Dec. 19, 1961 F. L. DAVIS, JR 3,013,498

VARIABLE HYDRAULIC PUMPS

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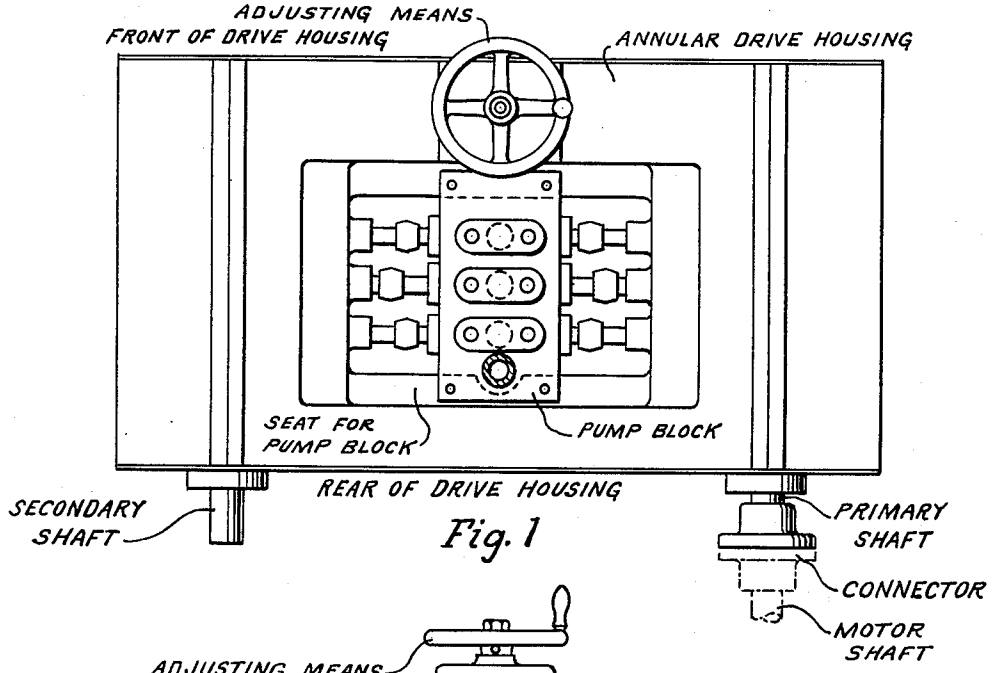


