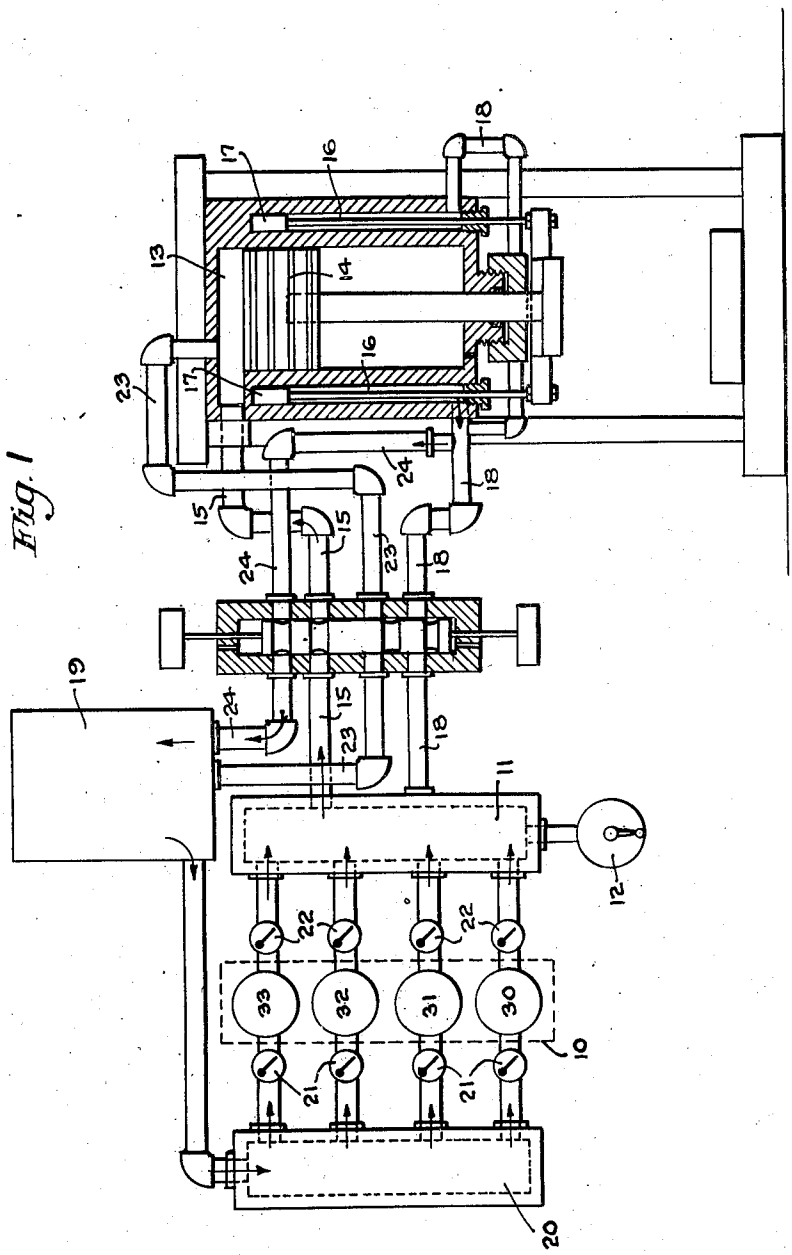
Feb. 18, 1947. C. B. GRAY 2,416,171

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Fig. 1



Inventor
CHARLES B. GRAY
By Leo Adelson
Attorney.

Feb. 18, 1947. C. B. GRAY 2,416,171

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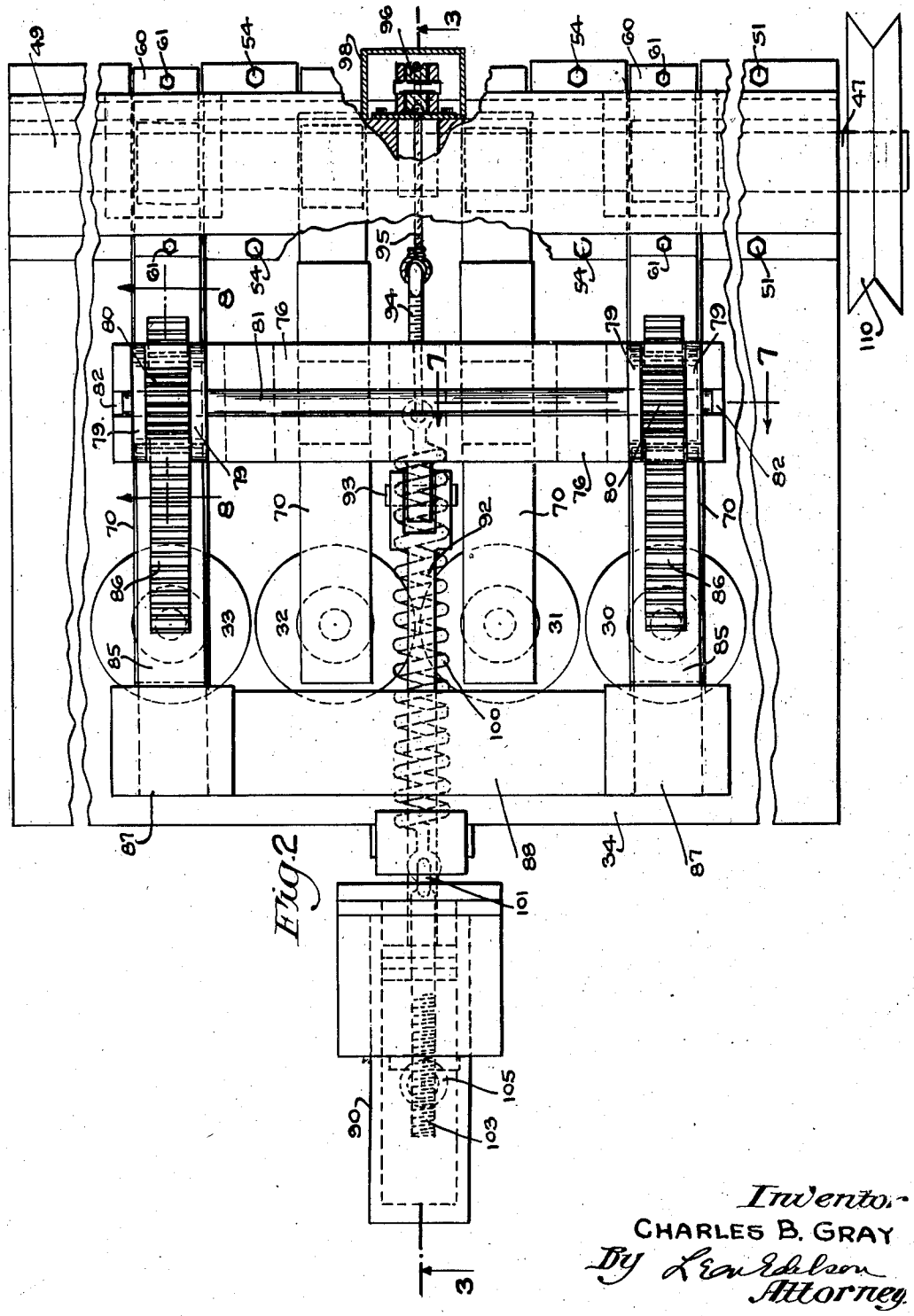


