamber through the medium of the ports 100. A sleeve 111 extends into the chamber and is secured to the top of the base 109 by welding or the like. The lower end portion of the sleeve is threaded and connected to a depending flange cage 112 which is arranged in the chamber 119 and has its lower end internally threaded and connected to a valve seat 113 which cooperates with a valve having an upstanding stem 115 guided by a spider 116 that is clamped within the cage.

The lower end of the base 109 is closed by a plate 117 secured by bolts 118 to the tank bottom 3. The plate is provided with a centrally disposed boss 119 having a threaded aperture 120, the threads of which are connected to a stud bolt 121 that extends to the exterior of the tank. The stud bolt is used for the purpose of lifting the valve 114 off its seat if for any reason pressure of fluid leaking downwardly past packing 122 should tend to keep the valve closed.

A cylinder 123 has its lower end extending into and welded to the sleeve 111. The sleeve 123 extends vertically upward through an aperture in the bottom of a housing 124, and is welded to the latter. Said housing is preferably made integral with the tank head 2. An inner cylinder 125, disposed in spaced relation to the cylinder 123, is threadedly secured to the valve cage 112 and extends upwardly therefrom to a point with-

in the housing 124. Due to the spaced relation of the cylinders 123 and 125, it can be readily seen that the auxiliary pump plunger 151 can be moved without the necessity of molesting the fluid under pressure in the tank 1. The head 2 is provided with an aperture 126 and disposed above the same, and resting on the head is a flanged stuffing box 127 secured to the head by means of bolts 128.

The auxiliary pump plunger rod 132 has its upper end extending into an aperture 133 in the end of an arm 134 which projects from the main plunger head 38. The upper end of the rod is provided with a threaded recess 135 for the reception of a stud bolt 136, which, in conjunction with a lock nut 137, secures the rod to the arm 134. A safety collar 138 is fixed to the upper end of the rod, and is adapted to contact a packing gland 139 secured to the stuffing box by bolts 140. Obviously, when the stud bolt 136 is disconnected from the upper end of the rod 132, the main plunger unit C can be lifted out of the tank without disturbing the auxiliary pump.

The rod 132 extends through packing rings 141 held in place by the gland 139 to prevent leakage along the auxiliary piston rod.

The lower end of the piston rod terminates in a threaded projection 143 that is secured to the upper valve cage 144 of the plunger 151. The cage may consist of a tubular body having longitudinal ports 145, and it is provided with threads 146 for use in securing it to a threaded rim 147 of a lower valve cage 148. An apertured valve seat 149 is clamped within the cage 144 and cooperates with a ball valve 150. The cage 148 is secured to a tubular member 154 of the plunger, and clamped between these members is a lower valve seat 152 which cooperates with a ball valve 153. The tubular portion 154 of the plunger has a reduced outer periphery for the reception of annular packing rings 122 held rigidly on the plunger by a flanged packing nut 155.

In operation, fluid from the lower rack chamber 86 passes through the ports 100 and into chamber 110, and it will be understood that vertical reciprocation of the plunger 151, caused by reciprocation of the main plunger unit C, effects displacement of said fluid upwardly through the plunger 151. On the downward stroke of the piston 151, simultaneous with the downward movement of the main plunger unit C, the fluid acting as a solid, seats the valve 114, and of course, causes such fluid to flow upwardly through the plunger 151 so that it eventually arrives in the chamber 131. Within this chamber, and integrally cast with the head 2, is an inner housing 160 having a chamber 161 that communicates with the interior of the tank 1 by means of a port 169. The bottom of the housing 160 has a threaded aperture 162 for the reception of an externally threaded tube 163. A tubular perforated valve cage 164 is secured to the upper end of the tube and provided with a valve seat 165 that cooperates with a ball valve 166 which functions as a check valve. A cover plate 167 closes an aperture in the top of the chamber 161, and is provided with a petcock 168 for the purpose of exhausting air from the tank 1 and the auxiliary pumping unit during overhauling or the like.

Obviously, fluid pumped by the auxiliary pump will be forced past the valve 166 and into the main tank 1.

At this point it may be stated the main plunger is reciprocated by use of the liquid 51 from the main tank, and there will be some fluid leakage through the packing provided in the main plunger unit. With this leakage, liquid deposited in the reservoir 27 and flowing through the ports 98 into the rack unit D, the auxiliary pump unit E will pump such leakage fluid back into the tank 1. Another function of the auxiliarp pump unit is to pump the fluid to be used in the actuation of the main control valve, as will be hereinafter described.

The leakage fluid pumped from reservoir 27 back into the tank 1, in no manner amounts to the capacity of the auxiliary pump unit E. Consequently, air from the atmosphere will pass through the ports 98 into the auxiliary pump unit to be displaced therethrough with the fluid present in the cylinder 125. On the down stroke of the piston 151, the air being lighter than the fluid is displaced first, but both air and fluid are displaced through the auxiliary pump E and opening 169 into the interior of the tank 1. This air pressure created by the auxiliary pumping unit functions to keep the pressure in the tank 1 substantially constant. If, for any reason, the air pressure created by the unit E exceeds the necessary tank pressure, it is allowed to be filtered as it occurs, to the atmosphere through a suitable relief valve (not shown) arranged in the tank head 2. It will therefore be apparent that a constant air pressure is maintained in the interior of the tank at all times. The structural arrangement of the auxiliary pumping unit is such that the stuffing box 127 can be unbolted from the head 2 to allow removal of the plunger 151 as a unit for the purpose of replacing packings, making repairs and the like.