Fig. 1

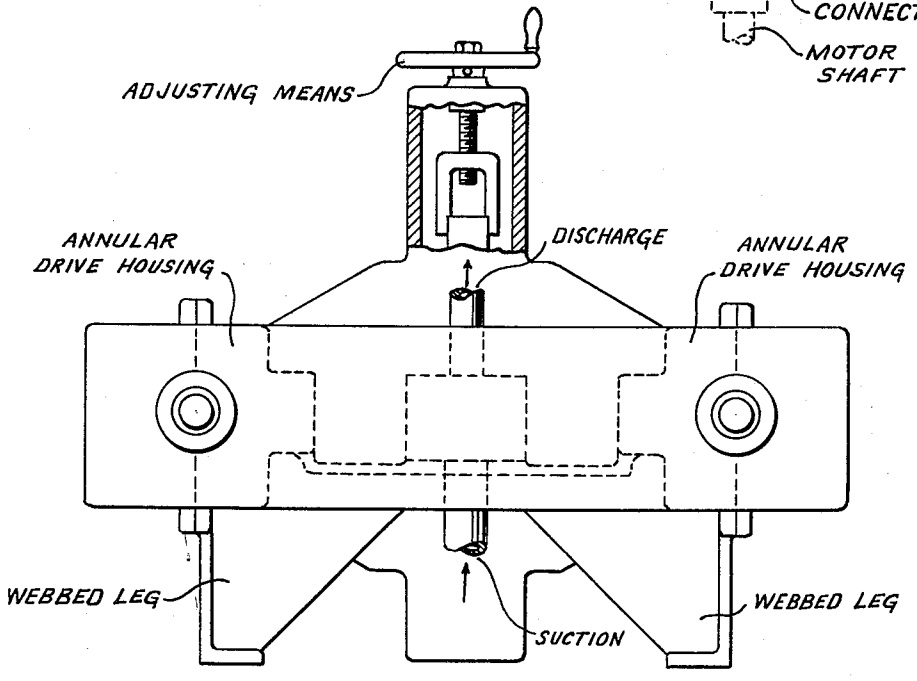


Fig. 2

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VARIABLE HYDRAULIC PUMPS

Filed Oct. 21, 1957 7 Sheets-Sheet 2

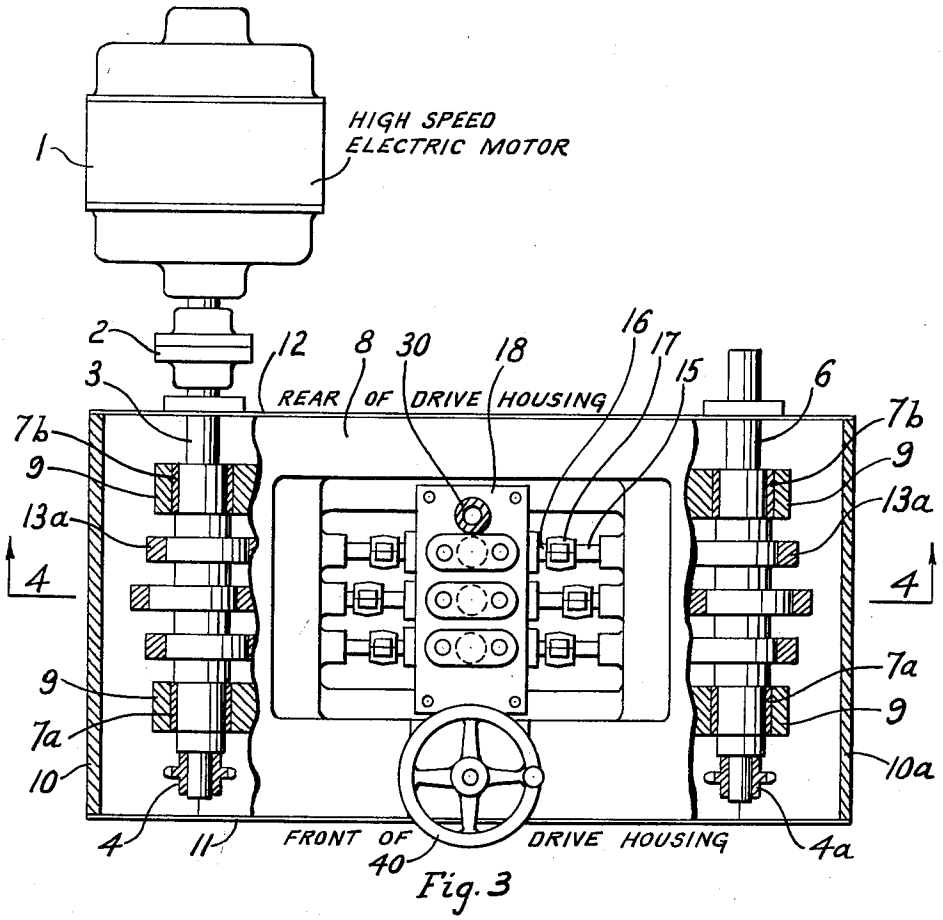


Fig. 3

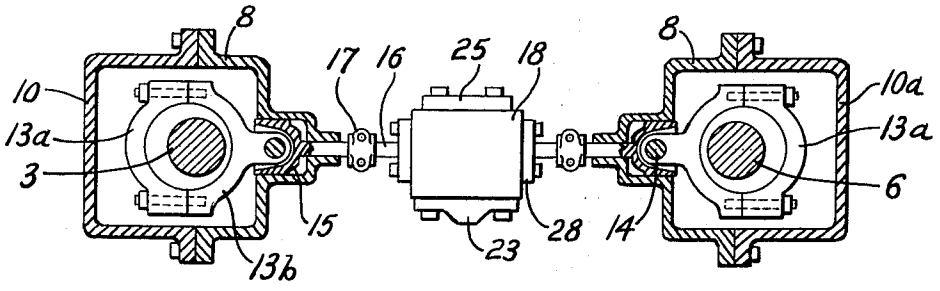


Fig. 4

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VARIABLE HYDRAULIC PUMPS

Filed Oct. 21, 1957 7 Sheets-Sheet 3

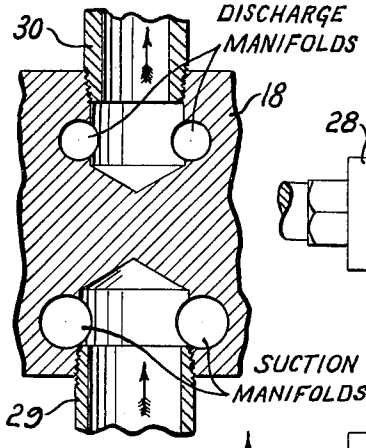


Fig. 7

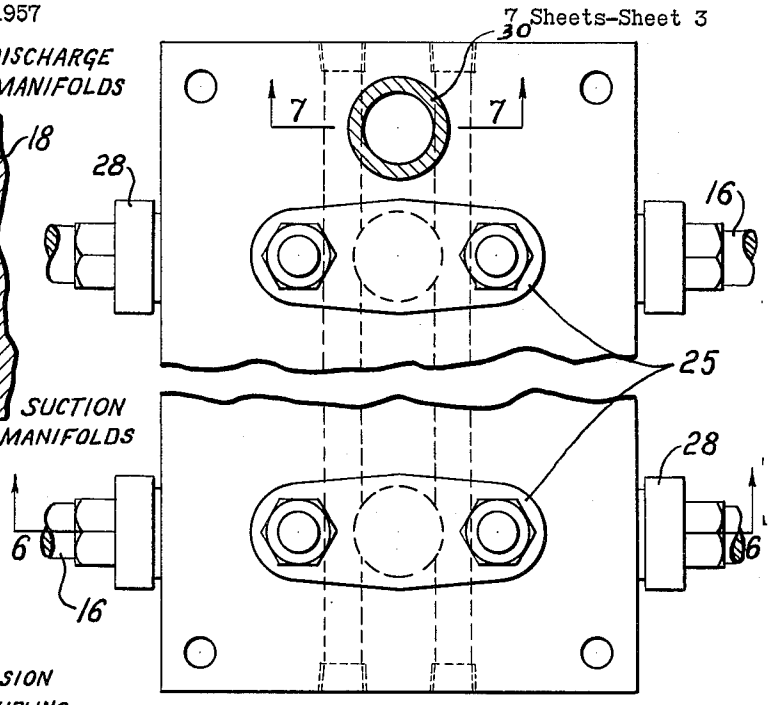


Fig. 5

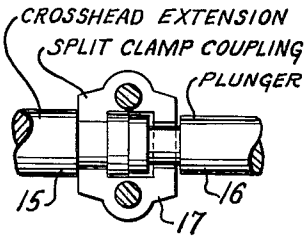


Fig. 8

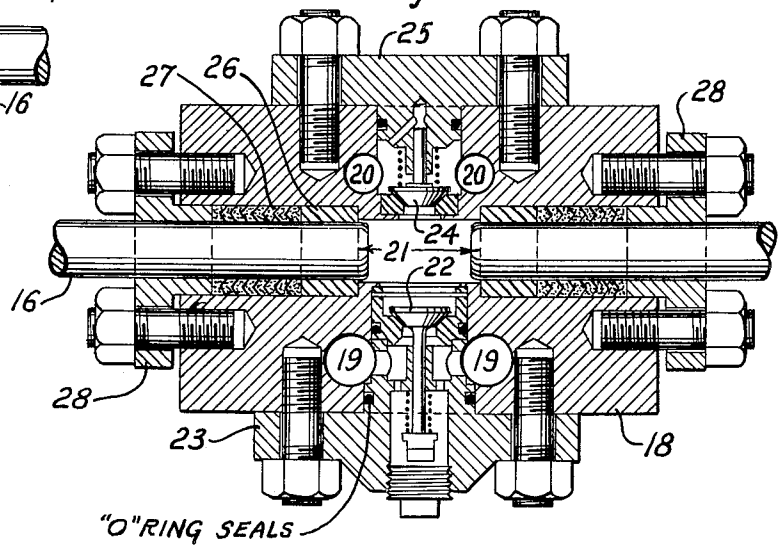


Fig. 6

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VARIABLE HYDRAULIC PUMPS

Filed Oct. 21, 1957 7 Sheets-Sheet 4

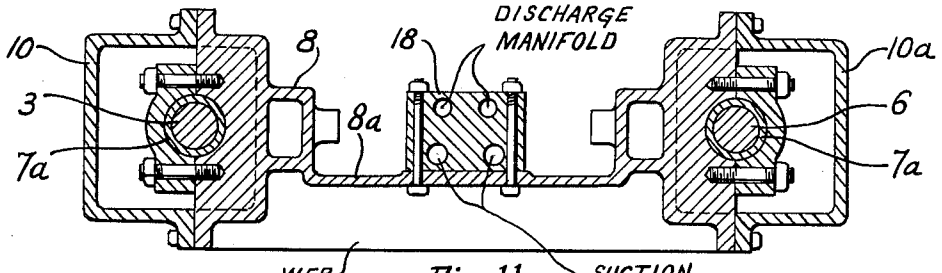


Fig. 11

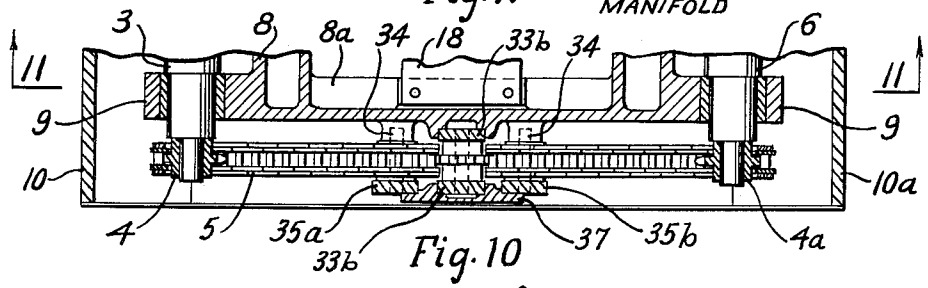


Fig. 10

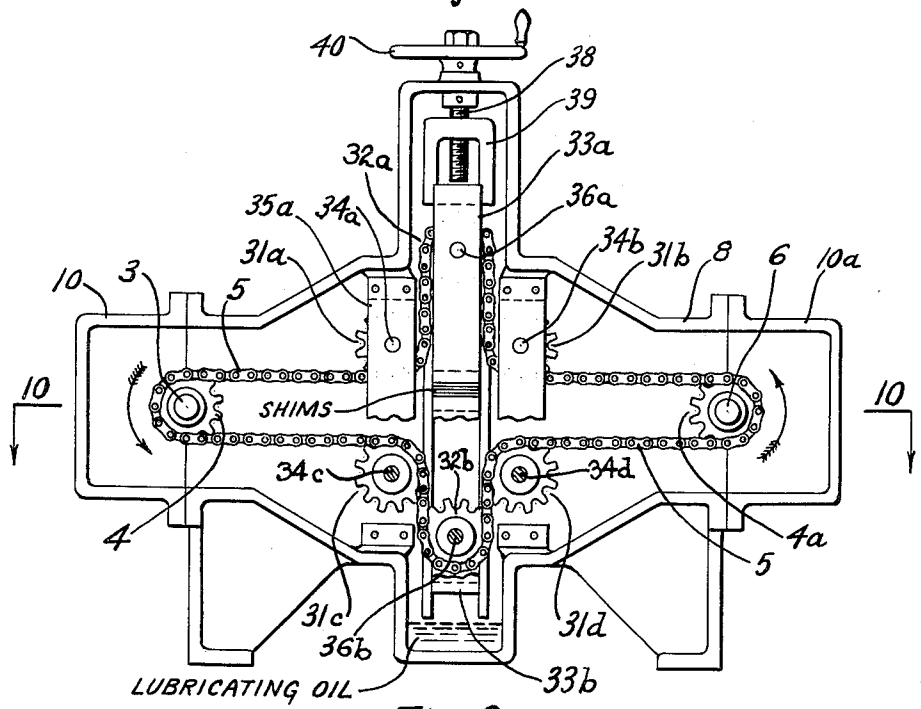


Fig. 9

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VARIABLE HYDRAULIC PUMPS

Filed Oct. 21, 1957 7 Sheets-Sheet 5

Fig. 14A — CONTROL MECHANISM ADJUSTED FOR AN INTERMEDIATE PARTIAL DELIVERY

Fig. 13A — CONTROL MECHANISM ADJUSTED FOR THE MINIMUM DELIVERY

Fig. 15

Fig. 12A — CONTROL MECHANISM ADJUSTED FOR THE MAXIMUM DELIVERY

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VARIABLE HYDRAULIC PUMPS

Filed Oct. 21, 1957 7 Sheets-Sheet 6

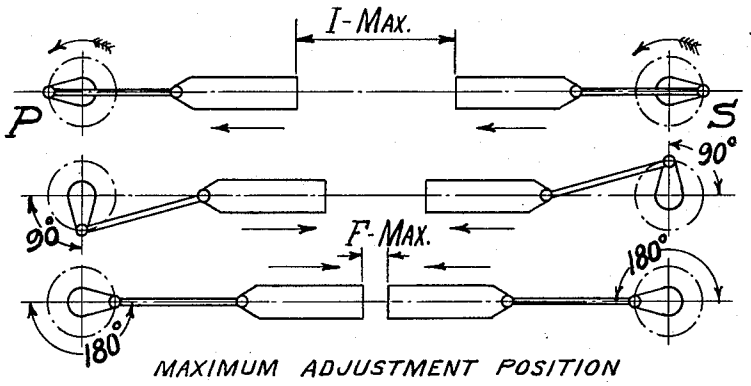


Fig. 12B

MAXIMUM ADJUSTMENT POSITION

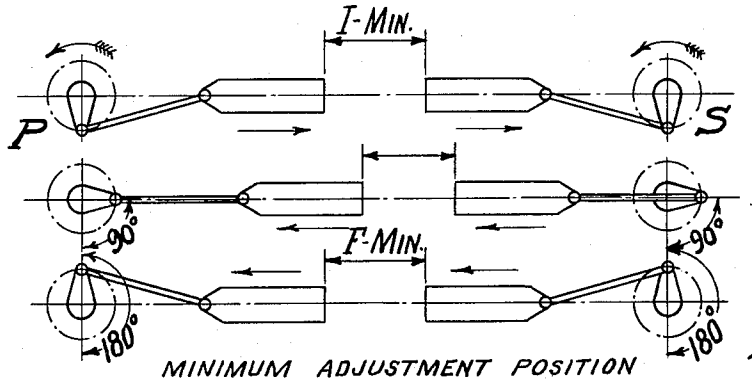


Fig. 13B

MINIMUM ADJUSTMENT POSITION

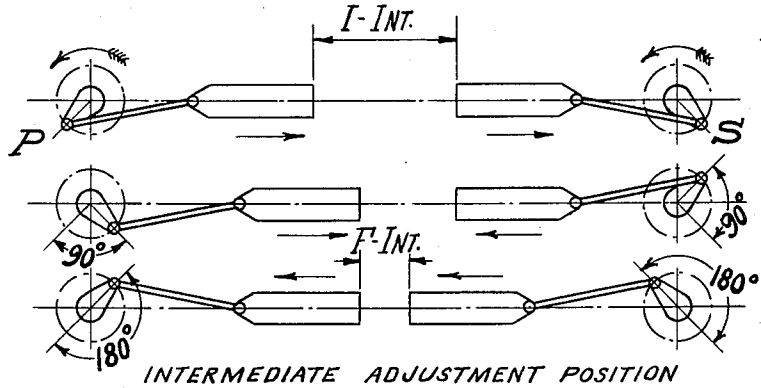


Fig. 14B

INTERMEDIATE ADJUSTMENT POSITION

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VARIABLE HYDRAULIC PUMPS

Filed Oct. 21, 1957 7 Sheets-Sheet 7

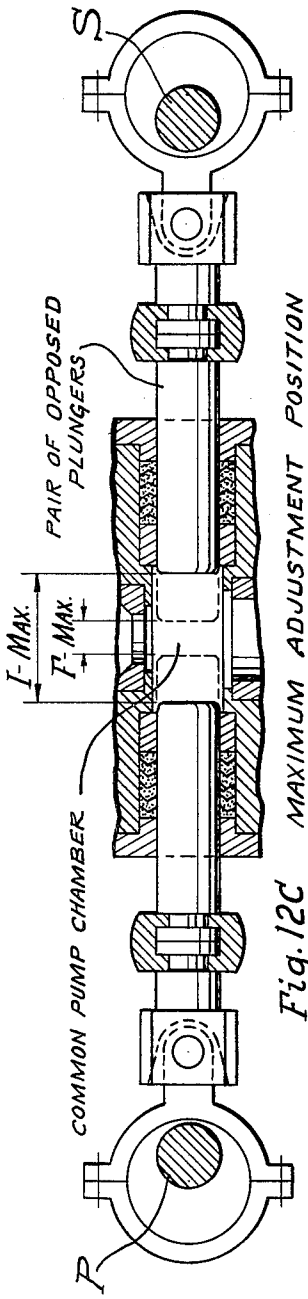


Fig. 12C MAXIMUM ADJUSTMENT POSITION

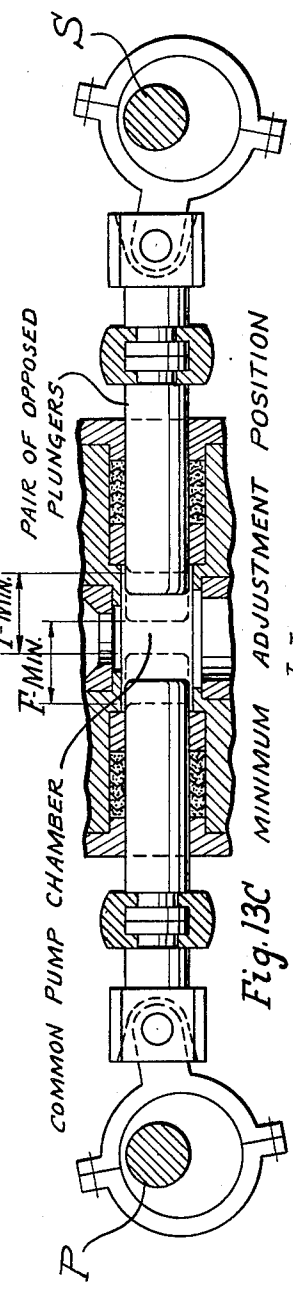


Fig. 13C MINIMUM ADJUSTMENT POSITION

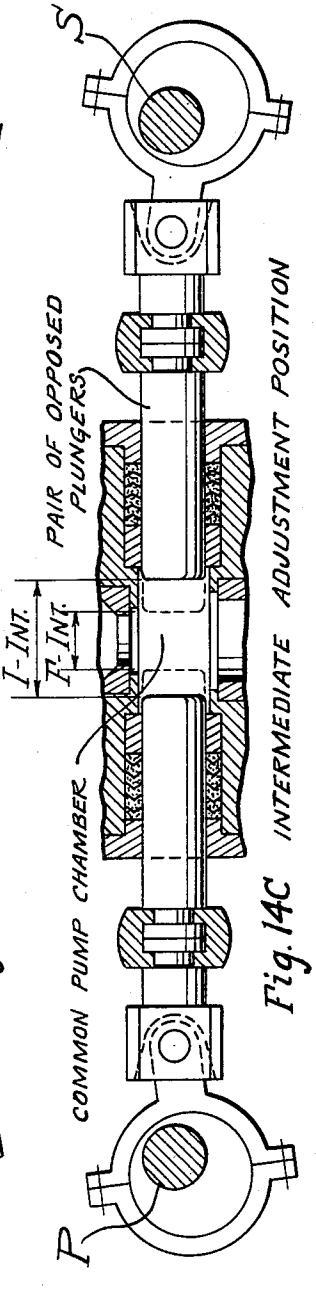


Fig. 14C INTERMEDIATE ADJUSTMENT POSITION

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United States Patent Office 3,013,498 Patented Dec. 19, 1961

3,013,498

VARIABLE HYDRAULIC PUMPS

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Filed Oct. 21, 1957, Ser. No. 691,481
5 Claims. (Cl. 103—38)

The present invention relates to variable hydraulic pumps, and, more particularly, to improved hydraulic pressure pumps having single acting reciprocating plungers and provided with seated type inlet and outlet valves and capable of a stepless or infinitely variable volume of delivery and/or pressure from a maximum to a minimum while the pump is running and is being driven at a relatively high rate of revolutions per minute.

Heretofore, the art has endeavored to provide variable hydraulic pumps which were capable of fulfilling exacting conditions of service and which could be constructed and operated in a practical manner. Hydraulic pumps now on the market are complicated and are expensive to manufacture and operate. Those skilled in the art know that the conventional and commercial pumps have many limitations and have many disadvantages, defects and difficulties.

It may be noted that the majority of the prior and conventional variable hydraulic pumps are of the packless plunger type, using oil as the pressure fluid and ports for governing the flow of oil. Such plungers require extra fine finished surfaces and extremely small clearances in their respective pump bores to reduce the leakage of the pressure fluid escaping past the plungers. As is well known, this leakage increases as pressure increases. These refinements add to the manufacturing cost and the small clearances require the filtering of the fluid to avoid jamming or scoring of the plungers by foreign particles.

The plungers are usually actuated on the pressure stroke through contact of conical or spherical shaped plunger heads with some form of ring or internal cam. This contact is theoretically a line contact at best and, in some cases, only a point contact which limits the driving thrust on the plunger. This in turn means using a small diameter for any appreciably high pressure which in this type of pump rarely exceeds about 2500 pounds per square inch (p.s.i.) and about 150 horsepower (H.P.) per unit pump. These limitations call for an excessive number of plungers in any specific pump in order to produce the desired volume of discharge and also call for a multiplicity of units for large horsepower requirements.

Admittedly the theoretical line or point contacts become actually small areas depending upon the local deformation of the contacting surfaces and the viscosity of the oil used as both the pressure fluid and the lubricant. Any attempt to increase the load-transmitting ability of these contact areas by increasing the viscosity of the oil introduces a difficulty in another respect. Increased viscosity means increased power required to force the fluid at high velocity through the very restricted passages and sharp edged ports inherent in these pumps. This results in considerable heating of the oil.

With the use of oil as the pressure medium, the pump operates in a closed circuit, that is, from tank to pump to work and return to tank. With frequent cycles and extensive proportion of peak load requirements, there will be considerable heating of the oil necessitating its return through a cooler or cooling coils which have to be installed in the tank or in the circuit.

The changes in viscosity in the oil with temperature changes sometimes necessitates operating the pump through idle cycles for a period of time until a heat balance is reached and a certain viscosity is established to insure uniform performance of the machine operated by the pump.

