July 9, 1957 R. H. SACHTLEBER 2,798,437

RECIPROCATING PUMP

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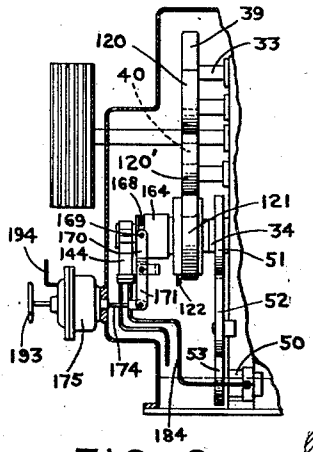


FIG. 6

FIG. 1

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RECIPROCATING PUMP

Filed Dec. 2, 1953 4 Sheets-Sheet 2

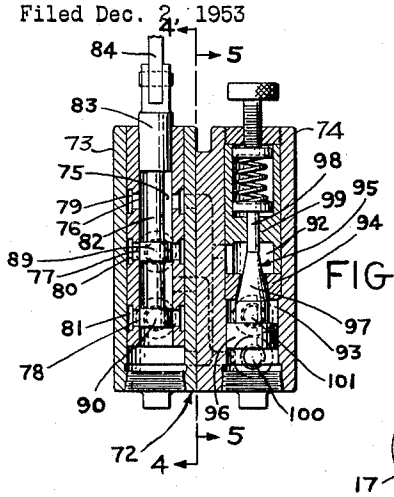


FIG. 3

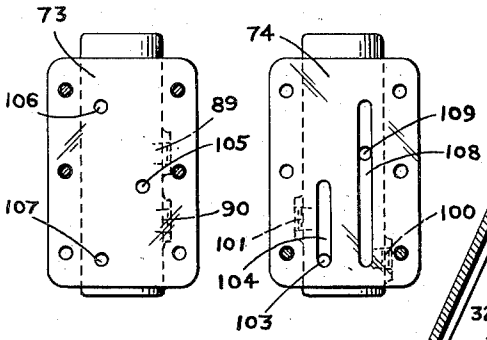


FIG. 4 FIG. 5

FIG. 2

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RECIPROCATING PUMP

Filed Dec. 2, 1953 4 Sheets-Sheet 3

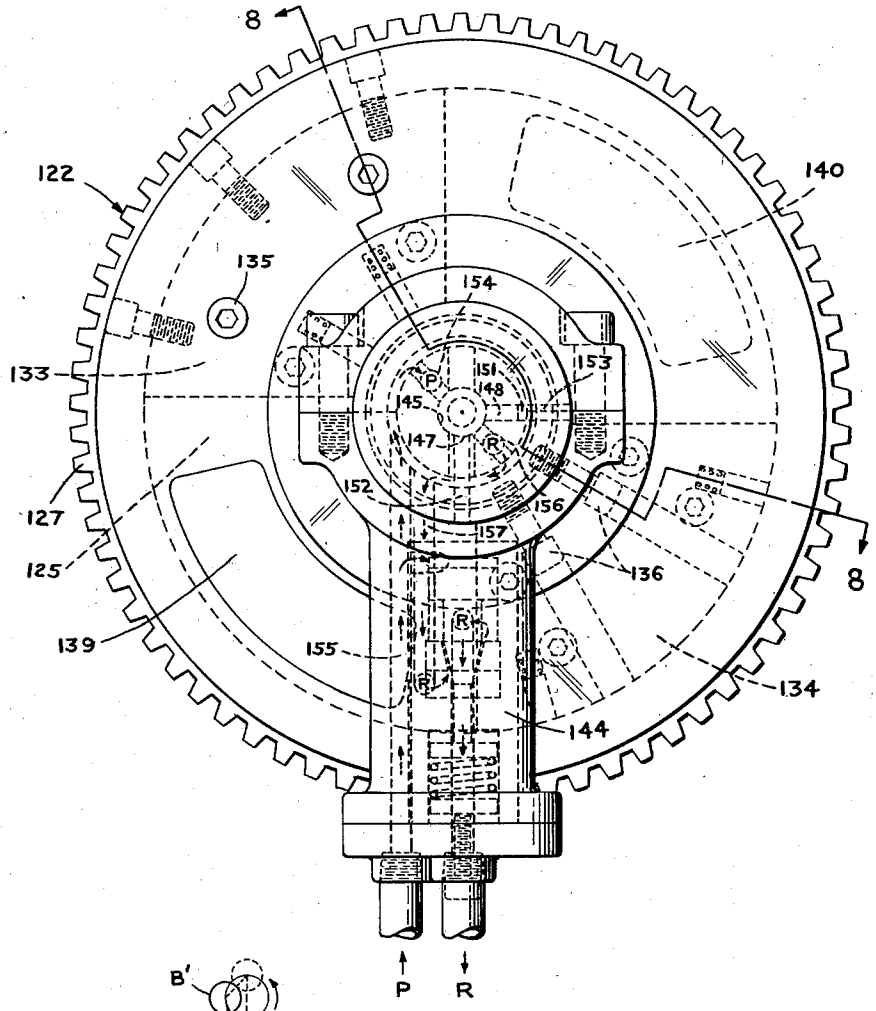


FIG. 7

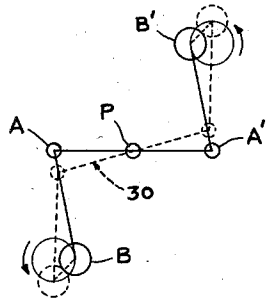


FIG. 10

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RECIPROCATING PUMP

Filed Dec. 2, 1953 4 Sheets-Sheet 4

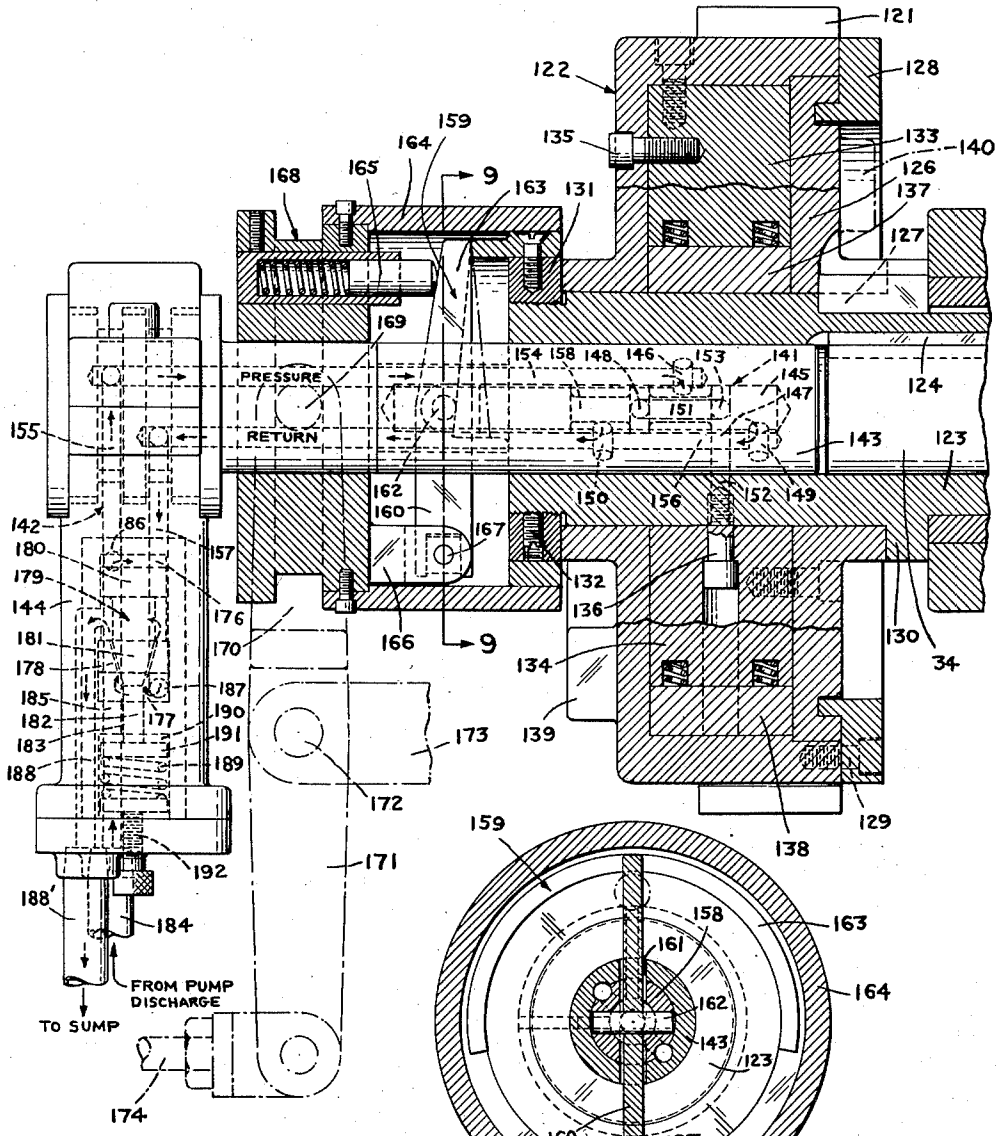


FIG. 8

FIG. 9

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RECIPROCATING PUMP

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Application December 2, 1953, Serial No. 395,673

11 Claims. (Cl. 103—38)

This invention relates generally to reciprocating pumps and more particularly to a variable capacity, constant speed pump having means to alter the length of the axial component of motion of the pump plunger whereby the operation of the pump may be varied from zero to full capacity.

In reciprocating pumps driven by constant speed motors in which the axial movement of the crossheads, and hence the output of the plungers connected thereto are varied by a lever means connected between the crossheads and spaced axially rotatable shafts, variations being produced by variations in the relative position of one of the lever connections on one of the crankshafts with respect to the other, such as is shown in Pat. No. 1,682,570 to Holveck, it has been found that if the shafts are disposed so that the effect of the respective connecting arms of the levers distorting the simple harmonic motion of the respective shafts to which they are connected does not cancel itself out in the unphased or unsynchronized position, i. e., when it is desired to produce minimal axial motion of the crosshead, that it is impossible to reduce the axial movement to absolute zero and hence impossible to secure with this type of connection the desired variation from absolute zero to full capacity operation of the pump.

The present invention covers an improved structure for meeting this problem in which lever means connected to the crossheads in the power end are provided with oppositely extending connecting arms coacting with a pair of spaced crankshafts and means for rotating at least one of the said crankshafts to vary the position of the lever arms connected thereto relative to each other so that the length of axial travel of the crosshead may be changed from absolute zero to maximum movement, whereby the pump operation will likewise be varied from absolute zero to full capacity.