The reversing mechanism

The reversing mechanism disposed adjacent the wall of the tank 1 is clearly shown in Fig. 6. At a point adjacent to the rack guide 91, the wall of the tank is provided with an aperture 171 for the reception of a flanged tubular sleeve 172 which surrounds a tubular housing 173 having a bore 174. The latter is provided with internal extensions 175 and 176 for anchoring roller bearings 178 and 177 respectively. A shaft 179 is journaled in the bearings and extends inwardly through the housing 173 to a point adjacent the rack plunger guide 91 and rack 96. A pinion 180 is secured to the inner end of the shaft and meshes with the teeth 181 of the rack. The opposite end of the shaft 179 carries a beveled gear 182 pinned to the shaft by pin and slot connection 183. As best shown in Fig. 7, a flanged housing 184 is secured to the housing 173 by bolts 185. The housing 184 has an axial opening or bore consisting of an upper major portion 186 and lower minor portions 187 and 188, the latter being separated by an annular internal shoulder 189 The bore 187 accommodates thrust bearings 190 surrounding a vertical shaft 191 which extends into the housing through the bottom thereof. Such bearings take up any downward thrust of the shaft 191, and also compensate for any irregularities in the vertical position of the shaft. The bore of the housing is closed at the top by a cover plate 192 having a depending hollow boss or pin 193, the lower end of which bears on a thrust washer 194 co-operating with a complementary thrust washer 195 secured to the upper end of the shaft 191. A bevel gear 196 is pinned to the upper end of said shaft, and it will be apparent that upon vertical reciprocation of the rack 96 simultaneously with

the reciprocation of the main plunger unit C, the pinion 180 will be rotated by the rack teeth and cause rotation of the shaft 179, bevel gears 182 and 196, and the reversing shaft 191.

A packing washer 197 encircling the shaft 191 is positioned in the bore 188, and the latter is provided with an annular groove 198 for the reception of an annular spring 200 which holds a washer retaining plate 201 in position. The bore 186 may be filled with a lubricant by means of the fitting 202 which closes the upper end of the hollow boss 193.

It is to be noted that the pinion 180 is substantially enclosed by a housing 203 integral with the rack guide 91 for the purpose of protecting the pinion.

The reversing shaft extends downward in proximity to the outer surface of the wall of the tank, and is held in spaced relation with said wall by a suitable number of bearings 204, one of which is shown in Fig. 6.

A reduced lower end 205 of the shaft is clamped in a split coupling 206 which also receives a shorter shaft 207 extending vertically downward into the chamber 208 of a housing 209. A thrust bearing 210 is disposed in an aperture 211 provided in the housing, which aperture is closed by an annular plug 212 through which the shaft 207 extends. The chamber 208 contains a seat 213 which accommodates a lower thrust bearing 214 in which the lower end of the shaft 207 is journaled. The housing contains a worm gear 215 meshing with a worm 216 rigidly mounted on the shaft 207. The housing has a lubricant receiving aperture 217 closed by a threaded plug 218, and also a bottom aperture 219 closed by a threaded plug 220, the purpose of which is to provide an outlet for any sediment or the like which may be deposited in said housing.

From an inspection of Figs. 9 and 12, it will be noted that the housing is united with a pair of horizontally extending bracket arms 221 and 222, formed integral with a circular plate 223 adapted to close a pilot valve guide housing 224. The housing 209 is provided with a removable cover plate 225 secured thereto by bolts 226. As will be noted in Fig. 9, the housing 209 is formed integral with a bearing sleeve 227 which extends into the same and receives the tubular portion 227*a* of a cam member 228. The cam is secured to a driven shaft 229 by keys 230. Longitudinal displacement of shaft 229 relatively to the cam is prevented by a lock nut 231 and a reduced shoulder portion 232 provided on the shaft. The worm gear 215 surrounds and is freely rotatable on the sleeve 227. As best shown in Fig. 10, one face of the worm gear 215 is provided with an annular grove 233 which communicates with a series of threaded apertures 234 and receives arcuately shaped pawls 235 held in place by set screws 235*a* threaded into certain of the apertures 234. It will be understood that a number of apertures are employed to provide adjustment for the pawls 235 with respect to the cam 228. Upon rotation of the worm gear 215 by the worm 216 in one direction or the other, one of the pawls 235 will contact one side of the cam 228 and cause the cam and the shaft 229 to rotate in one direction. It will be apparent that upon reverse rotation of shaft 191 simultaneously with the movement of the main plunger unit C, that the worm gear 215 will be rotated in the opposite direction, and the other one of the pawls will now come into engagement with the other side of the cam 228 and cause reverse rotation of the shaft 229. The structure is such as to permit some lost motion at the beginning of each stroke of the main plunger unit C.

The pilot valve

The pilot valve unit G is best shown in Figs. 9 to 12 inclusive, and it will be noted that the shaft 229 extends outwardly from the housing 209 through a stuffing box 237 disposed in the cover plate 223, and is journalled in a roller bearing 238 positioned in a recess 239 in that plate. The bearing 238 not only functions as a journal for the shaft, but it takes up all hydraulic thrust against that shaft and directed toward the casing 209. A cam 240 is integral with an end of the shaft.

The pilot valve guide housing 224 has a bore 241 in which a pilot valve guide 242 is disposed. The latter is provided with upper and lower vent ports 243 and 244, respectively, to allow fluid to flow to both sides of the guide for a purpose hereinafter set forth. The lower part of the guide is provided with an apertured cage or spider 245 which is connected to a rod or stud 246 that carries the pilot valve 247. The central body portion of the guide 242 is provided with a recess 248 into which the cam 240 extends for the purpose of reciprocating the guide and pilot valve, due to rotation of the shaft 229. The pilot valve is disposed in a housing 249 secured to the guide housing by bolts 250. It has been found that the weight of the valve guide and its cooperating parts have a tendency to move the valve downwardly, and to prevent this tendency, I employ a friction mechanism for balancing purposes in order to prevent any possibility of accidental movement of the guide 242 and valve 247. For this purpose, the housing 224 is provided with an external extension or hollow boss 251 having a bore 252 in which a sleeve 253 is arranged, the latter being provided at its inner end with a guide flange 254 which impinges against the guide 242 and acts as a friction shoe. A helical spring 255 is arranged in the sleeve to exert tension against the shoe. Adjustment of the spring is provided by a threaded stud 256 arranged at the outer end of the extension 251. The head 257 of the screw is disposed within the sleeve so as to abut against the inner surface of the outer end portion of the latter to prevent withdrawal of the screw in case tension of the spring is to be released. The shoe efficiently holds the guide and its cooperating valve in the desired position until the guide is actuated by the cam 240.