In the case of such types of pumps having radially disposed plungers and where the pump body carrying the plungers revolves around a pintle, in which the ports and inelt and outlet passages are located, there occurs another difficulty. Since at any one instant only one-half of the plungers create pressure on one side of the pintle, there results a transverse bending moment on the pintle causing it to deflect between supports like a loaded beam. Ultimately, the far side of this bent pintle would contact the bore of the pump body embracing the pintle. This again limits the possible unit loading on the plungers. Any attempt to provide more running clearance to postpone the moment of contact merely increases the fluid loss across the "lands" or division wall between the channels and also along the pintle.

The majority of these packless plungers have no positive "pullback" on the suction stroke. This necessitates the use of some form of pre-fill pump feeding into the suction manifold with sufficient pressure to force the plungers out on their suction stroke. It also has to be of a volumetric capacity greater than the maximum output of all the plungers at full delivery with by-pass valves to relieve the excess pre-fill supply. This condition likewise tends to heat the oil.

Further analyses could be made of other limitations of the various commercial pumps now on the market but it would seem that the foregoing is sufficient to point up the many factors eliminated by the present invention as will become evident from the description set forth hereinafter of the construction and operation of the novel variable hydraulic pump. Furthermore, the prior pumps of the types discussed hereinbefore are of such a precision nature, in assembly and adjustment, that the manufacturers urge the return of the pumps to the factory for repairs. In contrast, the novel variable hydraulic pumps embodying the present invention are of such a nature that any competent maintenance mechanic can do any necessary gland packing replacement or adjustment, etc., on the job at the place of operation of the pump. Although many attempts were made to overcome the foregoing difficulties and other disadvantages, none as far as I am aware, was entirely successful when carried into practice commercially on an industrial scale, particularly when the attempt was made to furnish pumps embodying existing or prior designs in large capacities and high pressures.

It has now been discovered that an improved variable hydraulic pump having a unique construction can be made from relatively simple component parts and that an improved variable hydraulic pump is made available to industry which has a compact structure, which is economical to manufacture, which can be used anywhere in the world with any presure medium, which can be adjusted from maximum delivery to a minimum delivery with a simple control device, which can be driven directly by a standard high speed electric motor and which can be operated in a simple manner under a great variety of inductrial conditions in conjunction with a great variety of machinery.

It is an object of the present invention to provide an improved variable hydraulic pressure pump provided with single acting reciprocating packed plungers and seated valves and capable of generating much higher pressures than those of conventional types of existing high speed pumps using oil as the pressure medium and having ports to govern the flow of oil.

Another object of the invention is to provide an improved variable hydraulic pressure pump capable of using water as the pressure medium and capable of operating hot extrusion presses and the like where hot metal is handled and where there is usually a fire or explosion hazard, especially with conventional pumps using oil as the pressure medium.

The invention also contemplates providing an improved variable hydraulic pressure pump having such a construction that the pump block is isolated from the driving mechanism and that leakage of water past the plungers in the pump and into the driving compartment, where it would emulsify the oil, is prevented.

It is a further object of the invention to provide an improved variable hydraulic pressure pump capable of operating with any fluid or liquid pressure medium and not limited to any special fluid or liquid such as oil.

The invention further contemplates providing an improved variable hydraulic pressure pump which is of such a type and which has such a unique construction as to permit operation at a relatively high rate of revolutions per minute and to lend itself to driving by standard prime movers such as electric motors without the use of reduction gearing.

It is another object of the invention to provide an improved variable hydraulic pressure pump which is constructed of relatively simple component parts which permit the production of a more economical unit for a given output.

Still another object of the invention is to provide an improved variable hydraulic pressure pump having a plurality of pairs of opposed single acting reciprocating plungers and provided with a simple control mechanism rendering the pump capable of a stepless or infinitely variable volume of delivery and/or of pressure medium from a maximum to a minimum while the pump is running and is being driven at high speed by a directly-connected standard electric motor.

It is also an object of the invention to provide an improved variable hydraulic pressure pump having a simple construction with a plain rugged housing having a generally annular contour in plan view for the driving mechanism and with a strong compact pump block mounted within the central space of said annular housing.

It is likewise within the contemplation of the invention to provide an improved variable hydraulic pressure pump having single acting reciprocating pairs of opposed plungers and provided with seated type inlet and outlet valves and capable of a stepless or infinitely variable volume of delivery from a maximum to a minimum.

It is also the purpose of the invention to provide an improved variable hydraulic pressure pump having such a construction as to permit driving one of its two crankshafts by a standard high speed electric motor and being provided with a chain and sprocket drive, from one shaft to the other, having a sliding control mechanism carrying a pair of sprockets to control the delivery of the pump.