Fig. 2

Inventor:
CHARLES B. GRAY
By Lean Adelson
Attorney

Feb. 18, 1947. C. B. GRAY 2,416,171

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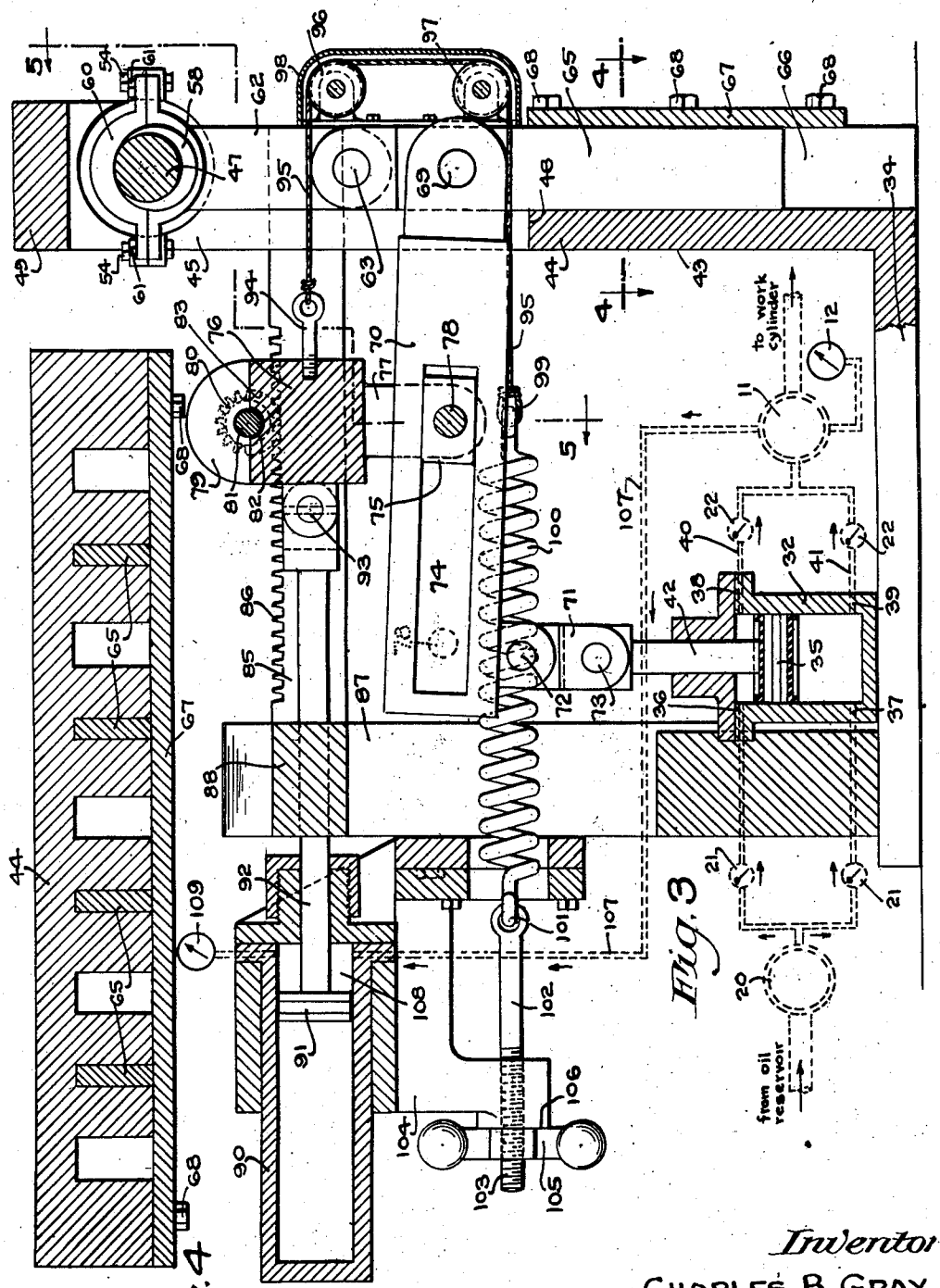