Accordingly, it is an object of the present invention to provide a constant speed pump having reciprocating fluid displacement pump means in which the capacity of the pump may be varied from zero to full capacity as a function of the variation in the means connected between the rotary driving means thereof and the reciprocating fluid displacement elements.

It is another object of the present invention to provide a control for automatically or manually varying the lever means to produce the desire variation in the pump from zero to full capacity.

With this and other objects in view, as may appear from the accompanying specification, the invention consists of various features of construction and combination of parts, which will be first described in connection with the accompanying drawings, showing a reciprocating pump of a preferred form embodying the invention, and the features forming the invention will be specifically pointed out in the claims.

In the drawings:

Figure 1 is a side elevation partly in section showing one form of the invention.

Figure 2 is a vertical section taken on 2—2 of Figure 1.

Figure 3 shows a vertical section taken through the pilot valve in the hydraulic system.

Figure 4 is a view of one segment of the pilot valve taken along line 4—4 of Figure 3.

Figure 5 is a view of the other segment of the pilot valve taken along 5—5 of Figure 3.

Figure 6 is a diagrammatic sketch showing the position of another form of the invention with respect to the driving means.

Figure 7 is an end view showing the other form of the invention.

Figure 8 is a side elevation partly in section taken on line 8—8 of Figure 7.

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

Figure 10 is a geometric illustration of one of the Z lever means in the unsynchronized position.

Referring more particularly to the drawings, 1 represents a vertical type reciprocating power pump, it being understood that while the invention is illustrated on a vertical type pump that it may be applied to horizontal or other type pumps without departing from the spirit of the invention.

Thus, Figures 1 and 2 show the pump 1 having a pump frame 2 upon which is mounted a liquid cylinder block 3 by means of suitable threaded members 4. The cylinder block 3 is provided with a plurality of cylinders or plunger chambers 5 arranged vertically in a straight line and spaced longitudinally along the cylinder block, only one cylinder or chamber 5 being illustrated, it being understood that the construction of the others will be clear to those skilled in the art. The plunger cylinders or chambers 5 each have plungers 6 which are slidably mounted in their respective cylinders and extend upwardly in the vertical axis of said cylinders, above the cylinder block 3. Bolted to the upper end of each of the plungers 6 is an upper crosshead 7, the reciprocation of which as hereinafter described imparts reciprocatory motion to the respective plungers 6 in accordance with the predetermined timing arrangement for the particular pump, all of which is clearly shown in Figures 1 and 2 and is well known in the art of pumps.

Side rod assemblies generally designated 8 are associated with each upper crosshead 7 and are disposed so that the side rod assemblies parallel their respective vertically positioned pump plungers 6. Each side rod assembly includes elongated rod elements 9 and 10 which are bolted at their upper ends as at 11 and 12 to the associated upper crossheads 7. The lower ends of each of said rod elements 9 and 10 extend downwardly through the cylinder block 3 through suitable bores provided therein to positions inside the frame 2 and are attached to the main crossheads 13 by suitable threaded means 14 and 15 on each of said crossheads 13. The side rod assemblies are arranged with their vertical axes parallel to each other as is well known in the art and hence are not more fully described. All of the above is clearly shown in Figures 1 and 2 of the drawings.

In Figure 2, the cylinders 5 are further shown as having suction inlets 16 which are connected to a common inlet chamber 17 and discharge outlets 18 connected to a common discharge chamber 19. Each of the suction inlets 16 is provided with suction inlet valves 20 and 21 and the discharge outlets with discharge outlet valve 22. A source of fluid supply (not shown) is connected to the common inlet chamber 17 to supply fluid to the pump, and the discharge chamber is connected to a suitable discharge pipe (also not shown) for leading the discharge fluid to any desired location or use.

In operation, on the upward movement or upward stroke of the plunger 6, the valves 20 and 21 will open to allow fluid to flow to the cylinder or pump chamber 5. On the downward stroke or downward movement of the

plunger 6, the valves 20 and 21 close and the discharge outlet valve 22 opens to allow fluid to flow to the discharge chamber whence it passes to waste or to any desired use. When the downward stroke is completed, as the plunger starts up again, discharge outlet valve 22 closes and the cycle repeats itself.

Driving means

The lower or main crossheads 13 connected through the side rod assemblies 8 to their respective upper crossheads 7, are also connected to the upper ends of vertically disposed connecting rods 23 which are slidably mounted in suitable bearing means 24 and 24' disposed on two transverse brackets 25 and 25' having their ends in turn connected to two spaced support members 26 and 27, all of which is clearly shown in Figures 1 and 2 of the drawings.

The lower end of each connecting rod 23 is pivotally connected as at 28 to the medial portion of each of the transverse members 29 on substantially Z-shaped lever means each generally designated 30. The transverse members 29 are in turn pivotally connected at opposite ends to one of the respective ends of an upper arm 31 and a lower arm 32, the other ends of each of the upper arms remote from their connected ends being connected to a first crankshaft 33, and the other ends of each of the lower arms remote from their connected ends being connected to a second crankshaft 34.

The crankshafts 33 and 34 are longitudinally disposed in the housing or frame 2 substantially parallel and in spaced relation to each other, and are mounted for rotary movement by means of bearings at either end thereof provided as at 35, 36, 37 and 38 on the support members 26 and 27.