The valve housing 249 has a bore or chamber 258 provided with internal annular shoulders 259 that separates the interior of the housing into annular ports or passageways which surround the pilot valve. These shoulders are coaxially arranged and of the same diameter, and each is provided with a tubular bushing or liner 260 that is pressed into tight engagement with such shoulders. The spacing of the shoulders provides the annular passageways 261, 262, 263, 264 and 265 within the housing. The passageway 261 serves as an inlet and is in communication with the lower balancing passageway 265 by means of a passageway 266 which extends lengthwise of the housing 249. As clearly shown in Fig. 10, the housing 249 is provided with integral conduits 267 and 268 which are secured to the bottom casting 3 of the main tank by bolts 269. These conduits provide communication between the tank and the pilot valve hous-

ing. The conduit 268 is for the intake of the fluid to the valve housing, and it is provided with a check valve 270 (Fig. 11) for the purpose of shutting off fluid from the main tank when necessary repairs are to be made in the pilot valve unit without necessarily dissipating the pressure in tank 1. This valve is normally open, and fluid from the tank passes by it to the inlet passageway 261 and through passageway 266 into the lower end of the housing 249 in order that the pilot valve may be hydraulically balanced. The lower end of the housing is closed by a removable plate 271 provided with an aperture that is closed by threaded plug 272 employed in releasing fluid from the lower end of the unit G for making repairs and the like. A petcock 273 is provided at the top of the housing 224 for releasing fluid from the upper end for repair purposes or the like.

Upon rotation of the cam 240 to move the valve 247 downwardly, such valve opens passageway or port 262, and with the fluid under pressure from the main tank acting as a solid, it will flow through a conduit 280 to one side of the main control piston 282 (Fig. 16), as will be hereinafter set forth. With the pilot valve at its extreme lower position, the port 264 communicates with a conduit 281 leading to the opposite side of the main control piston 282. The communication between the passageway 264 and conduit 281 allows fluid from the main control piston 282 to flow through conduit 281, port 264, around the valve 247, and into passageway 263 that communicates with conduit 267, and hence, the pressure fluid will be exhausted back into the chamber 86 of the rack unit D from which it will travel to the auxiliary pump unit E in the manner heretofore explained, from whence it is pumped back into the tank 1. It will be understood that simultaneously with such flow, fluid is flowing from tank 1 through conduit 268, passageways 261 and 262, and conduit 280 to the opposite side of the control piston 282.

With the pilot valve in its uppermost position, as illustrated in Fig. 9, the fluid flows from tank 1 through 268, 261, 266, 265 and 264, beneath the pilot valve 247, and through conduit 281 to one side of the main control piston 282. Simultaneously with the flow of fluid through pipe 281, toward the main piston 282, the fluid flows from the opposite side of the control piston through pipe 280 and back to the auxiliary pump unit E in a manner which will be clearly understood from the foregoing. It will be observed that through this system of motivating, the fluid at the main control piston 282 is actuated by a small quantity of pressure fluid from the main tank, so as to control the movement of the main or control piston 282, and that this small quantity of fluid is returned by the auxiliary pump unit E to the tank 1. This particular feature has the advantage of creating the tremendous amount of hydraulic pressure required to actuate the control piston 282 for the purpose hereinafter set forth.

The control piston and main valve

The control piston and main valve unit H is best shown in Fig. 16, and will be described in connection with that figure, and Figs. 9, 14 and 15. Its housing 284 is chambered at 285 and provided internally with a guide sleeve 286 for the control piston 282. One end of the housing is closed by a threaded plug 287 having an internal recess 288 serving as a buffer for one end of the piston. The latter is assembled on a rod 289 which is coaxial with the sleeve 286 and extends through an apertured boss 290 integral with a flanged plate 291 that is clamped between adjacent ends of the housing 284 and the main valve housing 292, to which the housing 284 is secured by bolts 293. Piston rod 289 extends axially through a packing gland 294 disposed in the boss 290 and held in place by a nut 294a that is screwed into the boss. At the end opposite that where the rod 289 is connected to the control piston, it is secured to the main valve 283, as may be seen from Fig 16. The control piston 282 is recessed at 295 to receive a bumper spring 296 which cooperates with the plate 291 to cushion the movement of the control piston in one direction.

Fluid present within the housing 284 is prevented from travelling through the sleeve 286 by a fabricated packing ring 297 surrounding the piston rod and held in spaced relation by a washer 298, the assembly being held as part of the piston by means of screws 299. A recessed piston follower 300 encircles the shaft and houses an additional bumper spring 301 held by a slidable gland 302 and nut 303. The spring 301 cooperates with the plug 287 to cushion the movement of the control piston in the opposite direction.

In referring further to the piston housing 284, it will be noted from an inspection of Figs. 9, 14 and 15 that the sleeve 286 is provided with diametrically opposite extensions 304 and 305. The extension 304 is provided with communicating passageways 306 and 307, respectively, while extension 305 has similar communicating passageways 308 and 309. From Fig. 14 it may be seen that the extension 304 has a threaded aperture 310 to receive a cushion valve 311. A web 312 separates the passageways 306 and 307, and is provided with a port 313 into which the needle 314 of the cushion valve extends. The extension 304 is provided with a threaded aperture 315 closed by a threaded plug 315a which permits the introduction or removal of a ball check valve 316. A threaded aperture 317 communicating with the passageway 306 is provided for the attachment of one end of the conduit 281 which provides communication with the pilot valve G, as hereinbefore explained. The web 312 has a port 318 into which extends a valve seat 319 for the valve 316. A port 320 places the passageway 307 in communication with one end of the guide sleeve 286 of the control piston, whereby fluid from the pilot valve unit G may flow to one end of the piston (the left end in Fig. 16) for the purpose of moving such piston in one direction.

It is to be understood that the extension 305 (Fig. 15), is constructed similar to the extension 304, and is provided with a cushion valve 321, check valve structure 322, and a port 323 providing communication between passageway 309 and the sleeve 286 at the opposite end of the piston. In view of the similarity of construction of the extensions 304 and 305, and since they function in identically the same manner, reference will be made only to the operation of the structure shown in the extension 304. With fluid flowing from the pilot valve through conduit 281 to the passageway 306, such fluid will flow through the port 313 into the passageway 307 and thence through port 320 to one end of the sleeve 286 which guides the control piston. At this point it may be stated that the needle 314 of the cushion valve is adjustable to control the flow of

fluid through port 313. The check valve 316 is closed during the flow of fluid through conduit 281 and port 313, but upon return movement of the fluid on a reverse stroke of the piston 282, the fluid passes through port 320, opens check valve 316, and thence flows through the passageway 306 and conduit 281 back to the pilot valve. It is to be understood that the extension 305, cushion valve 321, check valve 322 and port 323 function to supply fluid to the opposite end of the control piston 282 upon receiving fluid passing through conduit 280.