Fig. 3

Fig. 4

Inventor
CHARLES B. GRAY
By Lear Edelson
Attorney

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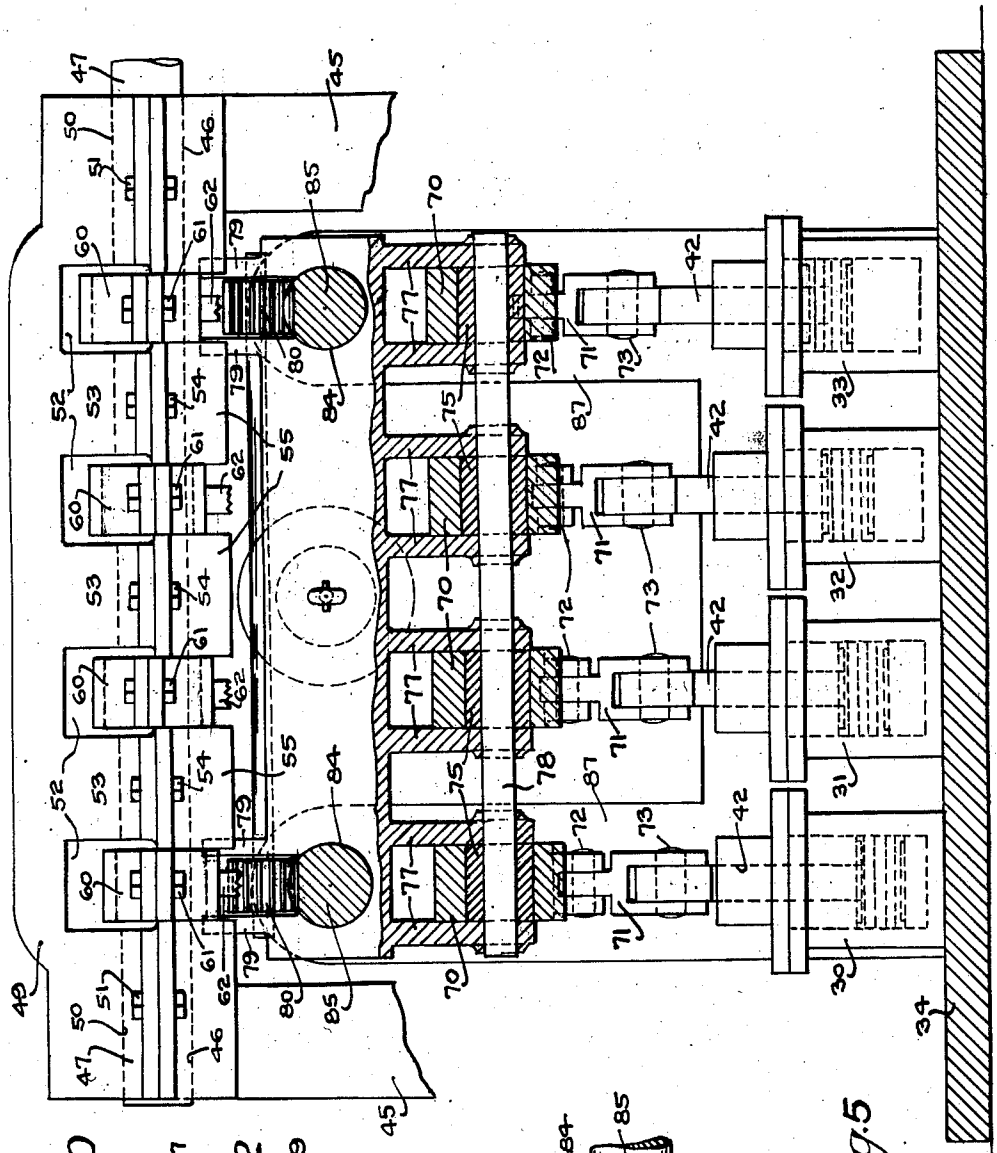