The crankshafts are rotated in the same direction through suitable gearing elements. Thus, a first driven gear 39 fixedly connected to one end of the first crankshaft 33 is in mesh with the main drive gear 40. The main drive gear 40 is fixedly mounted on and rotatable with the main drive shaft 41 which extends outwardly of the frame 2 to receive a pulley element 42 thereon. The pulley element 42 is connected through suitable belt element 43 to a prime mover (not shown) of any suitable type such as a constant speed electric motor. It will be understood that while this type of belt drive is shown, that any other suitable type of drive or prime mover might be utilized for this purpose without departing from the spirit of the invention. The main drive gear 40 also engages a first intermediate gear 44 which is fixedly connected and rotatable with one of the beveled gears 45 of a differential stroke-changing assembly generally designated 46. The beveled gear 47 opposite the said beveled gear 45 on the differential stroke-changing assembly 46 is in turn connected to a second intermediate gear 48. The intermediate 48 meshes with a driven gear 49 keyed to the outer end of the second crankshaft 34, all of which is clearly shown in Figures 1 and 2 of the drawings.

Thus when the prime mover (not shown) is started, the belt 43 causes the pulley 42 and hence the main drive shaft and main drive gear 41 and 40 to rotate. The main drive gear 40 will thus directly drive the first driven gear 39 and its crankshaft 33 and indirectly through the first intermediate gear 44, differential stroke-changing assembly 46, and second intermediate gear 48, the second driven gear 49 and its respective crankshaft 34.

A gear pump 50 or other suitable pump will be continuously driven simultaneously therewith through a gear train composed of gears 51, 52 and 53, gear member 51 being fixed connected to and rotatable with the crankshaft 34 and 53 connected to the gear pump 50 and receiving its rotary motion through the idler gear 52 mounted on a suitable bracket on the support means 27. The gear pump will of course be in continuous operation as long as the crankshaft 34 is rotated, and is provided with a bypass to prevent overloading the pump, which gear pumps are well known in the art and hence not more fully shown and described. The gear pump acts to pump fluid from the sump 54 located in the frame 2 of the pump.

As the crankshafts 33 and 34 are rotated, the respective positions of the arms 31 and 32 of the Z-shaped levers become very important, for as the arms are raised and lowered by the rotation of the crankshaft, they will in turn raise and lower the respective ends of the transverse members 29 of the respective levers to which they are connected. Where the upward and downward movement of the respective upper and lower arms 31 and 32 are synchronized; that is, as the ends of the respective transverse levers connected to the upper arms move up, the ends of the transverse levers connected to the lower arms also move up, the upward movement is at a maximum and the plungers in turn are moved through the respective crossheads and side rod assemblies a maximum axial amount. However, if one or the other of the crankshafts 33 and 34 are so rotated that either the lower arm or the upper arm is disposed to a partially or a wholly unsynchronized position, the degree of upward movement of the transverse member 29 of each of the Z-shaped levers can be regulated until there will be absolutely no upward movement thereof in the wholly unsynchronized position, and the total effect will be that each of the transverse members 29 will seesaw back and forth about the pivot 28, the upper arm and lower arm in the unsynchronized position working in opposite directions.

In Figure 10, the unsynchronized position is geometrically illustrated for one of the three levers 30 to show that the respective upper and lower arms thereof bear such relationship to each other and to the point P connected to the respective crossheads that the point P can be positioned at zero axial movement. This is accomplished when points A and A' and points B and B' reach the same peak velocity at the same relative point of rotation of the respective crankshafts 33 and 34 when these crankshafts are disposed on opposite sides of the transverse lever 29 of the Z lever 30.

Means for regulating the position of one of the lever arms

In the present form of the invention illustrated herein, means are shown for varying one of the lever arms. It will be understood that while this means shows the lower lever arm being regulated, that the same result could be secured by varying the position of the upper lever arm, without departing from the spirit of the present invention.

The regulation of the position of the lower arm connected to the crankshaft 34 to vary its movement with respect to that of the upper arm is obtained by rotating the end thereof attached to the crankshaft. This rotation is about the axis of the shaft and is accomplished through the differential stroke-changing assembly 46.

Figures 1 and 2 show that the differential stroke-changing assembly 46 includes a stroke-changing shaft 55 which is mounted between the frame 2 and the support member 27 by means of bearings 56 and 57. The stroke-changing shaft 55 has a squared block-like section 58 in the central portion thereof and is disposed to extend outwardly of each of said bearings to receive at the end inside the frame, a quadrant gear 59 adapted to rotate the stroke-changing shaft through a predetermined arc of movement as hereinafter described and at the opposite end which extends through the sidewall of the frame 2 a stroke indicator to provide a visual aid 60 for determining the degree of movement of the stroke-changing shaft.

Medially disposed in the stroke-changing shaft 55 and extending through the block-like portion 58 transversely of the said stroke-changing shaft is an idler shaft 61 which mounts on either side of the stroke-changing shaft idler gears 62 and 63. The idler gears 62 and 63 mesh with the beveled gears 45 and 47. The beveled gears 45 and 47 and the respective first and second intermediate gears

44 and 48 connected to and rotatable therewith are both rotatably mounted in turn on the stroke-changing shaft 55 itself and are held in meshing engagement by the idler gears on one side and by the respective bearing structures 56 and 57 on the other. The stroke-changing shaft is moved simultaneously with the quadrant gear 59 which is rotated by a rack element 64. The rack element 64 is vertically disposed to slide in a bearing means 65 connected to the support 27 by a suitable bracket 66 so that the teeth of the rack element are held in engagement with the gear teeth of the quadrant gear 59.