The purpose of the check valves 316 and 322 is to allow the maximum flow of fluid on the exhaust side of the control piston 282. From the foregoing it will be understood that a small quantity of fluid under pressure from the tank 1 flows into the pilot valve, and thence to the extensions 304 and 305, where it controls the movement of the main control piston 282 to position the main valve 283; it being apparent that the position of the pilot valve 247 is controlled by the reciprocation of the main ram unit C through the medium of the reversing mechanism F (Fig. 6).

The main valve housing 292 is cast integral with the tank bottom 3, and is disposed in a position beneath the tank, offset from the axis of the main plunger unit C, as will be clear from Fig. 16. Such housing is substantially circular, and is provided with an internal chamber 324 into which a plurality of spaced annular flanges 325 extend, each being provided with a shoulder 326 to receive an annular liner 327 frictionally pressed against the shoulders, and held in position by the hydraulic pressure from the motor unit A. It will be apparent that the liners cooperate with the flanges to form a plurality of spaced seats or guides 328, 329, 330 and 331 in which the main valve 283 slides. The main valve comprises a tubular body portion 332 having oppositely disposed end flanges 333 and 334. The central portion of the flange 334 forms a shoulder 335 against which an apertured gland 336 abuts. An annular disc 337 impinges against the gland and is secured to the flange by bolts 338, thus clamping the gland against said shoulder. The piston rod extends through the gland and is secured thereto by a lock nut 339, the arrangement being such as to provide a flexible connection between the rod and the main piston which will compensate for any dis-alignment of the rod during reciprocation. The flange 333 of the main valve is provided at its central portion with a shoulder or recess 340 for the reception of an apertured gland 341 which is secured to the flange by bolts 342.

It is to be noted that each end flange 333, 334 is formed at opposite sides thereof with a circumferential series of V-shaped serrations or teeth 343 to assist in the gradual diminishing of the flow of fluid upon the opening or closing of a port due to reciprocation of the valve 283. Gradual diminishing has a tendency to eliminate any shocks on the valve, due to hydraulic pressure. It will be apparent that the action of the fluid on the serrations or teeth would have a tendency to rotate the valve, and to overcome this, a square or non-circular shaft 344 (Figs. 16 and 20) extends into the tubular body portion 332, and through a complementary shaped aperture in the gland 341. The shaft has a reduced threaded end portion 346 which extends into and is secured to a boss 347 arranged at the inner side of a cover plate 348 that closes one end of the main valve housing, and is secured in position by bolts 349.

The space in the main valve housing between the valve seats 328 and 329 forms an annular passageway 350 which communicates with a conduit 351 that leads to the main tank. Such conduit is arcuately shaped, and its upper end is secured to the bottom of the tank by bolts 356 (Fig. 8). From an inspection of that figure, it may be seen that the conduit also acts as a housing for a speed valve to be hereinafter described. The space in the main valve housing between the seats 330 and 331 provides an annular passageway 357 communicating with a passageway 358 (Fig. 13) formed by an extension 359 cast integral with the main valve housing 292 and the tank bottom 3, and arranged immediately below the main plunger unit C. The central portion of the main valve housing 292 forms an annular passageway 360 in communication with the crank case 361 (Fig. 17) of the radial pump unit which will be hereinafter described.

One side of the main valve housing 292 is provided with a plurality of outwardly projecting flanged extensions 362, 363 and 364, and are used in securing the main valve housing to the crank case 361 of the radial pump by any conventional means such as bolts or the like (not shown). The extensions 362, 363 and 364 form passageways 365, 366 and 367, respectively, (Figs. 16, 17 and 18), and the ports 365 and 367 are in communication with a substantially circular annular passageway 368 (Figs. 17 and 23) provided in the crank case 361. The port 368 extends substantially annularly around said crank case, and is in communication with the outlet ports of each cylinder of the radial pump, as will be hereinafter explained. The lower part of the passageway is blocked off as shown at 368a in Fig. 23, to prevent out-going fluid from the pump being mixed with the fluid entering the pump.

The radial pump

From an inspection of Figs. 17 and 23, it will be observed that the radial pump unit B comprises an annular housing or crank case 361 provided at its periphery with radially extending auxiliary housings 371 which contain the radial pump pistons and cylinders proper. The heretofore mentioned crank shaft 4 extends through the housing 361 and is guided by a sleeve member 372, as will be hereinafter set forth. The auxiliary housings 371 are preferably ten in number, corresponding to the number of cylinders of the radial pump, and since the construction of each cylinder and its piston, valves, etc., are identical, only one of these assemblies will be described. Each housing 371 is secured to the crank case at 373 by conventional bolts and the like (not shown). It has a bore 374 provided internally with a sleeve 375, lined by a cylindrical liner 376 which guides a tubular pump piston 377. The liner is removable to allow for wear, and is shouldered at 378 in the sleeve to prevent movement thereof by hydraulic pressure. The piston 377 is secured to a connecting rod (to be hereinafter described in connection with the connecting rod assembly), by a wrist pin 380 extending through a bearing 381, and held therein by any suitable means. The piston is provided internally with an apertured guide 383 for the stem 384 of a valve 385. The disposition of the sleeve 375 within the housing provides for three passageways 386, 387 and 388 through the housing, with the piston disposed in the passageway 387.

As will be apparent from Figs. 17 and 19, the passageway 386, which forms one of the fluid in-

lets, has disposed therein a plurality of apertured spiders 389 and 390 for guiding the valve stems 391 and 392 of a pair of inlet valves 394. Only one of these valves is shown in Fig. 17. At this point it will be understood that the outer face 395 of the housing 371 acts as a seat for the inlet valves 394. The outer end of each housing is closed by a plate or cylinder head 396 which is secured to the housing by bolts 397. A plurality of apertured spiders 398 (preferably three in number), are disposed within the outlet passageway 388 (Fig. 19) for the mounting of valve spring containers 401 for the discharge valves 402. It will be understood from an inspection of Fig. 19 that there are three identical discharge valves, but only one of them is shown in Fig. 17. Each spring container 401 is anchored on shoulders (not shown), provided in a liner 403 disposed in the apertured spider 398. The opposite end of the cylindrical spring container restricts the opening or lift of the discharge valve 402 by a helical spring 404 disposed within the container to provide tension against one face of the valve to normally hold it in position against its valve seat 405 provided by the inner face of the cylinder head 396. A stem 407 for the valve extends through an apertured plate forming part of the head 396, and into a guide spider 408 integrally disposed within the head 396.