Fig. 5

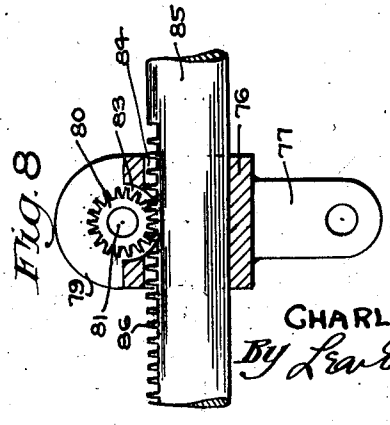


Fig. 8



Fig. 10

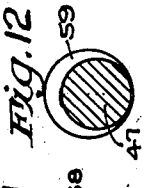


Fig. 12



Fig. 9

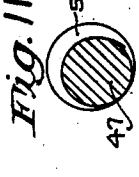


Fig. 11

Inventor
CHARLES B. GRAY
By Lea & Elson
Attorneys

Feb. 18, 1947. C. B. GRAY 2,416,171

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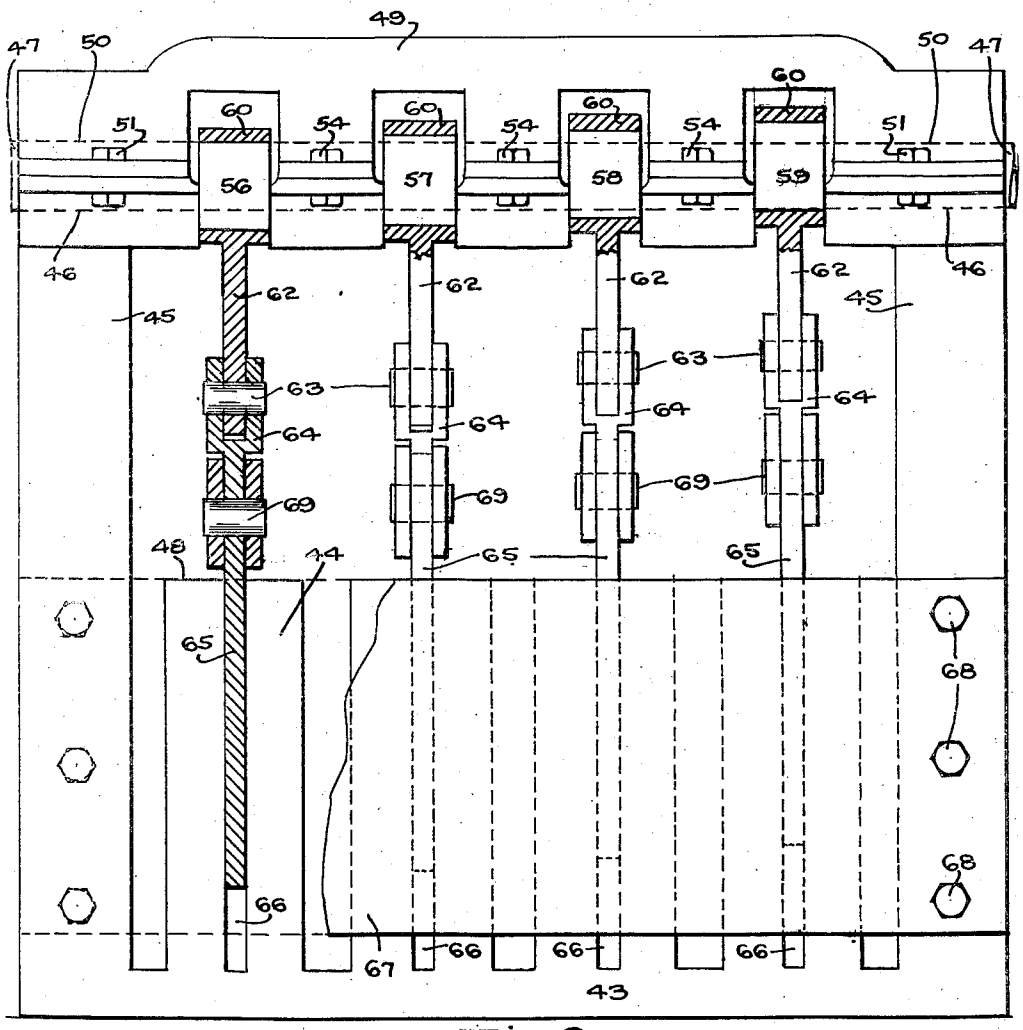
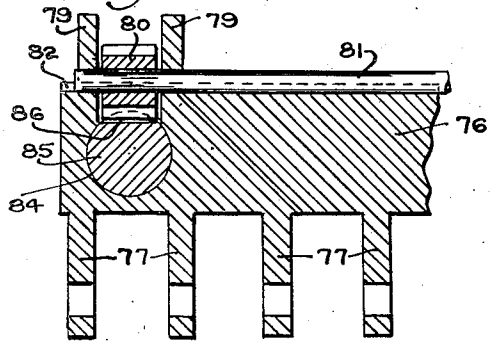


Fig. 6

Fig. 7



Inventor
CHARLES B. GRAY
By Leo Edelson
Attorney.

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UNITED STATES PATENT OFFICE

2,416,171

PUMP

Charles B. Gray, Springfield, Pa.

Application October 19, 1944, Serial No. 559,400

4 Claims. (Cl. 103—38)

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This invention relates generally to fluid-pressure power mechanisms and more particularly to an improved construction of a fluid pressure pump having a plurality of reciprocating pistons, the displacement of which may be varied from zero to full stroke to vary the capacity of the pump without changing the speed of the prime mover for the pump.

Among the principal objects of the present invention is to provide a variable displacement pump of simple construction in which the pressure fluid is displaced by rectilinearly movable piston elements operating sequentially, the design, construction and operation of the pump being generally such as to provide for a high power-to-weight ratio, high efficiency and an ability to respond readily to high and rapid accelerations as required of the developed fluid pressure.

Still another object of the present invention is to provide a multiple piston type of variable capacity pump wherein the necessity for extremely close clearances and tolerances between the moving parts thereof to prevent leakage of the high pressure fluid is obviated; which is suitable for use with either oil or water as the fluid medium; and which is capable of developing working pressures unlimited in amount.

A still further object of the present invention is to provide a variable capacity reciprocating piston type of pump having means for limiting the fluid pressure to a preselected value as well as means automatically operative to maintain the developed pressure at its said preselected value.