The movement of the rack is illustrated as being controlled hydraulically, it being understood that manual lever operating means or other type control could be used without departing from the spirit of the invention.

Thus the rack 64 is connected to the piston rod 67 continuous with a piston 68 which is slidably mounted for reciprocatory movement in a double-acting cylinder 69. The double-acting cylinder 69 is provided with spaced inlet and outlet conduits 70 and 71 which act to lead pressure fluid towards and away from said double acting cylinder 69, in response to the signals of a combined pilot and back pressure valve 72, shown in Figures 3, 4 and 5 of the drawings, which receives the pressure fluid directly from the gear pump 50, as hereinafter described.

Thus, Figure 3 shows the power and back pressure valve 72 as a substantially rectangular block-like element comprising a first section 73 and a second section 74.

The first section 73 is substantially similar to other type sliding valves and accordingly includes an elongated valve chamber 75 having spaced transversely disposed ports 76, 77 and 78 which open into the annular passageways 79, 80 and 81. The ports 77 and 78 will be opened and closed by a slide valve element 82 having an elongated valve stem 83 which extends outwardly of the valve chamber 75 which pivotally connects to an operating arm 84 linked on one side through linkage elements 85 and 86 to a manual-automatic control valve 87, such as a Mason-Neiland type valve which is easily purchasable on the open market, and on the other end through a linkage element 88 to the quadrant gear 59. Communicating with the annular passageways 80 and 81 are openings 89 and 90 which connect to the inlet and outlet conduits 70 and 71 respectively of the double-acting cylinder 69. The pressure fluid will be led from one or the other of these openings through its respective conduit 70 or 71, as the sliding valve 82 will signal by movement along the axis of the elongated valve chamber as hereinafter described. The respective inlet and outlet conduit 70 or 71 not leading through to the cylinder will act to return the same through one or the other of the said openings to the elongated valve chamber 75.

The second section 74 acts as a back pressure regulating valve to prevent the hydraulic fluid from acting too quickly in the double-acting cylinder 69. It is interposed between the discharge conduit 91 of the pump 50 and the first section, above described, of the pilot and back pressure valve generally designated 72. Thus the second section includes a return chamber 92 and a balancing chamber 93 which are separated by a valve seat 94. A combination valve and back pressure regulating member 95 having a piston-like end 96 continuous with a conical-shaped body portion 97 and a valve stem 98 is slidably mounted, the valve stem being disposed in a valve guide 99 and the conical-shaped body portion 97 so positioned that it engages the valve seat from the balancing chamber side in which the piston-like element 96 is slidably disposed. The balancing chamber 93 communicates by means of an opening 100 with the fluid pressure conduit 91 of the continuously acting gear pump 50 and the return chamber 92 communicates with the sump through the opening 101 which is connected to an outlet pipe 102 which returns pressure fluid to the sump directly.

The pressure fluid entering through opening 100 in the balancing chamber also communicates with the elongated chamber 75 of the first section through an outlet port 103 which opens into an elongated passage 104 in the second section. The elongated passage 104 in turn communicates with an inlet port 105 for the elongated valve chamber 75. The elongated valve chamber 75 communicates with the return chamber through its ports 106 and 107 which communicate with a second elongated passageway 108 in the second section having a return port 109 opening into the return chamber 92.

Operation

In operation, when the driving means is placed into operation, the crankshafts 33 and 34 will be rotated, the gear pump 50 placed into continuous operation and the Z levers 30 will act to move the plunger element 6 depending on the relative position of the lower arms 32 all as above described.

The pilot and back pressure valve which signals changes to the double-acting cylinder 69, to move the lower arm 32 for changing its position relative to the axis of the crankshaft 34 is actuated either manually by turning the handle 110 or automatically through the action of a fluid in the conduit 111 whereby the linkage elements 85 and 86 act to move the operating lever 84 to change the position of the sliding valve 82 connected thereto thus opening one or the other of the transverse ports 77 or 78.

Pressure fluid which is pumped by the gear pump 50 through the fluid pressure conduit 91 to the balancing chamber 93 will pass from the balancing chamber 93 through the outlet port 103 into passageway 104 and thence to the elongated valve chamber 75 through the inlet port 105. The pressure fluid passes through whichever of the transverse ports 77 or 78 are open thence to the respective annular passages 80 or 81 and openings 89 or 90 through the inlet and return conduits 70 or 71 to the double-acting cylinder 69.

Pressure fluid acts on one side of the piston 68 to move it either upwardly or downwardly. Excess fluid in the double-acting cylinder 69 being returned through the inlet and return conduit 70 or 71 which is not admitting the pressure fluid to the double-acting cylinder 69.