Other objects and advantages will become apparent from the following description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a plan view of the novel variable hydraulic pump embodying the present invention;

FIG. 2 depicts a rear elevation of the novel pump illustrated in FIG. 1;

FIG. 3 illustrates a plan view, partly in section to show the driving shafts, of the pump shown in FIG. 1 together with a driving electric motor;

FIG. 4 is a sectional view taken on the line 4—4 of FIG. 3;

FIG. 5 depicts a fragmentary plan view of the pump block illustrated in the central portion of FIGS. 1 and 3;

FIG. 6 is a sectional view taken on the line 6—6 of FIG. 5;

FIG. 7 is a fragmentary sectional view taken on the line 7—7 of FIG. 5;

FIG. 8 shows a detail view of the split coupling which clamps the end of a plunger from the pump to the end of a crosshead extension as illustrated in FIGS. 1, 3 and 4;

FIG. 9 is a front elevation of the novel pump as shown in FIG. 3 with front cover and detachable bridging member 37 removed for purposes of clarity;

FIG. 10 is a fragmentary sectional view taken on the line 10—10 of FIG. 9;

FIG. 11 is a sectional view taken on the line 11—11 of FIG. 10;

FIG. 12A depicts a fragmentary front elevational view of the control mechanism illustrated in the central portion of FIG. 9 and adjusted for maximum delivery, the detachable bridging member 37 being omitted for purposes of clarity;

FIG. 13A is a view similar to FIG. 12A except the control mechanism is adjusted for a minimum delivery;

FIG. 14A is a view similar to FIG. 12A except the control mechanism is adjusted for a partial intermediate delivery between the maximum and minimum delivery;

FIGS. 12B, 13B and 14B are diagrammatic views representing various relative positions of the primary and secondary crankshafts with their corresponding connecting rods and pump plungers and the resulting plunger travels, produced by 90° and 180° rotation for the crankshafts when the control mechanism is in position for maximum delivery, minimum delivery, and intermediate delivery, respectively;

FIG. 12C is a fragmentary view, partly in section, showing pump plungers and associated mechanism in position for maximum delivery;

FIG. 13C is a view similar to FIG. 12B except it is shown in a position for minimum delivery;

FIG. 14C is a view similar to FIG. 12B except it is shown in a position for a partial intermediate delivery; and

FIG. 15 is a sectional view taken on the line 15—15 of FIG. 12A.

In carrying the invention into practice, it is preferred to provide an embodiment such as illustrated in the drawings. A prime mover 1, shown herein as an electric motor, is connected by a coupling 2 to a rearward extension of the left-hand drive shaft 3 which in the present embodiment has been provided with a series of eccentrics. Shaft 3 may be referred to as the "primary" shaft. On an extension of the near end of shaft 3 is secured a sprocket 4 of a type to suit a roller chain 5 which engages this sprocket. Chain 5 is of sufficient but fixed length to extend across to the right-hand side of the pump where it engages another identical sprocket 4*a* secured on an extension of the near end of a "secondary" shaft 6 similar to the "primary" shaft 3. "Secondary" shaft 6 has been shown with a rearward extension which may be used, if desired, to drive, by suitable gearing or belting, a small forced feed or spray type lubricating system. It may be omitted if the lubricator is of a self-contained type as those skilled in the art will readily understand.

The primary and secondary shafts are supported by and revolve in bearings 7*a* and 7*b*. These bearings are partly housed in suitable recesses in casing 8 and are retained in place by removable caps 9. It may be noted that while plain bushing type bearings have been shown herein, higher mechanical efficiencies can be realized by using some form of ball or roller bearings as will be readily appreciated by those skilled in the art.

The main casing 8 is of a general annular shape, in plan view, surrounding an open central space. The casing width from left to right is equal to the space between the axes of the two shafts 3 and 6. On the right and left sides of casing 8 are attached removable enclosing extension members 10 and 10*a*. With the addition of plate-like front cover 11 and rear cover 12, all the driving parts are completely enclosed and well adapted to spray-type lubrication.

Eccentrics are provided on the drive shafts 3 and 6. Embracing these eccentrics and reciprocated by them are straps comprised of two separable elements 13*a* and 13*b*. Although the straps are illustrated in the drawings as riding or resting directly on the eccentrics, it is quite practical to interpose some form of anti-friction bearing between them for obtaining higher mechanical efficiency. Element 13*a* is in the nature of a cap and element 13*b*

has an extended limb embracing near its end a wrist pin 14. Each wrist pin is also embraced by a box type crosshead 15. Through this wrist pin the reciprocation of the eccentric straps (in effect a connecting rod) is transmitted to the crosshead 15. The crossheads 15 have cylindrical rod-like portions extending through suitable guide holes to the outside of the casing and into the open space in the center of the main casing 8. These crosshead extensions are in turn connected to pump plungers 16 by a split clamp-type of coupling 17. These clamps are of a type having lip-like rims at each end of the coupling. One lip fits into a groove in the crosshead extension 15 while the other lip fits into a corresponding groove in the plunger 16. This provides a positive "pull-back" of the plunger. The main heavy thrust load is carried by having the crosshead extension and plunger abut against one another.

In the open space in the center of the main casing 8 midway between the two shafts 3 and 6, there is a one-piece block-like pump body 18 containing suction manifolds 19, discharge manifolds 20, pump chambers 21, inlet valve 22 and valve bonnet 23, discharge valve 24 and valve bonnet 25, plunger bushings 26, packing 27 and packing glands 28. The pump block 18 is supported by and detachably secured to suitable ledges or seats 8*a* on the main casing 8.

The suction and discharge manifolds 19 and 20 are each comprised of a pair of passages or channels extending lengthwise through the pump block 18 with both ends of each passage sealed off from the outside. The spacing sideways of these manifold passages 19 and 20 is such that they partially intersect the sides of the successive valve pockets, thus connecting each valve pocket with a common source of supply or discharge, respectively. The use of a pair of passages as manifolds on opposite sides of the respective valve chambers has the advantage of a balanced reaction on the valves from the in-rush and out-rush of the pressure medium. This avoids the tilting and jamming effect of the valves in their guides which would be present with only one manifold at one side of the valve chamber.

At the far end of the pump block 18, there are provided suction pipe connection 29 and discharge pipe connection 30 in a manner indicated in FIG. 7. It involves extending the pipe tap-drilled holes or ports up from the bottom and down from the top until they partially intersect the corresponding suction and discharge manifolds 19 and 20. Bolted flanged pipe connections may equally well be used in place of the screwed connections shown herein.

FIGS. 12A, 13A and 14A are mainly devoted to showing several positions of the control mechanism including roller chain transmission system and the associated or cooperating idler sprocket functions, as they apply to the novel variable pump, whereby the relative rotational positions of the two drive shafts 3 and 6 (primary and secondary) may be changed. Identical sprockets 4 and 4*a* are secured to shafts 3 and 6, respectively, both being engaged by roller chain 5 which is in the form of a continuous loop or belt of constant or fixed length. In its passage from sprocket 4 to sprocket 4*a* and back again, the chain passes around six idlers or free running sprockets. Four of the idler sprockets 31*a*, 31*b*, 31*c* and 31*d* are in fixed locations and serve merely to change the direction of travel of the chain through a 90° angle. The other two of the idler sprockets 32*a* and 32*b* are mounted on a rigid slide 33*a* and 33*b*, which slide can be moved in a path perpendicular to a line joining the centers of the two drive shafts 3 and 6.

The four idler sprockets 31*a*, 31*b*, 31*c* and 31*d* turn on shafts 34*a*, 34*b*, 34*c* and 34*d*, respectively, whose far ends are housed in bores in bosses on main casing 8. The near ends are housed in bores in detachable members 35*a* and 35*b* which span the sprockets and are bolted against lugs on the main casing. The other two idler sprockets 32*a* and 32*b* turn on shafts 36*a* and 36*b*, respectively, which are housed in bores in front and rear members of slide 33*a* and 33*b*. This slide has been shown in two parts, an upper and lower section, bolted together, thus allowing for the insertion, between the sections, of sufficient shims or spacers, to allow for initial differences in the length of chain and for stretching due to subsequent wear. Any other equivalent means for adjustment may be applied instead.

The slide is guided on its rear side by lips outstanding from main casing. The front side is guided by similar lips on a detachable member 37 which bridges the gap between the members 35*a* and 35*b* and is attached to the same. The slide may be moved up and down in these guides by suitable means, depending upon the size of the pump, i.e. depending upon the power required. The means depicted in the drawing is merely illustrative and is a manually-operated screw 38 and nut 39 device, the screw being rotated by a hand-wheel 40 on the outside of the top of main casing.

For heavier duty requirement, the hand-wheel 40 on the outside of the top of main casing may be replaced by a worm gear with motor driven worm. Since the slide travel is in a straight line, it also lends itself to a pull and push action by an auxiliary hydraulic cylinder and piston on top of the casing. The use of a push and pull cylinder would be most useful when the pump delivery is governed by some automatic control which is responsive to delivery volume and/or pressure requirements.

It is to be noted that with direction of rotation as indicated by the arrows, the left-hand ("primary") shaft being the driver, then the portion of chain on the top-side of the sprockets is the pulling or tight portion. This will result in a downward pull on the upper idler sprocket 32*a* on the rigid slide 33*a*—33*b*, of an amount statically equal to about twice the chain pull needed to transmit the required power to the "secondary" shaft. Consider a movement of the single rigid slide 33*a*—33*b* from its upper position, as shown in FIG. 12A, downward by an amount equal to one quarter of the pitchline circumference of the identical sprockets 4 and 4*a*. This downward movement will pull down an equal amount of that portion of the chain that leads to the underside of each of the two sprockets. This will have the effect of rotating the "primary" shaft 90° in a counterclockwise direction and the "secondary" shaft 90° in a clockwise direction. This is possible because, since the upper idler 32*a* moves in unison with the lower idler 32*b* on the rigid slide 33*a*—33*b* through the same distance, it feeds as much chain on to the top of the two sprockets 4 and 4*a* as was removed from the bottom. The total effect of this amount of slide movement is to change the phase relationship between the "primary" and "secondary" shafts by 180°. An upward movement of the slide to its upper limit will restore the original phase relationship between the two shafts. Since the total length of chain remains constant or fixed and the chain is in the form of an endless loop, it will be evident that this slide movement may take place while the pump is running without interfering with its function as a power transmission element. FIG. 13A shows the control mechanism adjusted for minimum delivery. In this adjustment or setting, rigid slide 33*a* is in its lowermost position. For intermediate partial delivery, the control mechanism is adjusted or set as shown in FIG. 14A. Rigid slide 33*a*—33*b* is in a position which is intermediate between its maximum and minimum positions.

FIGS. 12B, 13B and 14B are diagrammatic in form to illustrate more clearly the effect of changing the phase relationship of these shafts 3 and 6 as it affects the resulting discharge volume of the pump. It is also to be noted that actual "crankshafts" are illustrated in these diagrams rather than "eccentric shafts" as illustrated in FIGS. 3 and 4 and also FIGS. 12C, 13C, and 14C. This results in exaggerating the plunger travel in order to bet-

ter visualize the space between the plungers in their various positions. The reference character "P" represents the "primary" shaft and "S" the "secondary" shaft.