Generally, it is among the objects of the present invention to provide a pump, the capacity or output of which may be readily varied at will without stopping the pump or varying the speed of its prime mover; to provide a pump which is exceedingly rugged in construction, which is capable of withstanding long periods of use at high speed and under high developed fluid pressures, and which has a minimum of moving parts, all of which are readily accessible for replacement, adjustment and repair; and to provide a pump wherein frictional and other resistances, so characteristic of the radial type of variable capacity pump, are reduced to a practically neglible minimum.

Still other objects and advantages of the invention will appear more fully hereinafter, it being understood that the present invention consists generally in the combination, construction, location and general arrangement of parts, all as will appear more fully hereinafter, as shown in

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the accompanying drawings and as finally pointed out in the appended claims.

In the said accompanying drawings, which are illustrative of a preferred embodiment of the principles of the present invention:

Figure 1 is a diagrammatic view illustrating the application of the pump of the present invention for hydraulic operation of a press;

Figure 2 is a top plan view of the pump unit as constructed in accordance with and embodying the principles of the present invention;

Figure 3 is a longitudinal sectional view of the pump unit taken on the line 3—3 of Figure 2;

Figure 4 is a sectional view taken on the line 4—4 of Figure 2;

Figure 5 is a transverse view, partially in section, taken on the line 5—5 of Figure 3;

Figure 6 is an end elevational view, practically broken away and sectioned, of the pump unit;

Figure 7 is a sectional view of a part of the pump taken on the line 7—7 of Figure 2;

Figure 8 is a sectional view taken on the line 8—8 of Figure 2; and

Figures 9 to 12, inclusive, are views showing the relative positions of the pump actuating eccentrics upon the main driving shaft for the pump unit.

Figure 1 illustrates more or less schematically an application of the pump of the present invention in a system for hydraulically operating a press, although it will be understood that this pump is equally applicable for use in the operation of all kinds of hydraulic machinery, in connection with which it is designed to produce a moving or holding force of unlimited magnitude for use in pressing, forming, extruding, drawing or forging operations on metals and other compositions, in shifting or moving heavy loads as in lift tables, elevators and the like, and in other fields wherein it is desired to employ a fluid under uniformly constant high pressure. In the schematic illustration of Figure 1, the pump mechanism of the present invention, as enclosed within the dotted line block, is represented by the reference numeral 10, this pump being operative to pump the fluid into a manifold 11 at a rate sufficient to maintain therein a preselected operating pressure for the fluid, the existing pressure in the manifold being visually determined by a suitable pressure guage 12.

The high pressure fluid is delivered from the manifold 11 to the fluid pressure cylinder 13 of the main ram 14 of the press by way of the conduit 15 and to the fluid pressure cylinders 16—16 of the pull-back rams 17—17 by way of the con-

duits 18. On the return or idle stroke of the main ram, which is effected by actuation of the pull-back rams under high fluid pressure, the fluid in the main cylinder is discharged at low pressure into a reservoir 19 by way of the low-pressure discharge conduit 23, while on the return or idle strokes of the pull-back rams the fluid in their cylinders is returned to said reservoir 19 by way of the low pressure discharge conduits 24. Any suitable means may be employed for controlling the proper circulation of the fluid to and from the power press, such as the multiple-port valve 25, the inner body 26 of which is axially shiftable from its full line position as shown in Figure 1 for maintaining open only the fluid conduits 15 and 24 into a second position in which only the conduits 18 and 23 are open to passage of fluid therethrough. The fluid is delivered from the reservoir 19 to a manifold 20 from whence it is drawn into the pump for forced discharge into the accumulator 11 or an equivalent pressure chamber. Suitable check valves 21—22 are interposed, respectively, in the intake and discharge conduits to insure unidirectional flow of the fluid.

As shown in Figure 1, the valve 25 is set for high pressure fluid actuation of the main ram 14 of the press and for discharge at low pressure of the fluid in the cylinders of the pull-back rams 17—17. By axially shifting the inner body 26 of the valve into its other operative position, the pull-back rams are actuated by the high pressure fluid to return the main ram to its initial position, while the fluid in the main ram cylinder is discharged therefrom at low pressure. Any suitable means may be employed for controlling the operation of the valve either manually or automatically, such means forming no part of the present invention which relates more particularly to the pump mechanism or unit per se.

Referring now more particularly to Figures 2 to 6 of the drawings, it will be observed that the pump unit of the present invention essentially includes a plurality of fluid pressure cylinders 30, 31, 32 and 33, suitably mounted upon a main supporting base 34 for the unit, each of said cylinders having operatively associated therewith a double-acting piston 35 designed for rectilinear, reciprocating motion. Each cylininder is provided with a pair of fluid intake ports 36—37 and a pair of fluid discharge ports 38—39 (see Figure 3), the operation of each cylinder being such that upon downward thrust of its piston, the pressure fluid is drawn into the cylinder through the intake port 36 and forced therefrom out of the discharge port 38, while upon upward thrust of the piston, the fluid is drawn into the cylinder through the intake port 37 and forced therefrom out of the discharge port 39. Thus, for each cycle of operation of each piston 35, fluid is alternately pumped by way of the conduits 40 and 41 and through the check valves 22 thereof into the high pressure fluid manifold 11. The several piston 35 are respectively guided for rectilinear movement by their piston rods 42 which reciprocate through the heads of the cylinders, suitable stuffing boxes or glands (not shown) being employed to prevent leakage of the fluid along the piston rods.