As the piston is moved the piston rod 67 and the rack element 64 integral and connected therewith are moved simultaneously. The rack rotates the quadrant gear 59 which simultaneously moves the stroke changing shaft 55 and the linkage arm 88. The linkage arm 88 re-positions the sliding valve 82 so that it closes the respective ports 77 and 78. The arcuate movement of the stroke changing shaft also rotates the transverse shaft 61, and idler gears 62 and 63 in equivalent amount. By reason of the braking friction of the engaging drive gears 40, 39 and 44, the first beveled gear remains fixed while the second beveled gear 47 opposite thereto will be rotated the equivalent amount of arcuate movement. Thus the intermediate gear 48 fixedly connected to the second beveled gear 47 and the second driven gear 49 will also be rotated in equivalent amount. Since the second driven gear 49 is connected to and movable with the second crankshaft 34 the crankshaft will be rotated on its axis whereby the axial position of the lower arms will be changed. Since the relative upward and downward movement of the arms of the Z levers are functions of their axial positions about the respective crankshafts 33 and 34, it is believed clear that the degree of upward and downward movement of the transverse element of the Z-shaped levers is also controlled. Since these transverse elements of the Z-shaped levers 30 act to drive the respective plungers 23, as above described, the axial movement of the plungers and thus the capacity of the pump is also controlled.

Modified form of the invention

In the modified form of the invention, the position of the lower crankshaft is altered by a hydraulically actuated assembly as shown in Figures 6, 7, 8 and 9. This hydraulically actuated assembly acts to replace the dif-

ferential stroke changing assembly shown in the preferred form of the invention. The change in the construction from the mechanical to the hydraulic means for changing the lower crankshaft will of course require some changes in the driving gear train as is diagrammatically illustrated in Figure 6 of the invention. The remaining structure and parts will otherwise be identical with that above described.

Thus in Figure 6 the main drive gear **40** engages and drives the first driven gear **39** fixedly connected to the first crankshaft **33**. The main drive gear **40** simultaneously meshes with and drives two idler gears **120** and **120'**, which in turn engages the spur gear **121** disposed on the outside of the hydraulically actuated stroke changing assembly generally designated **122** and hereinafter more fully described. The hydraulically actuated stroke changing assembly **122** is connected to and adapted to rotate and actually re-position the second crankshaft **34**. As in the preferred form of the invention the gear pump **50** is driven by the respective gear trains **51**, **52** and **53**, the gear **51** being connected to and rotatable with the crankshaft **34** and conveying its rotatory power transmission through the idler gear **52** to the gear **53** which drives the pump **50** whenever the crankshaft is in operation.

Hydraulically actuated stroke changing assembly

The hydraulically actuated stroke changing assembly **122** is mounted about one end of the second crankshaft **34**, and is adapted to rotate therewith through a coupling connector **123** keyed as at **124** to the said crankshaft **34**. The coupling connector **123** has the spur gear **121** rotatably mounted thereon, the spur gear **121** being constructed with a solid hub portion which forms a fluid chamber **125** when closed by a sealing collar **126** keyed as at **127** to the coupling connector **123**. The sealing collar **126** is held from outward movement during operation by an annular locking ring **128** which is connected by threaded means **129** to the spur gear **121**. An annular flange **130** medially disposed on the coupling connector **123** and a combined locking and cam actuating member **131** threaded adjacent the outer end of the coupling connector **123**, will act to hold the above described assembly in axial position on the coupling connector. A set screw **132** acts to lock the member **131** to the coupling connector **123** so that it will be rotated therewith, all of which is clearly shown in Figures 6 and 7 of the drawings.

The second crankshaft **34** keyed to the coupling connector **123** will be rotated about its axial line when the hydraulic stroke changing assembly **122** is actuated so that the coupling connector **123** is moved relative to the spur gear **121**. Since the spur gear **121** will be held in fixed relationship by reason of the braking action of the remaining driving gears the movement conveyed will be to the coupling connector connected to the second crankshaft **34**. This is accomplished by the action of hydraulic fluid on two segment elements **133** and **134** which are disposed in the hydraulic fluid chamber **125** in substantially opposed relation about the axis of the shaft **34**.

As is shown in Figures 7 and 8 segment element **133** is fixedly connected by means of threaded elements **135** to the spur gear **121**, while segment element **134** is fixedly connected to the coupling connector **123**, also by a threaded element **136**. Spring actuated sealing elements **137** and **138** are provided on the respective segments to prevent leakage of fluid during rotation of the hydraulic assemblies.

The segments occupy only a portion of the fluid chamber **125**, the remaining portion of the fluid chamber **125** being at all times full of hydraulic fluid. Balancing weights **139** and **140** are added to the spur gear and sealing collar **126** to counterbalance the weight of the respective segments. All of the above is clearly shown in Figure 7 of the drawings.

The movement of the coupling connector **123** relative to the spur gear **121** will be accomplished by actuating the movable segment **134** through pressure fluid which can be admitted into one or the other side of this segment and simultaneously allowing the excess fluid from the side opposite to that in which the pressure fluid is admitted to drain back to the sump by means of a pilot valve generally designated **141** and a back pressure valve generally designated **142**.

Pilot valve

The pilot valve **141** is disposed in the axial line of a shaft **143** connected to and rotatable with the coupling connector **123** in the axial line of the second crankshaft **34** so that one end thereof is substantially adjacent the end of the crankshaft **34** and the other end extends outwardly of the coupling connector **123** so that it is disposed to rotate in a collar assembly **144** provided in the frame **2** of the pump. The pilot valve **141** includes an elongated axial valve chamber **145**. The elongated valve chamber **145** is provided with a pressure fluid inlet port **146**, pressure fluid outlet ports **147** and **148** and return ports **149** and **150** which are disposed transversely to the elongated valve chamber **145**. The pressure fluid outlet port **147** communicates through a passageway **151** with a first fluid inlet and return passageway **152** opening into the hydraulic fluid chamber **125**, and pressure fluid outlet port **148** communicates with a second pressure fluid inlet and return passageway **153** opening into the hydraulic chamber **125**. The pressure fluid inlet and return passage **152** is disposed on one side of segment **134** and the inlet and return passage **153** is disposed on the opposite side of the segment **134**, all of the above being clearly shown in Figure 7 of the drawings.