Referring further to inlet valves 394, the head 396 has an apertured spider 409 integrally disposed therein, which receives a spring container 410 identical with the container 401, and containing a helical spring 411 to exert tension against the valve 394 which abuts against the outer end of the housing 371. From the foregoing, it will be apparent that the structural arrangement of the inlet valves and the discharge valves are identical, with the exception that they are disposed in an inverted position with respect to each other. Secured to the outer end portion of each piston 377 is a spider 412 for anchoring a spring container 413 cooperating with valve 385 in a manner identical with the inlet and discharge valves. From an inspection of Fig. 17, it will be apparent that the valve 385 seats against a shouldered portion 414 of the piston.

At this point it will be noted that the piston valve is also an inlet valve, so each of the radial cylinder units will have three inlet valves and three discharge valves.

With the main valve in a position as in Fig. 16, fluid from tank 1 flows through passageway 350, through port 329 and passageway 366, into the chamber 415 of the pump crank case 361, thence through passageways 386 and 387, past inlet valves 385 and 394, into the chamber 416 of cylinder head 396. It will be understood that with the plurality of pistons and cylinders in the radial pump 370, that rotation of the crank shaft 4 will cause one-half the pistons to work on a pumping stroke in order to displace fluid from the chambers 416 past the discharge valves 402, while the remaining pistons are being actuated in an opposite direction to allow fluid to be passed by the inlet valves 385 and 394 to fill the chambers 416. A petcock 406 (shown at the left in Fig. 17), is provided on each cylinder head 396 to allow dissipation of fluid from the head in making repairs and the like. With the flow of fluid into the chambers 416 through passageways 386 and 387, the discharge valves 402 remain seated to allow filling of the chambers 416. Upon the pumping stroke of the pistons, the fluid acting as a solid, is caused to be discharged past the valves 402 into the passageways 388 and 368 which are in communication with the passageways 365 and 367 of the main valve structure shown in Fig. 16. As previously referred to, the passageway 368 is blocked off from the passageway 366 in order to prevent any passage of discharge fluid into the passage 366.

The passageways 365 and 367 are in communication with each other by a by-pass 417 (Figs. 18 and 23). Consequently, with the flow of the fluid past the discharge valves into the passageway 368 and ports 365 and 367, the fluid will be by-passed from one port 365 or 367, to the other, depending upon whether fluid is to be pumped from the tank to the plunger unit C, or from the plunger unit to the tank. If fluid is pumped by the radial pump unit B from the tank 1, to the main plunger unit, the fluid is by-passed through port 417 from passageway 365 into port 367, so that all of the fluid will pass through passageway 357 into the bottom of the main plunger unit C. It is to be noted that the flanged end 334 of the valve 283 prevents passage of the fluid to the passageway 350. With the fluid acting as a solid, and being pumped into the main plunger unit C, and forcing the latter upward, the reversing unit F cooperates, causing actuation of the pilot valve 247 through which a small quantity of the pressure fluid from the main tank flows into the chamber 285 of the piston housing 284, whereby the control piston 282 is shifted in one direction, and moves the valve 283. When the main plunger unit C is at its uppermost position, the flanged end 334 of valve 283 is contacting valve seat 331, while the end 333 contacts seat 329. Upon downward movement of the main plunger unit C, the fluid is forced by the radial pump unit from beneath the main ram through the passageways 357 and 360, back into the bore 415 of the crank case of the pump whence it is forced by the radial pump through the passageways 368, 365, 367, 350 and 358, back into the main tank. It will be understood with this movement of fluid from the ram into the tank, that the fluid being pumped into the passageway 368 is by-passed from passageway 367 to 365.

It will be apparent that, due to the construction of the radial pump valves, that the fluid can pass through them only in one continuous direction. Consequently, the fluid being pumped always flows through the passageway 366 to the radial pump valves to be discharged through passageways 365 and 367, regardless of whether the fluid is being pumped from the ram unit to the tank, or from the tank unit to the ram unit.

It has been found that with gas pockets present in the column of oil pumped, that such condition would decrease the load, causing the working barrel plunger in the well to speed up, and consequently, cause an increased acceleration of the fluid beneath the main plunger unit C. However, the construction of the radial pump and the inlet and discharge valves therefor are such that upon any increased acceleration of fluid, the fluid can pass through such valves without the need of energy from the radial pump pistons. It has been found that when the working barrel plunger in the well starts on the down stroke, there is an increased acceleration of the same, due to the oil load remaining on the working barrel plunger. The discharge valve in the working barrel will not open immediately at the beginning of the stroke, because the fluid has been

taken into such barrel through the standing valve of the well pump on the upward stroke, in a gaseous condition. Therefore, on the beginning of the down stroke of the working barrel plunger, the fluid must be compressed until its pressure more than equals the pressure existing in the tubing and on the working barrel plunger. During this time, the working barrel plunger falls rapidly, so that at the beginning of the upward stroke, the work to be done by the radial pump is also decreased, because there is a period of lighter load resulting in stretch of the rods, and the picking up of friction and acceleration before the working barrel plunger actually starts upward.

As above mentioned, the construction of the radial pump is such that during this period, there is a decreased load on the radial pump pistons, but the accelerated fluid can pass freely by the radial pump valves from the main piston unit C to the tank, consequently causing very little use of power.

It will be understood that under normal pumping conditions, the reciprocation of the main valve 283 is not progressive with the reciprocation of the main plunger unit C. The cam 240 (Fig. 9) determines at which point of the travel of the main plunger unit the control piston 282 is moved, to cause movement of the main valve 283. Adjustment of the pawls 235 in the recess 233 (Fig. 10) determines at which point of the main piston travel the control piston 282 will be actuated. This arrangement allows variances from a point at the end of the stroke of the main plunger unit C to a position two or three feet approaching the end of its upward or downward movement.

The outer side of the crank case 361 of the radial pump (Fig. 17) is closed by a plate 418 secured thereto by bolts 419. Such plate has an outwardly extending sleeve portion formed by the guide sleeve 372 of the crankshaft 4. A tubular bushing 420 is disposed in the sleeve 372, and receives a liner 420a forming a bearing for the crankshaft which extends therethrough. A stuffing box 421 is provided on the outer end of the sleeve, and comprises a plurality of packing rings 422 and glands 423 to prevent leakage of the fluid from the radial pump unit along said shaft.