Provided at the frontal end of the main supporting base 34 of the apparatus is a vertically extending structure 43 in the form of a transversely arranged body member 44 provided at the opposite edges thereof with vertically projecting standards or pillars 45—45, each of which latter is provided with an upwardly presenting semi-

cylindrical seat 46 upon which is suitably journalled one end of a main power shaft 47 extending transversely across the top of the said front structure 43. The upper edge 48 of the body member 44 intermediate the power shaft supporting pedestals 45—45 terminates at a point spaced well below the main shaft 47 to provide the necessary clearance for other parts of the apparatus to be presently described. Also extending transversely across and bridging the space between the shaft-supporting pedestals 45—45 is a top member 49, the opposite ends of which are respectively provided with downwardly presenting semi-cylindrical seats 50—50 which are complemental to the fixed seats 46—46 to provide therewith complete journal boxes for the opposite ends of the main power shaft 47. Preferably, these journal boxes may be internally fitted with suitable roller bearings or the like (not shown) for the shaft. The complementally shaped parts of the pedestals 45—45 and the bridging member 49 are secured together by bolts 51.

As most clearly appears in Figures 5 and 6, the bridging member 49 is undercut or notched at uniformly spaced intervals, as at 52, to provide a series of spaced portions 53 to which are respectively secured, as by the bolts 54, intermediate supporting members 55 for the main shaft 47. These intermediate supporting members 55 are also complementally shaped to provide, conjointly with the portions of the bridging member to which they are secured, auxiliary journal boxes for the shaft, which auxiliary journal boxes may be fitted with roller bearings as in the case of the end journal boxes for the shaft.

The several unsupported portions of the shaft disposed within the spaces 52 formed in the bridging member 49 are respectively provided with eccentric enlargements 56, 57, 58 and 59, each of these eccentric portions of the shaft being in turn embraced by an eccentric strap 60 suitably formed of two parts secured together, as by the bolts 61. As appears most clearly in Figure 6 and in Figures 9 to 12, these eccentric portions 56, 57, 58 and 59 are angularly spaced apart to the extent necessary to equalize and balance the effort of the shaft and insure the production of uniform pulsations of the pressure fluid as discharged from the several pressure cylinders which are respectively operatively associated with the several angularly related eccentric portions of the main drive shaft. In the apparatus as shown, four such pressure cylinders are employed and by angularly spacing the ecentric portions of the power shaft 60 degrees apart, each pressure cylinder is caused to deliver two fluid pressure impulses for each revolution of the main drive shaft 47, the several impulses per shaft revolution being delivered sequentially at uniformly timed intervals.

As most clearly appears in Figures 3 and 6, the lower halves of the eccentric straps 60 are each provided with a depending stem 62, which in each instance is secured, by means of a pin 63, to the upper clevised end 64 of a vertically reciprocable bar 65. The several bars 65 are respectively received within guide channels or grooves 66 formed in the front face of the transversely extending body member 44 and are confined against displacement therefrom by a plate 67 extending across the said front face of the member 44 and secured thereto by the bolts 68. The guide channels or grooves 66 thus insure rectilinear motion of the bars 65 upon reciprocation

thereof by the several eccentrics on the main shaft 47.

Pivotally secured to each of the vertically reciprocable bars 65, as by a pivot pin 69, is a rearwardly extending lever 70. The freely extending rear ends of these levers 70 are respectively connected, through the intervention of links 71, to the upper ends of the several piston rods 42 of the fluid pressure cylinders 30, 31, 32 and 33. The opposite ends of the intervening links 71 are respectively secured, in each instance, to the lever 70 and to the piston rod 42 by pivot pins 72 and 73, the arrangement being such that the oscillating motion of the lever 70 may be translated into a straight line reciprocating motion for its associated piston rod 42.

Each of the levers 70 is slotted to provide a longitudinally extending opening 74 within which is slidably fitted a fulcrum block 75, this block being slidable lengthwise of the slot 74 to vary the position of the fulcrum for the lever 70. Extending traversely across the several laterally spaced parallel levers 70 and in vertically spaced relation with respect thereto is a relatively heavy beam 76 from the lower edge of which depends a plurality of pairs of spaced parallel lugs 77. Each pair of these lugs embraces one of the levers 70, as most clearly appears in Figure 5, these lugs being of sufficient length to likewise embrace the opposite sides of the slidable fulcrum block carried by the lever. A transversely extending rod 78 projects commonly through the several fulcrum blocks 75 and their embracing pairs of lugs 77 carried by the beam 76, thereby insuring against lateral displacement of each fulcrum block from its associated lever 70 while at the same time permitting the several blocks to shift lengthwise of their guide slots 74 in the several laterally spaced levers 70. Shifting of the fulcrum blocks 75 lengthwise of their respective guide slots 74 is effected in unison by bodily shifting the beam 76 in a direction normal to its transversely extending vertical plane, it being apparent that as said beam 76 is so shifted, it correspondingly shifts the fulcrum rod 78 and so varies the fulcrum point of oscillation of the several levers 70.

It is, of course, desirable to prevent skewing of the beam 76 with respect to its normal line of shifting movement, and in order to prevent any such possibility of skewing, the opposite ends of the beam are each formed with a pair of spaced flange elements 79—79, each pair of which embraces a toothed pinion 80. These pinions 80—80 are respectively journalled for rotation upon a common shaft 81 which extends lengthwise along the top of the beam 76 and rests in a groove formed in the top surface of said beam. The beam is suitably recessed or chambered, as at 83, immediately beneath each of the pinions 80 to provide the necessary clearance for free rotation thereof relatively to the beam and about the axis of the pinion shaft 81.