The pressure fluid inlet port **146** communicates with a longitudinal passage **154** extending parallel to the axis of the rotatable shaft **143** so that pressure fluid may be fed thereto through a communicating passage **155** disposed in the collar support which takes its inlet at the back pressure control generally designated **142** also disposed in the collar support as is hereinafter described. Similarly the pressure fluid return ports **149** and **150** communicate with a longitudinal return passage **156** also disposed parallel to the axis of the shaft **143** and which also communicates with a connecting passage **157** in the collar support also having its inlet in the above mentioned back pressure control, in the collar support.

To control the flow of pressure fluid towards and away from the hydraulic pressure fluid chamber **145**, a slide valve **158** is slidably disposed in the elongated valve chamber **145**, so that when it is moved inwardly and outwardly towards or away from the crankshaft end of the shaft **143** it will open and close either one or the other of the respective pressure outlet ports **147** and **148**. The slide valve **158** is actuated through a cam follower and lever member **159**. As is shown in Figure 9 of the drawings, the cam follower and lever member **159** includes a vertical member **160** which extends through a slot **161** in the shaft **143** for pivotal contact as at **162** with the outer end of the slide valve **158**. Attached to the upper end of the vertical member **160** is an arcuate cam follower arm **163** which is in operative engagement and hence moved by the cam and locking means **131** on the end of the coupling connector **123**.

The lever is moved in response to the movement of a sliding collar **164** which has a fulcrum **165** in contact with the upper end of the cam follower and lever member and a link construction **166** pivotally connected as at **167** with the lower end of the vertical member **160**. The sliding collar **164** is provided with a groove **168** which receives and is engaged by a ball type element **169** in the arms **170** of a yoke linkage **171** which is pivoted as at **172** for movement about the end of a bracket **173**, the lower end of the yoke linkage being actuated by a suitable connecting rod linkage **174** to the manual-automatic type control valve **175**, of the type above described in the preferred form of the invention.

Back pressure control valve

The back pressure control valve **142** disposed in the collar support **144** is similar to that above described for the preferred form of the invention and accordingly includes a balancing chamber **176** and a return chamber **177** separated by a valve seating portion **178**. A combination valve and back pressure regulating member **179** is also provided having a piston-like end **180** continuous with a conical body portion **181** and a valve stem **182** which is slidably mounted so that the valve stem **182** slides in a valve guide **183**, the conical body portion **181** engages the valve seat **178** from the balancing chamber side in which the piston-like portion **180** is disposed.

Inlet pressure fluid is discharged from the continuously acting gear pump **50** through a connecting conduit **184** to a passageway **185** which has its outlet into the balancing chamber **176**, on the outer side of the piston-like enlargement **180**, so that pressure fluid can act thereon. The inlet **186** of the communicating passage **155** has its inlet in the balancing chamber also so that pressure fluid simultaneously passes to this passageway **155** and thence to the pilot valve through the communicating passage **154** above described.

Returning pressure fluid comes into the return chamber from the connecting passage **157** through its inlet **187**. It will act against the conical face of the valve member **179** and act to raise the same off the valve seat **178** and thence pass through into the balancing chamber and through the outlet of a connecting passage **188** connected to the discharge pipe **188'** leading to the sump of the pump **1**, all of which is clearly shown in Figures 7 and 8 of the drawings.

The back pressure on the returning pressure fluid is of course balanced somewhat by the inlet pressure fluid. However, additional manual regulating means is provided in the form of a spring element **189** which is mounted in a spring chamber **190** provided in the support collar **144**, which spring member is disposed between the flattened end **191** at the valve guide end of the combination valve and back pressure regulator **179** and the end of a thumb screw **192** which is threadable into and out of said spring chamber to increase or decrease the tension of the spring member **189** and hence the force acting against returning fluid in the return chamber will be reduced or increased proportionately along with the balancing action in the balancing chamber **176**.

Operation of modified form of the invention

In operation, when the driving means is placed into operation, the main driven gear **40** will rotate simultaneously the first drive gear **39** and first crankshaft **33** connected thereto and through idler gear **120**, spur gear **121** and the hydraulically actuated stroke changing assembly **122** integral therewith, the second crankshaft. Rotation of the second crankshaft will also place the gear pump **50** into operation as above described.

As the crankshafts **33** and **34** are rotated the Z levers **30** will act to move the plunger element **6** connected thereto depending upon the relative position of the lower arms **32** of the Z levers.

When it is desired to change the stroke of the plungers and hence the capacity of the pump, the pilot valve which signals the changes to the hydraulically actuated stroke changing assembly **122**, whereby the relative axial position of the second crankshaft **34** and hence the position of the lower arm **32** connected thereto is changed, is actuated either manually by turning the handle **193** or automatically through the action of a fluid in the conduit **194** in the control valve **175**. The manual-automatic control valve **175** will act through the connecting rod **174** to move the yoke member **171** and the sliding collar **164**. This causes the cam follower and lever member **160** to actuate the slide valve **158** in one or the other direction opening the pressure outlet ports **147** or **148**. Depending upon whether pressure fluid outlet ports **147** or **148** is opened by the slide valve **158**, pressure fluid passes from the passageway **154** through the pressure fluid inlet port **146** and through either ports **147** or **148** to its respective connecting inlet and outlet conduits **152** or **153** which open into the pressure fluid chamber **125** and the hub of the spur gear **121**, above described.