By reference to Fig. 23, it will be noted that a stuffing box 424 for the crankshaft is shown covered by an open housing cradle 425 bolted to the tank bottom casting 3, and it will be understood that the casting 3 has integrally cast therewith the main valve housing 292 in which is partially disposed the crankshaft sleeve 372. The cradle 425 has an internal annular flange 426, which, in conjunction with a cover plate 427 and the cradle, forms a chamber 428 having a roller bearing assembly 429 positioned therein. The crankshaft extends through the flange 426, bearing assembly 429 and cover plate 427, and is provided at its outer end with a drive pulley 430 that may be connected to any suitable source of motive power. The roller bearing assembly 429 comprises an annular split collar 431 of frusto-conical shape externally, and complementary with the frusto-conical inner surface of a bearing race 432. Rollers 433 are interposed between the race 432 and a collar 433a in the housing 425, and the parts are held in assembled relation by a nut 434 which is threaded on to the reduced end of the split sleeve 431. It will be seen that any frictional adjustment of the split sleeve can be made by adjustment of the lock nut 434. This construction allows for perfect aligning of the crankshaft at any time, and also takes up any thrust caused by the drive pulley 430. A particular feature of the crankshaft assembly is that the crank case 361 of the radial pump can be released from the main valve housing 292, whereby the radial pump unit and crankshaft 4 can be replaced by an entirely new unit, if necessary, thus reducing the shut-down time of the main unit, and consequently keeping the pumping unit in operation practically at all times.

The safety valve

From an inspection of Figs. 8 and 23, the construction of the safety valve I may be obtained, and it will be noted that the conduit 351 is provided with a depending apertured boss 436 having the lower end of a cylinder 437 disposed therein. The upper extremity of the conduit extends into an aperture 438 provided in the tank bottom 3, and immediately adjacent said aperture, the tank bottom is provided with a slightly inclined flange 439. Extending upwardly into the tank 1, a spider 440 is united with the inner portion of said flange. As shown in Fig. 16, the spider preferably consists of three arms supporting an annular guide 441 for the active member or head 442 which reciprocates vertically. The head 442 is hollow, and its lower end is of greater diameter than the cylinder 437, and although the upper end of the cylinder extends into the valve head, fluid can flow through said head for a purpose hereinafter explained. The lower portion of said head is of substantially frusto-conical shape, so that its outer surface may engage a tapered valve seat 443 at the upper end of the conduit 351. The cylinder 437 is threadedly secured at its lower end to a plate 444 which in turn is secured to the boss 436 by bolts 445. The cylinder extends upwardly in the conduit to a position substantially parallel with the valve seat 443. The plate 444 has an apertured boss 446 for the reception of an adjusting screw 447. The latter extends upwardly into the cylinder and is held in any desired adjusted position by a lock nut 448. The screw has an upper unthreaded portion 449 extending through the valve head 442, and terminating in a tapered head 450 that cooperates with a tapered seat 451 provided at the upper end of the passageway which extends through the head 442. At the point where the threaded and unthreaded portions of the screw meet, the screw has an annular shoulder 452 against which a washer 453 abuts. A helical spring 454 disposed within the sleeve 437 bears at one end against the washer, and at its opposite end against a spider 455 integral with the head 442.

It will be seen that with the flow of fluid from the main valve to conduit 351, the head 442 is held in open position by tension of the spring 454, allowing passage of fluid into the interior of tank 1. With flow of fluid from tank 1 into the main control valve, hence into the main plunger unit C, if, for any reason, the hydraulic pump unit A became unbalanced, for example, by a rod breakage in the well releasing the load and increasing the fluid velocity in the unit A, this, if allowed to continue, would cause damage to the working parts of the unit A. Any increase of fluid velocity exerts force enough against the head 442 to overcome the tension of the spring 447, causing the head to seat on 443. With the head 442 seated, obviously, fluid is prevented from flowing from the main tank into the main

valve housing 292, and hence, to the main plunger unit C. Any sudden stoppage of the flow of fluid would consequently cause an unusual and sudden stoppage of the working parts of the unit A, causing shock to the main reciprocating plunger C. In order to prevent complete stoppage of the flow of fluid from the tank, some of the fluid is allowed to flow through the valve head 442, so that the main plunger unit C will be allowed to move slowly in a pumping stroke, and will be cushioned by the shock absorbing spring 49 (Fig. 3) of the main plunger unit.

The screw 447 can be rotated in a counterclockwise direction, when desired, to pull the head 450 downward, thus relieving the tension of the helical spring 454 which allows the head 442 to engage its seat 443, and closing the passageway through said head. With this procedure, any overhauling or repairing of the pump may be accomplished without disturbing the pressure of the fluid in the tank 1.

The radial pump split crank bearing

As clearly shown in Figs. 17, 21 and 23, the crankshaft 4 has a solid or integral crank pin 460 to which is secured a split main master connecting rod bearing, consisting of semi-circular sections 461 and 464. Interposed between the crank pin and the main bearing is a babbited split bearing sleeve or liner 402 dove-tailed to the half sleeves 461*a* and 463*a* of the main bearing. The split sleeve is provided with a pair of complementary outwardly extending spaced flanges 461*b* and 463*b*; the flanges of the two sections being detachably connected together by bolts 466. Four bolts are preferred, arranged in parallel relation, two at each side of the crank pin 460 in order to hold the sections together. A main connecting rod 467 is integrally cast and rigid with the bearing section 461, and the flanges 461*b* of the latter, which are preferably provided with apertures to receive pins 480 employed in pivotally connecting pitmans 469, 470, 471 and 472 to the section 461. The complementary section 464 also has its flanges 463*b* provided with apertures to receive the pins 480 which pivotally connect connecting rods 474, 475, 476, 477 and 478 to the section 464. It will be understood that all the connecting rods except the master rod 467, are secured in an identical manner to the bearing sections 461 and 464.

The particular novelty of this construction is the split bearing providing two sections in order that the crank pin may be made integral with the crankshaft. As previously mentioned, the two sections are held in place by the bolts 466, and it will be obvious that if all of the connecting rods were of the same length, there would be no space provided to allow passage of the coupling bolts which secure the sections together. In order to provide space for such bolts, some of the apertures for the pins 480 are positioned nearer the axis of the pin 460 than the remaining apertures. As will be apparent from Fig. 21, the apertures for the pins of the rods 470, 471, 475, 476 and 477 are closer to the axis of the pin 460 than are the remaining apertures for the pins of the connecting rods 469, 472, 474 and 478. With this arrangement, the bolts 466 may readily pass through the flanges along parallel lines spaced inwardly from the pins 480 which connect the rods 469, 472, 474 and 478 to the crank pin bearing. Although certain of the pins 480 are arranged nearer the axis of the crank pin than are the other pins 480, it will be noted that the overall radii of the connecting rods from the center of the crank pin is equal. This is accomplished by making the rods 469, 472, 474 and 478 shorter than the remainder of the connecting rods, so that the assembly comprises four short connecting rods, and six long ones.