The beam 76 is transversely bored, as at 84—84, at points located respectively immediately beneath the pinions 80, these bores being so located as to be in communication with the arcuate recesses or chambers which receive the lower portions of the said pinions. Projecting through each of the bores 84—84 are the supporting bars or rods 85 for the beam 76, these rods 85 being respectively disposed at opposite sides of the apparatus and extending in parallel relation. The crowned upper edges of these longitudinally extending guide and supporting bars 85 for the beam 76 are each toothed to provide longitudinally extending racks 86 which are respectively in toothed engagement with the pinions 80—80. The forward ends of these longitudinally extending parallel guide bars 85 are suitably secured in any manner to a fixed part of the front structure of the apparatus, while the rear ends of these bars are similarly secured in any suitable manner to a fixed structure provided at the rear end of the apparatus, such, as for example, the vertically extending pedestals 87—87, the upper ends of these pedestals 87—87 being suitably interconnected by transversely extending rear frame member 88 (see more particularly Figures 2 and 3).

From the foregoing, it will be apparent that the beam 76, which commonly supports and carries the laterally spaced fulcrum blocks 76 for the several levers 70, is in turn slidably supported upon the laterally spaced, parallel guide bars 85. It will be apparent also that by reason of the interengagement of the pinions 80 with their respective toothed rack portions 86 of the guide bars 85, the beam 76 is free to be moved along said guide bars by the means and for the purpose presently to be described. The pinions 80 respectively coacting with the longitudinally extending toothed racks 86 serve as equalizers for insuring the beam 86 at all times maintains a position normal to its direction of shift.

Suitably mounted upon the rear structure of the apparatus centrally between the laterally spaced standards 87—87 thereof is a fluid pressure cylinder 90 with which is operatively associated a piston 91 having a rod 92 projecting through the top cross member 88 of the said rear structure. The forward end of the piston rod 92 is connected, as at 93, to the rear side of the transverse beam 76 preferably at a point disposed centrally between its opposite ends. Secured to the frontal side of the said transverse beam 76, as by means of an eye bolt 94 or otherwise, is a cable 95 which extends over and around a pair of vertically spaced sheaves 96—97 suitably mounted upon a fixed part of the front structure 43 of the apparatus, these sheaves being preferably housed within a removable casing 98 (see Figure 3). The opposite end of the said cable 95 is secured, as at 99, to the forward end of a coiled tension spring 100. The rear end of this spring is in turn connected, as at 101, to a rod 102, the threaded portion 103 of which projects through a bracket 104 rigidly secured in any suitable manner to the rear fixed structure of the apparatus. A hand wheel 105 or other such tension adjusting device threadedly engages the threaded portion 103 of the rod 102 and bears against the surface 106 of the bracket 104 under the influence of the biasing action exerted by the coiled spring 100. A conduit 107 extends between the manifold 11 and the interior 108 of the pressure adjusting cylinder 90, while a pressure gauge 109 is also connected to the said interior 108 of the cylinder 90.

In describing the operation of the pump mechanism or the present invention as hereinbefore described, it will be assumed that the several parts of the apparatus are in their related position, as shown in Figure 3 of the drawings. In this condition of the apparatus, the beam 76 is practically at its forward limit of movement, in consequence of which the several levers 70 are so related to their common fulcrum axis 78 as to provide for a maximum magnitude of oscillation of the rear end of each of these levers. The oscillation of these levers is effected, of course,

by the vertical reciprocation of the stems 62 which depend from and are actuated by the several angularly related eccentrics on the main shaft 47. This main shaft 47 may be driven in any suitable manner and by any suitable prime mover, and to that end it is preferably fitted with a driving pulley 110 (see Figure 2). Shifting of the several levers 70 in a direction longitudinally of their lengths is precluded by reason of the fact that the frontal ends thereof are pivoted, as at 69, to the vertically reciprocable bars 65 which in turn are confined to a rectilinear motion. Thus, the levers 70 partake only of an oscillating motion about their common fulcrum 78 to effect reciprocation of the several pistons 35 of the fluid pressure cylinders 30, 31, 32 and 33.

In normal operation of the apparatus, the rotative speed of the main driving shaft 47 is maintained constant and each lever 70 performs a complete oscillation about its fulcrum 78 for each revolution of the main shaft. The magnitude of this oscillation is, however, dependent upon the relative position which is assumed by the fulcrum shaft 78, it being apparent that as said shaft 78 is shifted toward the rear extermity of the slot 74 in the lever 70, the magnitude of oscillation of the rear end of the shaft is correspondingly reduced. When the fulcrum 78 is shifted to the dotted line position shown in Figure 3, oscillation of the rear ends of the shafts 70 is reduced to zero and in such event reciprocation of the pistons 35 no longer takes place.

Assuming that it is desired to establish and maintain an operating fluid pressure of say four thousand pounds, all that is necessary is to start the pump working by imparting rotation to the main shaft 47 thereof by means of its prime mover (not shown). With the parts of the apparatus as shown in Figure 3, the several levers 70 will oscillate to in turn effect reciprocation of the fluid pressure cylinder pistons 35 at their full or maximum strokes. As the fluid pressure developed by the several pressure cylinders builds up toward the preselected value, the developed pressure will be indicated in the pressure gauges 12 and 109. Simultaneously as the fluid pressure builds up toward its predetermined limit, as indicated by the gauges, the hand wheel 105 is manipulated to relieve the tension pull exerted by the spring 100 on the fulcrum-carrying beam 76 sufficiently to permit the latter to be drawn rearwardly under the influence of the fluid pressure which has been developed in the pressure chamber 108 of the compensating fluid pressure cylinder 90, the final adjustment of the hand wheel 105 being such that the effort of the fluid pressure pull on the beam 76 relatively to that of the spring 100 thereon causes the beam 76 to shift rearwardly to an extent sufficient to locate the fulcrum axis 78 of the several levers at the dotted line or neutral position shown in Figure 3 when the fluid pressure, as indicated by the gauges 12 and 109, reaches its predetermined limit.