In FIG. 12B, the top line illustrates the initial position or stage of the plungers in their outermost position. Crankpin on primary shaft "P" is shown horizontally to the extreme left of its shaft and crankpin on secondary shaft "S" to the extreme right of its shaft, i.e., on the furthermost opposite sides of the two crankshafts. In this initial position or stage, the plungers are at a maximum distance "I-Max." from each other. The middle line of FIG. 12B shows the relative position of the two plungers at an intermediate point in the stroke or cycle after a 90° counterclockwise revolution of the shafts "P" and "S." The bottom line of FIG. 12B shows the conditions after a further 90° revolution or 180° from the start where the plungers are in their final or innermost position "F-Max."

Inspection of the diagrams shows the initial gap between the plungers to have decreased from distance "I-Max." to distance "F-Max." as they move towards each other with the said 180° revolution. Thus, "I-Max." minus "F-Max." equals the combined displacement of the two plungers. In other words, the maximum discharge from a single pump chamber from the initial position to the final position as illustrated in FIG. 12B.

Referring to FIG. 13B, the top line illustrates the initial position or stage of the plungers for the minimum adjustment where crankpin on primary shaft "P" which is vertically below its shaft and where the crankpin on the secondary shaft "S" is vertically below its shaft, i.e., where each crankpin is 90° away from its position as originally illustrated in FIG. 12B. In this minimum setting or adjustment, the plungers are a distance "I-Min." from each other. The middle and bottom lines of FIG. 13B show successive positions of the plungers after 90° and 180° rotation, respectively, which illustrate the intermediate and final positions of the plungers. In the final position, the plungers are a distance "F-Min." from each other.

Inspection of FIG. 13B indicates the plungers are moving in the same direction at the same time and apparently through the same distances. It may be stated at this point without going through the geometrical proof of the statement that with "infinite length" connecting rods the distances traveled by the two plungers would be exactly alike as understood by those skilled in the art. With "finite length" connecting rods where they are relatively long compared to a small eccentricity of the driving eccentrics, the actual discrepancy between the ideal and practical is extremely small and not of sufficient amount to militate against the practical use of this type of pump. Since, therefore, "I-Min." and "F-Min." are practically the same distance, it means that a trapped volume of liquid is merely moved back and forth between the two plungers without being discharged from the pumping chamber. In other words, the plungers are adjusted for minimum delivery. Theoretically, this adjustment should give zero delivery but in practice there is a very small delivery as well known by those skilled in the art.

It is likewise to be noted, however, that if it is desired to secure the "ideal" effect of an "infinite length" connecting rod, it can be done. The type of mechanism for such a drive is commonly called a "Scotch Yoke" drive.

Assuming that a horizontal reciprocation of plungers is desired from a given crankshaft, then the parts and their movements are as follows: The crankpin is embraced by a block having two sliding surfaces on opposite vertical faces. These faces slide between two vertical members whose top and bottom ends are held apart by spacers. The frame thus formed is what is termed the yoke.

During each revolution of the crankshaft, at any instantaneous angular position of the crank radius, the tangential direction of motion of the crankpin may be resolved into two components, one vertical and one horizontal.

The vertical components result in sliding the block up and down within the "yoke." The horizontal components result in the block pushing the yoke back and forth horizontally, thus transmitting a horizontal reciprocation to any plunger attached to the yoke.

Owing to the necessity of providing suitable guides for this type of mechanism and as there are considerable frictional power losses, it is only rarely used in practical and industrial operations of a commercial nature. It depends upon whether the geometrical perfection of motion produced outweighs its practical disadvantages.

Now referring to FIG. 14B, the top line illustrates the initial position of the plungers for an intermediate adjustment or setting where the crankpin on primary shaft "P" is shown below and to the left of its shaft and crankpin on secondary shaft "S" is shown below and to the right of its shaft, or, midway between its position in FIGS. 12B and 13B. The initial distance between the plungers for the intermediate adjustment is "I-Int." It is to be understood, however, that FIG. 14B is not restricted to this specific starting or initial position, but, rather, in a general sense, it is illustrative of each and every condition between the two extremes of FIGS. 12B and 13B. The middle and bottom lines of FIG. 14B illustrate the position of the plungers where the crankshafts have rotated 90° and 180°, respectively, from the initial position. In the final position, the plungers are a distance "F-Int." from each other.

The net discharge represented by FIG. 14B is "I-Int." minus "F-Int." which is somewhere between "I-Max." minus "F-Max." and "I-Min." minus "F-Min." From the foregoing, it will be clear to those skilled in the art that it is possible to so change the relative angular position of the two crankpins, with respect to one another, as to obtain a stepless or infinitely variable discharge from the novel variable pump anywhere between the two extremes of FIGS. 12B and 13B, to wit: the maximum position and the minimum position.

The value of the present invention as embodied in the novel combination involving sprockets, chain and a slide adjustment mechanism will be evident to those skilled in the art, since this novel combination permits both the driving of the "secondary" shift from the "primary" shaft and at the same time placing the shafts in any of their relative positions as illustrated in FIGS. 12C, 13C and 14C to vary the discharge from the pump. In FIGS. 12C, 13C and 14C, the initial positions of the pump plungers are shown in full lines whereas their limits of travel corresponding to these initial positions are shown in dotted lines. In FIG. 12C, the maximum displacement of the plungers will amount to "I-Max." minus "F-Max." This will give the maximum delivery. In contrast, FIG. 13C shows the minimum position. The minimum displacement is "I-Min." minus "F-Min." which produces the minimum delivery. The intermediate position is shown in FIG. 14C with an intermediate displacement equal to "I-Int." minus "F-Int." In this position or setting, an intermediate delivery is introduced. As those skilled in the art will understand, an infinite number of intermediate positions or adjustments can be made by the control mechanism between the maximum and minimum positions or adjustments.

The present invention is particularly applicable to operating extrusion presses and die casting machines where the material, such as metal, etc., is in a red hot or a molten condition, thus constituting a fire or explosion risk with those pumps which use oil as the pressure medium. The ability of the novel pump to use water as the pressure medium eliminates the fire and explosion risk.

The water handling ability of the new pump also adapts it for boiler feed purposes where fluctuating "steam de-

mands" necessitate corresponding changes in volume of water supplied to the boiler. This is especially so with the trend towards larger outputs both in volume and in the use of higher pressures which this new type of pump is capable of producing.

Another application of this variable volume delivery pump is in operating those types of hydraulic presses where a large part of its ram stroke merely brings the "tools" into contact with the work, the final heavy pressure and slow movement occurring in a short distance. Such presses are used for coining, stamping, forging, etc., and for injection molding, etc., as is well known in the art.

It is to be observed that the present invention provides an improved variable hydraulic pump wherein the isolated location and one-piece nature of the pump body has many advantages including the following:

(1) The new pump is especially useful for the handling of acidulated or corrosive liquids as the block may be a stainless steel forging or any appropriate alloy capable of handling and of being resistant to such liquids.

(2) Any fluid leakage from the pump body past the plunger packing cannot get into the driving mechanism and do harm or cause trouble.

(3) For maintenance of gland packing, valve grinding or bonnet seal replacement, the novel pump body is accessible from all sides. In the event of a general overhaul of the pump body and its working parts, it is readily removable to a workbench for convenience. This can be done by merely uncoupling the plungers from the crosshead extensions, removing the four hold-down bolts and uncoupling the suction and discharge pipes, whereupon it may be removed without disturbing the driving mechanism.

Furthermore, the invention provides an improved variable hydraulic pump having such relatively short stroke plungers that it is possible to drive the pump at such high speed of revolution that it may be coupled direct to a prime mover, such as a standard electric motor, without the need of reduction gearing. The short stroke prevents high velocities of flow through the valves and passages even with the relatively high revolutions per minute.

The short stroke also allows the use of "eccentric" drive shafts instead of "crankshafts." The former are cheaper to manufacture and lend themselves to providing the strength and bearing areas to carry the heavy loads imposed by the high pressures on the relatively large diameter plunger ends.

The ability of the new pump to vary the volume of discharge while running permits an added function. It is possible to have the pump governed by some automatic control device responsive to pressure changes whereby the maximum delivery would be at low pressure. Then as the pressure increased, it would cause the volume of delivery to be correspondingly decreased. By suitable design of the control device, this would result in a "constant horsepower" input. Thus, the pump can be of both a variable volume and a variable pressure type at the same time.

Another advantage of the short strike, together with the unique arrangement of the component parts of the new pump, is the resulting compactness. Investigation has shown that the new pump occupies less than half the cubic space of equivalent capacity pumps of the packed plunger and seated valve type. This compactness means smaller and less massive frames and housings, i.e., an economic gain in manufacturing them and lower capital costs.

Moreover, the invention provides an improved variable hydraulic pump having the prime distinction of controlling the volumetric output of the pump by varying the phase relationship of two separate crankshafts driving opposed pairs of plungers.

Considering the vital function of the rigid control slide (*33a* and *33b*), it seems advisable to summarize here the various references to it throughout the specification and also to point out other advantages it offers.

The slide moves up and down in vertical guides and carries two idler sprockets (*32a* and *32b*), one near the top and one near the bottom. The direction of rotation of the drive shafts shall be so chosen that the "pulling" portion of the chain passes around the top half circumference of the upper sprocket. The "slack" portion passes around the under half circumference of the lower sprocket.

The slide and its guides are of such lengths that there will be possible a total travel either up or down equal to one-quarter of the pitch line circumference of the sprockets (4 and *4a*) on the drive shafts. If preferably has a two-part construction, an upper and lower portion, bolted together to allow for the insertion between them of shims or spacers. This construction provides a convenient method of allowing for initial variations in the length of chain and for "take-up" of slack resulting from subsequent wear as those skilled in the art will readily appreciate.

Since both sprockets (*32a* and *32b*) are carried on the one rigid slide, it follows that they are transported through equal distances whenever the slide is raised or lowered. This means that the total length of the chain loop or belt connecting the two drive shafts remains fixed and unchanged, since with, say, a downward movement of the slide, then for any amount of chain dragged down by the lower sprocket (*32b*), there will be an equal amount supplied by the upper sprocket (*32a*).

With the "slack" portion of the chain coming off of the under side of the two sprockets (4 and *4a*), the effect of a downward movement of the slide will be to produce a counterclockwise rotation of the left-hand or primary drive shaft and a clockwise rotation of the right-hand or secondary drive shaft. Thus, any shifting of the slide, either up or down, will produce corresponding angular changes in the phase relationship of the two shafts. With the stipulated amount of maximum travel of the slide, there will occur a 90° rotation of each shaft or 180° total phase changes between them.