From an inspection of Figs. 1 and 23, it is to be noted that a relief valve 485 is secured to the bottom of the main valve housing 492. The structural arrangement of the relief valve will not be considered in this description. However, it has the effect of relieving any damaging or detrimental pressure which might occur in the hydraulic pump, due to the stopping of the main ram for any cause. Such valve is in communication with the intake passageway 366 of the pump, and also with the by-pass 417 which connects the passageways 465 and 467 (see Fig. 23).

Referring further to Fig. 1, it will be observed that the hydraulic unit A is provided with a pressure gauge 490 communicating with the interior of the tank 1, in order that the pressure in said tank may be observed at all times. A gauge 491 is in communication with the piston unit C, whereby the pressure acting against the main piston unit C may be seen. An indicator 492 is connected with the reversing unit F in order to indicate the position of the main plunger unit C during its length of travel.

A flexible conduit 493 is inter-connected between the suffing box 421 of the crank shaft of the radial pump and the lower part of the auxiliary pump unit E, in order that any fluid leaking from the crank case of the pump along the shaft in one direction, will be returned to the auxiliary pump unit E, which will force it into the tank 1.

A cover 495 is provided at the top of the tank 1, and covers the upper part of the main plunger unit C, including the plunger head 38 and the polish rod clamp 74, as well as the arms 81 and 134. It protects these upper part from rain, snow, wind and the like.

Operation

With the hydraulic unit A installed over the well, as shown in Fig. 1, the polish rod 75 is clamped at 74 to provide a connection between the unit A, the sucker rods and the working barrel in the well hole (not shown). The tank 1 is partially filled with a fluid, such as light oil or water, and then air is pumped into the tank by a compressor (not shown), so that the combined pressure in the tank is such that it will equal all the weight of the rods, one-half of the oil weight to be pumped, one-half of the friction of the oil in the tubing, and one-half of the acceleration load necessary to start the plunger unit C and its cooperating parts on an upward stroke. It will be seen that all the work is balanced with the exception of one-half the oil weight, one-half the load of friction, and one-half the load of acceleration. In order to raise the plunger unit C, this additional energy that is not balanced must be produced by the radial pump unit B, and upon rotation of the crank shaft 4 to start motivation of the radial pump unit, and with the fluid in the unit A acting as a solid, the radial pump discharges a volume equal to the pressure energy necessary to overcome the unbalanced load. This energy in cooperation with the balanced pressure in the tank, acts on the plunger unit C to cause its movement upwardly.

It will be understood that with all the cooperating parts of the unit A moving in unison, the plunger unit C moves upwardly at a speed determined by the speed of the radial pump unit B. This can be varied in accordance with the required piston displacement. Although it is thought that the previous description of the cooperating individual units is sufficient, it will be apparent that with the upward movement of the plunger unit C, the rack unit D through its connecting arm 81 moves upwardly simultaneously with the plunger unit to cause operation of the reversing unit F, whereby the cam 240 causes movement of the pilot valve 247 to allow a small quantity of the fluid under pressure to flow from the tank 1 around the pilot valve into one end of the control piston 282 to move the main valve in an opposite direction. Also, it will be apparent that due to the connection 134 of the auxiliary pump unit E with the main plunger unit C, that the auxiliary pump unit functions to return any fluid leakage in the unit A back into the tank 1.

Due to the change of position of the main valve 283, the fluid that was necessary to raise the plunger unit C to its upward position is pumped by the radial pump, back through the conduit 351 into the tank 1. It is to be understood that with the piston unit C at the top of its stroke, and the attendant parts of the unit A reversed, a different load condition exists. The rod weight is still present on the plunger, while the oil, friction and acceleration loads have disappeared, therefore the balanced pressure in the tank 1 is greater than the rod load on the plunger by an amount equal to one-half the oil, friction and acceleration loads. In order for the plunger to descend, it is necessary for the radial pump unit B to generate enough energy to overcome this greater pressure in the tank. With the reversal of the attendant parts, the automatic actuation of the unit A removes the additional pressure from beneath the plunger unit C allowing it to move downward due to its own weight, forcing the fluid beneath it into the intake port 360 of the radial pump whence it goes through the radially disposed intake valves of the pump into the discharge ports 365 and 367 through the speed valve I (Fig. 8) and back into the tank 1. Obviously, this downward stroke continues until the reversing unit F is actuated to again reverse the operation as heretofore set forth.

To explain this cycle of operation, reference is made to Fig. 22, showing hypothetical data wherein the rod weight is assumed to be 100 lbs., the oil weight 100 lbs., and the friction and acceleration weights 100 lbs., making a total load of 300 lbs., per sq. in. Alluding further to the balanced pressure in the tank, it will be seen that the rod weight plus ½ the oil, friction and acceleration loads will be equal to 200 lbs. Since the total load is 300 lbs., it will be seen that the remaining ½ oil, friction and acceleration load will be equal to 100 lbs., which must be generated by the radial pump unit B, and which, in cooperation with the 200 lbs. pressure in the tank 1, will be equal to the 300 lbs. necessary to lift the entire load of rods, oil, friction and acceleration. With the plunger being moved to the top by these cooperating pressures, we find that the oil, friction and acceleration loads have been eliminated, leaving only the 100 lb. weight of the rods effective on the plunger or ram unit C. Since the balanced pressure in the tank is 200 lbs. sq. in., and the rods are only 100 lbs. per sq. in., the plunger cannot be moved downwardly until the radial pump generates another 100 lbs. per sq. in. of energy capable of cooperating with the 100 lbs. rod weight to allow the plunger unit to descend.