Thus, by proper manipulation of the spring tension adjusting knob 105, the pull of the spring on one side of the beam 76 is overbalanced by the pull of the fluid pressure actuated piston 91 on the opposite side of the said beam 76 to maintain the latter in neutral position when the developed fluid pressure is of the desired magnitude. Should the fluid pressure as developed by the several pressure cylinders 30 to 35 drop below the desired predetermined limit, the pull of the piston 91 of the compensating cylinder 90 on the beam 76 immediately drops, with the result that the said beam 76 is then drawn forwardly through the effort of the tension spring 100, thereby positionally readjusting the fulcrum axis 78 to provide for an increased magnitude of oscillation of the rear ends of the several levers 70 and corresponding increased length of stroke of the reciprocating pistons 35 in the main fluid pressure cylinders. As the pressure increases due to the increased displacement of the fluid from these pressure cylinders, the pull differential between the spring 100 and the compensating pressure cylinder 90 is reestablished for the predetermined pressure desired to be maintained.

Should it be desired to obtain a higher fluid pressure than aforesaid, then the hand wheel 105 is manipulated to increase the tension pull of the spring 100, thereby requiring a greater effort to be exerted by the fluid pressure piston 91 to overcome the same and so permitting a correspondingly greater pressure to be developed by the pump. Conversely, should it be desired to reduce the fluid pressure limit, the tension pull of the spring 100 on the beam 76 is relieved to the desired extent by proper manipulation of the adjusting knob 105, in consequence of which the beam 76 is drawn to its rearmost or neutral position by the piston 91 when the fluid pressure is at its predetermined maximum value.

It will be understood, of course, that the apparatus of the present invention is susceptible of various changes and modifications which may be made from time to time without departing from the general principles or real spirit of the invention as hereinbefore set forth. For example, instead of employing a tension spring such as is shown in the accompanying drawings, a movable counter-balancing weight may be employed for exerting a pull on the fulcrum-carrying means in position to the fluid pressure effort exerted by the piston 91 of the compensating fluid pressure cylinder. Also, instead of employing double acting pressure cylinders as hereinbefore described and shown in the accompanying drawings, such fluid pressure cylinders may be of the single acting type. Of course, the number of fluid pressure cylinders employed may be varied as desired, and in fact a pump may be constructed in accordance with the principles of the present invention in which only a single fluid pressure cylinder of adequate capacity is employed. It is accordingly intended to claim the same broadly, as well as specifically, as indicated by the appended claims.

What is claimed as new and useful is:

1. In a fluid pressure pump mechanism of the character described, in combination, a plurality of fluid pressure cylinders each having its own reciprocating piston, a fulcrumed lever for each cylinder having one end thereof operatively connected to the cylinder piston for effecting rectilinear reciprocation thereof, the opposite end of the lever being pivotally connected to a rectilinearly reciprocable member spaced from but paralleling the axis of reciprocation of the piston, a positionally adjustable fulcrum for each lever disposed intermediate the opposite ends thereof, means operative at constant speed for commonly effecting oscillation of the several levers about their respective fulcrums, means serving as a common support for the several fulcrums and shiftable lengthwise of the levers to uniformly vary the positions of the several fulcrums and so change the magnitudes of oscillation of the several levers, said fulcrum-supporting means

being normally biased to maintain the fulcrums in position for maximum oscillation of the several levers, and a fluid-pressure motor actuated by the fluid pressure developed by the pump mechanism and operative to overcome the aforesaid normal bias on said fulcrum-supporting means whereby to present the several fulcrums in position for reducing the magnitude of oscillation of the several levers as the developed fluid pressure increases to a predetermined value.

2. In a fluid pressure mechanism of the character defined in claim 1, means for insuring against skewing of the fulcrum-supporting means during positional adjustment thereof lengthwise of said oscillatable levers.

3. In a fluid pressure mechanism of the character defined in claim 1 wherein said fulcrum-supporting means is in the form of a beam extending transversely across the said several oscillating levers, the opposite ends of said beams being slidably supported upon a pair of guide-rods extending in parallel relation to the planes of oscillation of the several levers.

4. In a fluid pressure mechanism of the character defined in claim 1 wherein said fulcrum-

supporting means is in the form of a beam extending transversely across the said several oscillating levers, a pair of laterally spaced parallel guide rods respectively extending through the opposite ends of said beam for supporting and guiding the same in its movement lengthwise of the several levers, and coacting rack and pinion means arranged at said opposite ends of the beam for insuring that the longitudinal axis of the beam is at all times normal to the parallel planes of oscillation of the several levers.

CHARLES B. GRAY.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
635,258	Lange	Oct. 17, 1899
870,630	Kinsman	Nov. 12, 1907
2,191,552	Zimmermann	Feb. 27, 1940
2,284,897	Harrington	June 2, 1942
762,055	Hibbard	June 7, 1904