With the previously explained condition of an unchanged or fixed total of length of chain, regardless of the slide movement, it is possible to utilize the chain as both a power transmission element and also as a means of changing the phase relationship of the two drive shafts while the pump is running. This positive action in either direction is its prime feature resulting from the novel arrangement of the eight sprockets. These comprise two identical sprockets secured to the drive shafts, four idlers in fixed locations and the two idlers mounted on the slide.

The straight line movement of the slide being of a relatively moderate amount of travel lends itself to simple methods of accomplishing the movement. They will vary with the size and output of the unit pump being governed mainly by the amount of power required to operate them but also by the type of volume control that pump duty calls for.

It may vary from a simple screw and nut device with handwheel for manual operation to power driven worm gearing for rotating the screw. Other means adaptable to the straight line movement are such devices as an air or hydraulically powered cylinder mounted overhead with its piston rod directly connected to the top of the slide as readily understood by those skilled in the art.

The straight line action also adapts it to the installation of simple stroke indicating mechanism such as a rod attached to the slide extending to the outside of the casing where it is provided with a pointer indicating on a calibrated scale. A similar rod arrangement may be connected externally to an appropriate automatic control instrument to govern the extent of slide travel needed to produce a desired volume of delivery.

It is to be observed that the present invention is not

to be confused with old pumps disclosed in prior patents and publications. In contrast with the present invention involving the aforesaid positive, straight line control movements, reference may be made to an old British Patent No. 508,703. While this patent discloses an old theoretical principle, the suggested or indicated arrangement disclosed in the patent of the structural elements including the chain connection from one crankshaft to the other is rather crude and primitive and very unmechanical. Thus, the use of springs or counterweights to take up the excess of chain on the bottom or "slack" portion of the complete chain loop occurring as the upper central sprocket is moved downward and causing a variation in the length or amount of slack of the driving chain is rather impractical for an industrial machine intended for commercial operations. This arrangement tends to result in a bouncing up and down of the springs or weights due to irregularities of chain travel or with sudden shifting of the upper sprocket position. In contrast thereto, the new variable hydraulic pump, by passing the "slack" portion of the chain around a second sprocket, mounted on the lower portion of the same slidable member as carries the upper sprocket, there is a positive "take-up" for this slack portion, with an unchanged or fixed total length of chain at all times.

In the embodiment illustrated herein, one of the objectives has been not only to disclose a novel method of controlling the output of the pump but to provide a novel pump design having many features needed to insure satisfactory and successful operation when carried into practice on an industrial scale. It represents a combination of simple, rugged, compact parts, easy to machine and assemble, accessibility for maintenance, adaptable to several methods of actuating the direct control and with the provision of ample bearing areas where needed to insure long life and dependable performance. In fact, the new pump embodying the present invention incorporates sound scientific principles and sound engineering construction. Investigation has demonstrated that there are available commercial chains and sprockets, anti-friction bearings of suitable capacities as well as other component parts permitting the new pump to be built in practical machines up to several thousand horsepower.

It is to be noted that the present invention provides a unique housing for the driving mechanism. In its preferred construction, it is made of cast iron in the smaller sizes and of cast steel in the larger and more highly stressed structures. The form of this housing being of a general annular shape in plan view and with the major portion in the same horizontal plane renders it particularly suitable to using a spray form of lubrication for the driving members enclosed in the housing. The excess lubricating oil after cascading down over the moving parts is readily collected in the bottom portion of the housing. Suitable internal gutters can drain it from the two eccentric shaft carrying portions of the housing into the front portion surrounding the sprockets and chain drive elements. Since this enclosure has a lower portion extending below the generally horizontal level of the sides it forms a very convenient sump. For such a use, the relatively small downward extension needed to clear the slide movement may be enlarged from what is illustrated in FIG. 9 to provide an ample oil reservoir. A small circulating pump can draw the oil from here through a filter and then to the spray nozzles again. This system together with the ample radiating surfaces of the housing tends to prevent an excessive temperature raise while running.

Due to the rather simple form of the housing with many flat surfaces, it is well adapted to welded steel plate construction in place of iron or steel castings. This would be especially advantageous when building a pilot model of a new size unit in that it avoids the cost of patterns until such time as it goes into commercial production.

The invention also contemplates the provision of a novel pump block or body having a special structure. This pump body is preferably constructed of a solid block of material. Such a solid block of material may be of such a composition of steel, for example, or heat treatment thereof as is best adapted to the particular service required. For practical and industrial purposes generally where the pressures do not exceed about 15,000 p.s.i. and where the liquid used is non-corrosive, then cuttings from an ordinary mild steel rolled bar or forging, depending upon the size, is acceptable. However, for corrosive liquids either stainless steel or other alloys having suitable corrosion-resistant properties should be used. As the generated pressures rise to higher limits, it becomes desirable to provide a steel with higher physical properties due either to an alloying element or heat treatment or both.

The solid block being of a general rectangular shape all over is readily machined on its faces by planing or milling. The internal machining is almost entirely of a drilling or boring nature thus lending itself to the use of jigs. On the other hand, the whole block may be completely handled and machined in a fixture for purposes of mass production. The machining operations are of such a simple nature and sequence that the machines may be governed by some form of automation.

It is likewise within the contemplation of the invention to incorporate a special control mechanism in the new variable pump. Such control mechanism involves the use of a rigid slide member in conjunction with a fixed and constant length of roller chain joined together in the form of a loop or belt. This loop or belt at some time during each complete circuit passes half-way around each of two idler sprockets mounted on this slide, one near its upper end and the other near its lower end. With the aid of four idler sprockets in fixed locations, the path of the chain is diverted so as to permit it to also engage two sprockets, one on each of the two drive shafts. The general relationship of these several sprockets to one another is clearly shown in FIG. 9.

The special arrangement makes possible a positive, infinitely variable change in the phase relationship of the two drive shafts, through a maximum of 180° (relative rotation) while the pump is running. This results from the fact that since the two sprockets are both mounted on the same slide they always move through equal distances as the slide is moved either up or down. Thus, any amount of chain being drawn from one side of the sprockets on the drive shafts causing relative rotation of the drive shafts is replaced by an equal amount on the opposite side of the sprockets.

With the foregoing compensating chain movements, it is evident that the total length of the chain loop or belt remains unchanged or fixed thus permitting it to serve simultaneously in two independent capacities as both a control device and as a power transmitting element.

The present invention embodying a novel slide device is of such simple construction as to readily adapt it to a variety of methods of accomplishing the movement of it and constitutes a unique solution to the problem confronting the art of a practical industrial machine capable of varying the phase relationship between two independent drive shafts and capable of commercial production and operation.

The new variable pump embodies a novel combination of structural elements including an annular drive housing, a driving mechanism mounted in said housing, a central pump block seated within the central portion of said annular housing and containing a plurality of single acting, opposed reciprocating plungers and provided with seated type inlet and outlet valves, and a control mechanism incorporated within the housing and operatively associated with the driving mechanism and being capable of stepless or infinitely variable volume of delivery and/or pressure from a minimum up to a maximum while the new pump is operating and is being driven at a relatively high rate of revolutions per minute by an electric motor. This novel combination pos-

sesses many valuable features. For instance, from a manufacturing viewpoint, it may be noted that the majority of the component elements are of a simple form and are readily machinable. The pump block is especially adaptable to the use of jigs or fixtures for the drilling, boring and thread tapping operations, thus rendering the product suitable for interchangeability while avoiding expensive hand lay-out work. The novel design lends itself to group assemblies on the bench as well as the whole pump structure being very accessible for final assembly. Likewise, the new design is helpful from a maintenance consideration. For inspection of and any necessary adjustments to a drive shaft, its bearings or allied parts, it is only necessary to remove the corresponding housing extension **10** or **10***a*. Similarly, access to the chain drive and control slide is accomplished by removal of cover **11**. However, apart from such favorable factors in the new design, the prime consideration is its ability to meet service requirements beyond the capacity of conventional pumps. This is chiefly due to the fact that while the majority of conventional variable delivery pumps must use oil as the pressure medium, this new pump is perfectly able to safely use water, if desired. Furthermore, with the use of packed plungers and seated valves in a solid metal pump block, this new pump is also capable of generating much higher pressures than those using packless plungers and ported valves. These factors added to its stepless variable volume characteristics and to its adaptability of being manufactured in large sizes enable it to meet the growing demand for larger outputs per unit pumps.

Although the present invention has been described in conjunction with preferred embodiments, it is to be understood that modifications and variations may be resorted to without departing from the spirit and scope of the invention, as those skilled in the art will readily understand. Such modifications and variations are considered to be within the purview and scope of the invention and appended claims.

I claim:

1. An improved variable hydraulic pressure pump having opposed, horizontal, single-acting, straight-line, reciprocating plungers and provided with seated type inlet and outlet valves and capable of a stepless or infinitely variable volume of delivery and/or pressure from the minimum to a maximum thereof while the pump is running, having such a construction that the pump block is isolated from the driving mechanism to prevent leakage of water past the plungers in the pump and into the driving compartment, and having such a construction as to permit operation at a relatively high rate of revolutions per minute and to lend itself to driving by a directly-connected, standard prime mover such as a standard high-speed electric motor without the use of reduction gearing which comprises a plain, rugged, hollow metal housing having an approximately annular contour of rectangular shape for completely enclosing driving and controlling mechanism, said housing having an open central area and being low and close to the supporting surface; parallel shoulders incorporated in the opposite sides of said housing and extending inwardly therefrom adjacent to the open central area to provide seats; a plain, rugged, rectangular, one-piece, block-like pump body removably fastened to said shoulders and mounted within the middle of said central area for generating pressure in the hydraulic fluid, said pump body being accessible from all sides and being readily removable as a unit without disturbing the interior of said housing; a primary driving shaft mounted in fixed bearings in said housing at one side thereof and adapted to be directly connected with a standard high speed prime mover without the use of reduction gears and a secondary driving shaft mounted in fixed bearings in said housing at the other side thereof and parallel to said primary driving shaft, said driving shafts being located in the same horizontal plane close to the supporting surface and being fixedly mounted at a fixed distance apart; a sprocket for roller chain mounted on each of said driving shafts for the transmission of driving power from a directly-connected standard, high-speed prime mover; four idler sprockets for roller chain mounted in fixed positions adjacent to the mid-section of the hollow housing, each of said four sprockets being secured to the interior of the housing near a corner of crossed lines formed by a horizontal line passing across and through the fixed axes of the driving shafts and a vertical line perpendicular to said horizontal line and lying midway between said primary and secondary driving shafts; a vertical, rigid control slide positioned midway between said driving shafts and arranged for movement from one vertical position to another in a straight line perpendicular to said horizontal line joining the fixed axes of the two driving shafts for controlling the delivery and pressure of the pump, said control slide having a maximum range of travel equal to one-quarter of the pitch line circumference of sprockets mounted on the primary and secondary shafts; two idler sprockets mounted in fixed bearings in said vertical, rigid control slide, one of said sprockets being positioned near the top of said slide and the other near the bottom thereof and said two sprockets together with the other sprockets having such relative location to each other that perpendicular movement of the control slide at the mid-section will change the phase relation of the two driving shafts with respect to each other; a roller chain belt of fixed length in the form of a continuous loop connecting said primary shaft with said secondary shaft and operatively associated with and driving all of said sprockets for functioning as a power transmission element and for controlling the phase relation of the primary and secondary shafts when the control slide is changed while the pump is running, said roller chain having a small pitch for transmitting the power delivered by a prime mover whereby sprocket diameters are kept to a minimum and chain velocities for the various chain pitches limited to a selected range; a plurality of pairs of opposed, horizontal, single-acting, straight-line, reciprocating plungers extending from and operatively associated with said pump block, said plurality being not less than three for minimizing the pulsations in the discharge from the pump and having a short stroke to permit driving with a high-speed, directly-connected prime mover without reduction gearing and to prevent high velocities of flow through valves and passages even with the relatively high revolutions per minute; a plurality of pairs of eccentric driving shafts with multiple eccentrics actuated by the primary and secondary driving shaft for imparting reciprocating motion to said pairs of plungers; a plurality of seated inlet and outlet valves for admitting hydraulic fluid to and for discharging the same from a pump chamber within said pump block; a main suction port connected via said inlet valves to said pump chamber; a main discharge port connected via said outlet valves to said pump chamber; and adjusting means connected to and capable of moving said vertical control slide perpendicularly to the horizontal line between the axes of the primary and secondary driving shafts for varying the phase relation between said two shafts and for making stepless or infinitely variable adjustment and for controlling the volume delivery and/or pressure from a maximum to a minimum volume delivery and/or pressure while the pump is running and is being driven at a relatively high rate of revolutions per minute by a directly-connected prime mover whereby a variable pump is provided capable of generating much higher pressures than those of conventional types of existing high speed pumps using oil as the pressure medium and having ports to govern the flow of oil, capable of using any type of fluid and liquid including water as the pressure medium

and capable of operating hot extrusion presses and the like where hot metal is handled and where there is usually a fire or explosion hazard, especially with conventional pumps using oil as the pressure medium, and capable of delivering any fluid and liquid under a variety of pressure up to those of a high order and in a variety of amounts up to those of a large order.

2. An improved variable hydraulic pressure pump having opposed, horizontal, single-acting, straight-line, reciprocating plungers and provided with seated type inlet and outlet valves and capable of a stepless or infinitely variable volume of delivery and/or pressure from a minimum to a maximum while the pump is running, having such a construction that the pump block is isolated from the driving mechanism whereby leakage of water past the plungers in the pump and into the driving compartment is prevented, and having such a construction as to permit operation at a relatively high rate of revolutions per minute and as to lend itself to driving by standard prime movers such as standard high-speed electric motors without the use of reduction gearing which comprises a plain, rugged, low rectangular annular housing made of a metal of the group consisting of cast irons, steels and alloys and completely enclosing the driving and controlling mechanisms, said housing having an open central area and being low and close to the supporting surface; parallel shoulders incorporated in the opposite sides of said housing and extending inwardly therefrom adjacent to the open central area to provide seats; a plain, strong, rectangular one-piece pump block made of a metal of the group consisting of cast irons, steels and alloys and removably mounted within the middle of the central area in said annular housing, each end of said rectangular pump block being seated and fastened on said shoulders extending from said housing and being accessible from all sides while at the same time being readily removable without disturbing the interior of said housing; a vertical, rigid slide control mechanism centrally located at a mid-section in said housing and arranged for vertical movement upwardly and downwardly in a vertical path for controlling the delivery and pressure of said pump, said control slide having a maximum range of travel equal to one-quarter of the pitch line circumference of sprockets mounted on driving shafts; a main primary driving shaft fixedly mounted in said housing at one side of said slide control mechanism and adapted to be directly connected with a standard high speed prime mover without the use of reduction gears and a secondary driving shaft driven by said primary driving shaft and fixedly mounted in said housing at the other side of said vertical control slide at such a position that a horizontal line passing through the axes of said shafts is approximately perpendicular to said vertical path of said vertical control slide, said driving shafts being located in the same horizontal plane close to the supporting surface and being fixedly mounted at a fixed distance apart; one pair of idler sprockets fixedly located to one side of control slide and secured to the interior of the housing, the upper of said sprockets being above said horizontal line passing through the axes of said driving shafts and the lower being below said horizontal line; a second pair of sprockets fixedly located to the other side of said control slide and secured to the interior of the housing, the upper of said sprockets being above said horizontal line and the lower being below said horizontal line; one idler sproket fixedly positioned near the top of said control slide and adapted for vertical movement with the said slide and a seocnd idler sprocket fixedly positioned near the bottom of said control slide and also adapted for simultaneous vertical movement with the said slide; a continuous driving chain belt of fixed length in the form of a loop passing around the primary driving shaft sprocket, the two pairs of idler sprockets secured to the interior of the housing, the sprockets at the top and bottom of the vertical control slide, and the secondary driving shaft sprocket, said chain belt transmitting the power from the driving shafts and for controlling the phase relation of the said shafts when the control slide is moved vertically while the pump is running; a plurality of pairs of opposed, horizontal, single-acting, straight-line, reciprocating plungers driven by said driving shafts, said plurality being not less than three for minimizing the pulsations in the discharge from the pump and having a short stroke to permit driving with a high-speed, directly-connected prime mover without reduction gearing and to prevent high velocities of flow through valves and passages with relatively high revolutions per minute; at least one main inlet valve of seated type and at least one main discharge valve of seated type mounted in a common pump chamber; a main suction port connected via said inlet valve to said pump chamber and a main discharge port connected via said outlet valve to said pump chamber; a standard high speed electric motor rotating at a high rate of r.p.m. and directly connected to said primary driving shaft without reduction gear; and adjusting means for actuating and controlling said vertical control slide to move it vertically upwardly and downwardly and to cause an adjustment of the phase relationship of the primary and secondary driving shafts for effecting a stepless or infinitely variable adjustment of the volume delivery and/or pressure from a maximum to a minimum adjustment while the pump is running and is being driven at a relatively high rate of revolutions per minute whereby a variable pump is provided capable of generating much higher pressures than those of conventional types of existing high-speed pumps using oil as the pressure medium and having ports to govern the flow of oil, capable of using any type of fluid and liquid including water as the pressure medium and capable of operating hot extrusion presses and the like where hot metal is handled and where there is usually a fire or explosion hazard, especially with conventional pumps using oil as the pressure medium, and capable of delivering any fluid and liquid under a variety of pressures up to those of a high order and in a variety of amounts up to those of a high order.

3. An improved variable hydraulic pressure pump having opposed, horizontal, single-acting, straight-line, reciprocating plungers and provided with seated type inlet and outlet valves and capable of a stepless or infinitely variable volume of delivery and/or pressure from a minimum to a maximum while the pump is running, having such a construction that the pump block is isolated from the driving mechanism whereby leakage of water past the plungers in the pump and into the driving compartment is prevented, and having such a construction as to permit operation at a relatively high rate of revolutions per minute and as to lend itself to driving by standard prime movers such as standard high-speed electric motors without the use of reduction gearing, which comprises a plain, rugged, low, rectangular annular housing made of a metal of the group consisting of cast irons, steels and alloys and completely enclosing the driving and controlling mechanisms, said housing having an open central area and being low and close to the supporting surface; parallel shoulders incorporated in the opposite sides of said housing and extending inwardly therefrom adjacent to the open central area to provide seats; a plain, strong, rectangular steel pump block made of a metal of the group consisting of cast irons, steels and alloys and removably mounted within the middle of the central area in said annular housing, each end of said rectangular pump block being seated and fastened on said shoulders extending from said housing and being accessible from all sides while at the same time being readily removable without disturbing the interior of said housing; a vertical rigid slide control mechanism centrally located at a mid-section in said housing and arranged for vertical movement upwardly and downwardly in a vertical path for controlling the delivery and pressure

of said pump, said control slide having a maximum range of travel equal to one-quarter of the pitch line circumference of sprockets mounted on driving shafts; a main primary driving shaft fixedly mounted in said housing at one side of said slide control mechanism and adapted to be directly connected with a standard high speed prime mover without the use of reduction gears and a secondary driving shaft driven by said primary driving shaft and fixedly mounted in said housing at the other side of said vertical control slide at such a position that a horizontal line passing through the axes of said shafts is approximately perpendicular to said vertical path of said vertical control slide, said driving shafts being located in the same horizontal plane close to the supporting surface and being fixedly mounted at a fixed distance apart; one pair of idler sprockets fixedly located to one side of control slide and secured to the interior of the housing, the upper of said sprockets being above said horizontal line passing through the axes of said driving shafts and the lower being below said horizontal line; a second pair of sprockets fixedly located to the other side of said control slide and secured to the interior of the housing, the upper of said sprockets being above said horizontal line and the lower being below said horizontal line; one idler sprocket fixedly positioned near the top of said control slide and adapted for vertical movement with the said slide and a second idler sprocket fixedly positioned near the bottom of said control slide and also adapted for simultaneous vertical movement with the said slide; a continuous roller chain belt of fixed length in the form of a loop passing around the main primary driving shaft sprocket, the two pairs of idler sprockets secured to the interior of the housing, the sprockets at the top and bottom of the vertical control slide, and the secondary driving shaft sprocket, said chain belt transmitting the power from the driving shafts and for controlling the phase relation of the said shafts when the control slide is moved vertically while the pump is running; a plurality of pairs of opposed, horizontal, single-acting, straight-line, reciprocating, packed plungers for heavy pressures fitting in and operatively associated with said pump block, said plurality being not less than three for minimizing the pulsations in the discharge from the pump and having a short stroke to permit driving with a high-speed, directly-connected prime mover without reduction gearing and to prevent high velocities of flow through valves and passages with relatively high revolutions per minute; a plurality of pairs of eccentric driving shafts with multiple eccentrics actuated by the primary and secondary driving shaft for imparting reciprocating motion to said pairs of plungers; box-type crossheads with cylindrical guides; split couplings connecting said plungers to crosshead extensions and permitting quick detachment and correction of misalignment; a plurality of poppet type seated inlet and outlet valves for admitting hydraulic fluid to and for discharging the same from pump chamber within said pump block; a main suction port connected via said inlet valves to said pump chamber; twin suction and discharge manifold passages, one of said passages being located on each side of valve pockets to provide balanced flow reactions on the valves from the in-rush and out-rush of the hydraulic fluid; flanged bonnets bolted to valve chambers and capable of being removed readily; "O-ring" seals mounted in said bonnets to insure a good seal; a main discharge port connected via said outlet valves to said pump chamber; a standard high speed electric motor rotating at a high rate of r.p.m. and directly connected to said primary driving shaft without reduction gear; and adjusting means for actuating and controlling said vertical control slide to move it vertically upwardly and downwardly and to cause an adjustment of the phase relationship of the primary and secondary driving shafts for effecting a stepless or infinitely variable adjustment of the volume delivery and/or pressure from a maximum to a minimum adjustment while the pump is running and is being driven at a relatively high rate of revolutions per minute whereby a variable pump is provided capable of generating much higher pressures than those of conventional types of existing high-speed pumps using oil as the pressure medium and having ports to govern the flow of oil, capable of using any type of fluid and liquid including water as the pressure medium and capable of operating hot extrusion presses and the like where hot metal is handled and where there is usually a fire or explosion hazard, especially with conventional pumps using oil as the pressure medium, and capable of delivering any fluid and liquid under a variety of pressures up to those of a high order and in a variety of amounts up to those of a high order.