As a summation, the hydraulic unit A is capable of lifting a 26,000 lb. constant barrel plunger load. This load may be divided into component parts of plunger diameter and head. For example, a 2¾ inch diameter may pull a load located at a depth of 6,000 feet, or the load of a 1¾ inch plunger at a depth of 9,000 feet. It will be apparent that any combination can be achieved, depending upon the plunger diameter and head. The hydraulic unit A is designed to normally run at 250 piston feet of travel per minute, and under favorable conditions, 3,000 barrels of fluid per day can be pumped. The machine weighs approximately 10 tons, and stands approximately 50 feet high from the derrick floor. It is self-contained, as heretofore mentioned.

Changes may be made in the combination and arrangement of parts, as heretofore set forth in the specification and shown in the drawings, it being understood that any modification in the precise embodiment of the invention may be made within the scope of the following claims without departing from the spirit of the invention.

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

1. A hydraulic transmission apparatus comprising a cylindrical member provided with an upper and lower head, said upper head disposed below the top of the cylindrical member to form a reservoir, a plurality of concentric cylinders provided within the cylindrical member, a piston disposed between the cylinders, a fluid under pressure contained within the cylindrical member, a radial pump secured to the lower head for supplying fluid to reciprocate the piston unit, said reservoir receiving any fluid leakage flowing by the piston unit, and means disposed within the cylindrical member in communication with the reservoir for delivering the leakage fluid back to the cylindrical member.

2. A balanced hydraulic transmission comprising a tank containing a fluid under pressure, said tank constructed with a reservoir at its topmost portion, a plurality of concentric cylinders disposed within the tank, a piston unit disposed between the cylinders, means cooperating with the fluid in the tank for reciprocating the piston unit, means providing communication between the cylinders and the reservoir whereby any fluid leakage around the piston unit is deposited in said reservoir, and means disposed within the tank and actuated simultaneously with the reciprocation of the piston unit for returning any deposited fluid to the tank as it occurs, to prevent any unbalancing of the system.

3. A balanced hydraulic transmission system comprising a tank containing a fluid under pressure, said tank constructed with a reservoir at its topmost portion, a plurality of concentric cylinders disposed within the tank, a piston unit disposed between the cylinders, means cooperating with the fluid in the tank for reciprocating the piston unit, means providing communication between the cylinders and the reservoir whereby any fluid leakage around the piston unit is deposited in said reservoir, and an auxiliary pump disposed within the tank and actuated simultaneously with the reciprocation of the piston

unit for instantly returning any deposited fluid to the tank as it occurs.

4. A hydraulic transmission for operating a well pump comprising a tank containing a fluid under pressure, said tank provided with a plurality of concentric cylinders, reciprocating means interposed between the cylinders, means secured adjacent the tank for supplying fluid to either the tank or the reciprocating means, valve means for controlling the flow of the fluid to the supply means, a rack mechanism synchronized with the actuation of the reciprocating means, a pilot valve in communication with the tank, a control piston in communication with the pilot valve and connected to the control valve, means interconnecting said rack mechanism and pilot valve to cause actuation of the pilot valve for delivering fluid from the tank to the control piston to cause movement of the control valve, said control valve, rack mechanism, and control piston substantially self-contained within the tank providing central disposition of the apparatus over a well hole.

5. A balanced hydraulic transmission for operating a well pump comprising a tank containing a fluid under pressure, a plurality of concentric cylinders disposed within the tank, a piston disposed between the cylinders, a radial pump cooperating with the fluid in the tank for reciprocating the piston, said cylinders and tank having means so associated whereby any fluid leakage around said piston is returned to the tank to prevent unbalancing of the system, valve means for controlling the supply of fluid to the radial pump, a rack mechanism synchronized with the reciprocation of the piston unit, a pilot valve in communication with the tank, a control piston in communication with the pilot valve and connected to the control valve, means interconnecting said rack mechanism and pilot valve to cause actuation of the pilot valve for delivering fluid direct from the tank to the control piston to cause movement of the control valve.

6. A balanced hydraulic transmission apparatus for operating a long stroke well pump comprising a tank containing a fluid under pressure, a plurality of concentric cylinders disposed within the tank, a reciprocating piston unit interposed between the cylinders, a radial pump secured adjacent the tank for supplying fluid to either the tank or the piston unit, reciprocating valve means providing communication between the tank and the radial pump for controlling the flow of fluid to the radial pump, means providing communication between the valve means, and the piston unit, a rack mechanism synchronized with the reciprocation of the piston unit, a pilot valve in communication with the tank, a control piston in communication with the pilot valve and connected to the control valve, means interconnecting said rack mechanism and pilot valve to cause actuation of the pilot valve for delivering fluid direct from the tank to the control piston to cause reciprocation of the control valve, said control valve, rack mechanism and control piston substantially contained within the tank to provide central disposition of the apparatus over a well hole, and capable of being moved without dissipating any fluid in the apparatus.

7. A balanced hydraulic transmission apparatus for operating a long stroke well pump comprising a tank containing a fluid under pressure, a plurality of concentric cylinders disposed within the tank, a reciprocating piston unit interposed between the cylinders, a radial pump secured adjacent the tank for supplying fluid to either the tank or the piston unit, reciprocating valve means providing communication between the tank and the radial pump for controlling the flow of fluid to the radial pump, means providing communication between the valve means and the piston unit, a rack mechanism synchronized with the reciprocation of the piston unit, a pilot valve in communication with the tank, a control piston in communication with the pilot valve and connected to the control valve, means interconnecting said rack mechanism and pilot valve to cause actuation of the pilot valve for delivering fluid direct from the tank to the control piston to cause reciprocation of the control valve, said control valve, rack mechanism and control piston substantially contained within the tank to provide central disposition of the apparatus over a well hole, capable of being moved without dissipating any fluid in the apparatus, and safety valve means interposed in the communicating means between the tank and the control valve for regulating the amount of flow therethrough.

8. A hydraulic transmission for operating a well pump comprising a tank containing a fluid under pressure, a plurality of concentric cylinders disposed within the tank, a substantially hollow reciprocating piston disposed between the cylinders, means cooperating with the fluid in the tank for creating energy to reciprocate the piston, auxiliary pump means disposed in the tank to return any fluid leakage around said piston and prevent unbalancing of the pressure, means for controlling the supply of fluid to the energy creating means, said means comprising a valve actuated periodically with the stroke of the piston, a rack mechanism synergetically cooperating with the reciprocation of the piston, pilot means providing communication between the tank and the control means, and means connecting the rack mechanism and the pilot means to cause operation of the pilot means for delivering fluid direct from the tank to cause operation of the control means.

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