4. An improved variable hydraulic pressure pump having opposed, horidontal, single-acting, straight-line, reciprocating plungers and provided with seated type inlet and outlet valves and capable of a stepless or infinitely variable volume of delivery and/or pressure from the minimum to a maximum thereof while the pump is running, having such a construction that the pump block is isolated from the driving mechanism to prevent leakage of water past the plungers in the pump and into the driving compartment, and having such a construction as to permit operation at a relatively high rate of revolutions per minute and to lend itself to driving by a directly-connected, standard prime mover such as a standard high-speed electric motor without the use of reduction gearing which comprises a plain, rugged, hollow metal housing having an approximately annular contour of rectangular shape for completely enclosing driving and controlling mechanisms, said housing having an open central area and being low and close to the supporting surface; parallel shoulders incorporated in the opposite sides of said housing and extending therefrom adjacent to the open central area to provide seats; a plain, rugged, rectangular one-piece, block-like pump body removably fastened to said shoulders and mounted within the middle of said central area for generating pressure in the hydraulic fluid, said pump body being accessible from all sides and being readily removable as a unit without disturbing the interior of said housing, a primary driving shaft mounted in fixed bearings in said housing at one side thereof and adapted to be directly connected with a standard high speed prime mover without the use of reduction gears and a secondary driving shaft mounted in fixed bearings in said housing at the other side thereof and parallel to said primary driving shaft, said driving shafts being located in the same horizontal plane close to the supporting surface and being fixedly mounted at a fixed distance apart; a sprocket for driving chain mounted on each of said driving shafts for the transmission of driving power from a directly-connected standard, high-speed prime mover, four idler sprockets for driving chain mounted in fixed positions adjacent to the mid-section of the hollow housing, each of said four sprockets being secured to the interior of the housing near a corner of crossed lines formed by a horizontal line passing across and through the fixed axes of the driving shafts and a vertical line perpendicular to said horizontal line and lying midway between said primary and secondary driving shafts; a vertical, rigid control slide positioned midway between said driving shafts and arranged for movement from one vertical position to another in a straight line perpendicular to said horizontal line joining the fixed axes of the two driving shafts for controlling the delivery and pressure of the pump, said control slide having a maximum range of travel equal to one-quarter of the pitch line circumference of sprockets mounted on the primary and secondary shafts, two idler sprockets mounted in fixed bearings in said vertical, rigid control slide, one of said sprockets being positioned near the top of said slide and the other near the bottom thereof and said two sprockets together with the other sprockets having such relative location to each other that perpendicular

movement of the control slide at the mid-section will change the phase relation of the two driving shafts with respect to each other; a driving chain belt of fixed length in the form of a continuous loop connecting said primary shaft with said secondary shaft and operatively associated with and driving all of said sprockets for functioning as a power transmission element and for controlling the phase relation of the primary and secondary shafts when the control slide is changed while the pump is running, said driving chain having a small pitch for transmitting the power delivered by a prime mover whereby sprocket diameters are kept to a minimum and chain velocities for the various chain pitches limited to a selected range, a plurality of pairs of opposed horizontal, tending from and operatively associated with said pump block, said plurality being not less than three for minimizing the pulsations in the discharge from the pump and having a short stroke to permit driving with a high-speed, directly-connected prime mover without reduction gearing and to prevent high velocities of flow through valves and passages even with the relatively high revolutions per minute, a plurality of pairs of eccentric driving shafts with multiple eccentrics actuated by the primary and secondary driving shaft for imparting reciprocating motion to said pairs of plungers, driving mechanism operatively associated with said eccentric driving shafts and interposed between said shafts and said plungers for reciprocating the latter to generate the said pressure and pump the hydraulic fluid; a plurality of seated inlet and outlet valves for admitting hydraulic fluid to and for discharging the same from a pump chamber within said pump block, a main suction port connected via said inlet valves to said pump chamber, a main discharge port connected via said outlet valves to said pump chamber; and adjusting means connected to and capable of moving said vertical control slide perpendicularly to the horizontal line between the axes of the primary and secondary driving shafts for varying the phase relation between said two shafts and for making stepless or infinitely variable adjustment and for controlling the volume delivery and/or pressure from a maximum to a minimum adjustment while the pump is running and is being driven at a relatively high rate of revolutions per minute by a directly-connected prime mover whereby a variable pump is provided capable of generating much higher pressures than those of conventional types of existing high speed pumps using oil as the pressure medium and having ports to govern the flow of oil, capable of using any type of fluid and liquid including water as the pressure medium and capable of operating hot extrusion presses and the like where hot metal is handled and where there is usually a fire or explosion hazard, especially with conventional pumps using oil as the pressure medium, and capable of delivering any fluid and liquid under a variety of pressure up to those of a high order and in a variety of amounts up to those of a large order.

5. An improved variable hydraulic pressure pump having opposed, horizontal, single-acting, straight-line, reciprocating plungers and provided with seated type inlet and outlet valves and capable of a stepless or infinitely variable volume of delivery and/or pressure from the minimum to a maximum while the pump is running, having such a construction that the pump block is isolated from the driving mechanism to prevent leakage of water past the plungers in the pump and into the driving compartment, and having such a construction as to permit operation at a relatively high rate of revolutions per minute and to lend itself to driving by a directly-connected, standard prime mover such as a standard high-speed electric motor without the use of reduction gearing which comprises a plain, rugged, hollow metal housing having an approximately annular contour of rectangular shape for completely enclosing driving and controlling mechanisms, said housing having an open central area and being low and close to the supporting surface; parallel shoulders incorporated in the opposite sides of said housing and extending therefrom adjacent to the open central area to provide seats; supporting means positioned underneath said housing to hold the same close to a supporting surface, a plain, rugged, rectangular one-piece, block-like pump body removably fastened to said shoulders and mounted within the middle of said central area for generating pressure in the hydraulic fluid, said pump body being accessible from all sides and being readily removable as a unit without disturbing the interior of said housing, a primary driving shaft mounted in fixed bearings in said housing at one side thereof and adapted to be directly connected with a standard high speed prime mover without the use of reduction gears and a secondary driving shaft mounted in fixed bearings in said housing at the other side thereof and parallel to said primary driving shaft, said driving shafts being located in the same horizontal plane close to the supporting surface and being fixedly mounted at a fixed distance apart, a sprocket for roller chain mounted on each of said driving shafts for the transmission of driving power from a directly-connected standard, high-speed prime mover, four idler sprockets for roller chain mounted in fixed positions adjacent to the mid-section of the interior of the housing, each of said four sprockets being secured near a corner of crossed lines formed by a horizontal line passing across and through the fixed axes of the driving shafts and a vertical line perpendicular to said horizontal line and lying midway between said primary and secondary driving shafts; a vertical, rigid control slide positioned midway between said driving shafts and arranged for movement from one vertical position to another in a straight line perpendicular to said horizontal line joining the fixed axes of the two driving shafts for controlling the delivery and pressure of the pump, said control slide having a maximum range of travel equal to one-quarter of the pitch line circumference of sprockets mounted on the primary and secondary shafts, two idler sprockets mounted in fixed bearings in said vertical, rigid control slide, one of said sprockets being positioned near the top of said slide and the other near the bottom thereof and said two sprockets together with the other sprockets having such relative location to each other that perpendicular movement of the control slide at the mid-section will change the phase relation of the two driving shafts with respect to each other, a roller chain belt of fixed length in the form of a continuous loop connecting said primary shaft with said secondary shaft and operatively associated with and driving all of said sprockets for functioning as a power transmission element and for controlling the phase relation of the primary and secondary shafts when the control slide is changed while the pump is running, said roller chain having a small pitch for transmitting the power delivered by a prime mover whereby sprocket diameters are kept to a minimum and chain velocities for the various chain pitches limited to a selected range, a plurality of pairs of opposed horizontal, single-acting, straight-line, reciprocating plungers extending from and operatively associated with said pump block, said plurality being not less than three for minimizing the pulsations in the discharge from the pump and having a short stroke to permit driving with a high-speed, directly-connected prime mover without reduction gearing and to prevent high velocities of flow through valves and passages even with the relatively high revolutions per minute, a plurality of pairs of eccentric driving shafts with multiple eccentrics actuated by the primary and secondary driving shaft for imparting reciprocating motion to said pairs of plungers, means connecting said eccentric driving shafts with said plungers for reciprocating the same and generating pressure in the hydraulic fluid and for isolating the water functioning as the hydraulic fluid in the pump from the primary and secondary driving shafts and associated eccentric shafts in the hollow annular casing, a plurality of seated inlet and outlet valves for admitting hydraulic fluid to and for discharging the same from a pump chamber within said

pump block, a main suction port connected via said inlet valves to said pump chamber, a main discharge port connected via said outlet valves to said pump chamber; and adjusting means connected to and capable of moving said vertical control slide perpendicularly to the horizontal line between the axes of the primary and secondary driving shafts for varying the phase relation between said two shafts and for making stepless or infinitely variable adjustment and for controlling the volume delivery and/or pressure from a maximum to a minimum adjustment while the pump is running and is being driven at a relatively high rate of revolutions per minute by a directly-connected prime mover whereby a variable pump is provided capable of generating much higher pressures than those of conventional types of existing high speed pumps using oil as the pressure medium and having ports to govern the flow of oil, capable of using any type of fluid and liquid including water as the pressure medium and capable of operating hot extrusion presses and the like where hot metal is handled and where there is usually a fire or explosion hazard, especially with conventional pumps using oil as the pressure medium, and capable of delivering any fluid and liquid under a variety of pressure up to those of a high order and in a variety of amounts up to those of a large order.

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