The entering pressure fluid will act uniformly against the segment elements **133** and **134**. However, the position of segment element **134** will remain relatively fixed by reason of the friction of the engaging drive gears. Hence, by differential pressure the force is exerted on the movable segment **134** which will rotate the connecting coupling **123** and hence the crankshaft **34** connected thereto the desired amount. The movement of the crankshaft **34** will of course alter the axial position of the lower arm **32** connected thereto relative to the axis of the crankshaft.

As the segment **134** moves, the excess pressure fluid is returned through the connecting inlet and outlet conduit which is not delivering pressure fluid to the pressure fluid chamber **125**.

Returning pressure fluid flows into valve chamber **145** and thence through either pressure return ports **149** and **150** through the return pressure fluid passageway and return passageway **156** and connecting passageway **157** through the back pressure valve to the sump as above described.

The segment **134** will continue to turn as long as excess fluid is removed from the pressure fluid chamber **125**. However, simultaneously with the movement of the connector coupling **123**, the cam and locking element **131** will be actuated to move the cam follower portion **163** of the cam follower and lever member **160** to or fro as determined from the original movement of the said lever whereby the sliding of valve **158** will close the pressure outlet ports **147** or **148** preventing further fluid from passing to or returning from the said valve chamber **145** until the next signal is given to change the stroke of the plunger elements of the pump.

The effect of changing the stroke in the modified form of the invention is of course the same as described above in the first or preferred form of the invention.

It will be understood that the invention is not to be limited to the specific construction or arrangement of parts shown, but that they may be widely modified within the invention defined by the claims.

What is claimed is:

1. The combination in a variable capacity pump including a cylinder having a reciprocatable plunger slidably mounted therein of means for varying the movement thereof from absolute zero to full stroke including a linkage comprising a cross-bar pivotally connected to said plunger, a connecting rod pivotally connected to each end of the cross-bar, said connecting rods extending in opposite directions, parallel crankshafts mounted in said pump on opposite sides of said cross-bar and connected to the other ends of the connecting rod on the same side thereof, means operatively interconnecting said crankshafts, and said means including adjustable means to vary the relative timing of said crankshafts with respect to one another.

2. The combination in a variable capacity pump including a cylinder having a reciprocatable plunger slidably mounted therein of means for reciprocating said plunger and for carrying the movement therefrom from absolute zero to full stroke including a linkage comprising a cross-bar pivotally connected to said plunger, a connecting rod pivotally connected to each end of the cross-bar and extending in opposite directions, parallel crankshafts in said pump each positioned on opposite sides of the cross-bar and connected to the end of one of said connecting arms remote from the point of connection to said cross-bar, means operatively interconnecting said crankshafts, driving means connected to said means and said first-mentioned means including adjust-

able means disposed between said driving means and one of said crankshafts for varying the relative timing of said crankshafts with respect to one another.

3. The combination in a variable capacity pump including a cylinder having a reciprocatable plunger slidably mounted therein of means for reciprocating said plunger and for varying the movement therefrom from absolute zero to full-stroke including a linkage comprising a cross-bar pivotally connected to said plunger, a connecting rod pivotally connected to each end of the cross-bar and extending in opposite directions, parallel crankshafts in said pump each positioned on opposite sides of the cross-bar and connected to the end of one of said connecting arms remote from the point of connection to said cross-bar, means operatively interconnecting said crankshafts, driving means connected to said means, and said first-mentioned means including adjustable means to vary the relative timing of said crankshafts with respect to one another.

4. In a variable capacity pump as claimed in claim 3 wherein said adjustable means includes a stroke-changing shaft, a differential gear mounted on said stroke-changing shaft and adapted to be rotated thereby, said differential gear being operatively connected to the driving means for rotating said crankshafts and to one of said crankshafts to transmit rotary motion thereto, and means to rotate said stroke-changing shaft a predetermined arc about its axis.

5. In a variable capacity pump as claimed in claim 3 wherein said adjustable means includes a spur gear operatively connected to the driving means for rotating said crankshafts, said spur gear forming a pressure fluid chamber, a coupling connected to one of said crankshafts, segment elements disposed in said pressure fluid chamber, a segment element fixedly connected to said spur gear, a segment element fixedly connected to said coupling connector, and valve means to convey pressure fluid towards and away from said pressure fluid chamber whereby said segments will be moved arcuately relative to each other a predetermined amount.

6. The combination in a variable capacity pump including a cylinder having a reciprocatable piston slidably mounted therein of means for reciprocating said piston and for varying the movement thereof from absolute zero to full stroke including a linkage comprising a cross-bar pivotally connected to said piston, a connecting rod pivotally connected to each end of the cross-bar, said connecting rods extending in opposite directions, parallel crank shafts mounted in said pump on opposite sides of said cross-bar and connected to the other ends of the connecting rod on the same side, whereby rotation of one of said crankshafts will act to regulate the movement of said linkage to produce the desired variation in stroke of said plunger, means operatively interconnecting said crankshafts, driving means connected to said means, said first mentioned means including a stroke-changing shaft to vary the relative timing of said crankshafts with respect to one another, a differential gear mounted transversely on said stroke-changing shaft and adapted to be rotated thereby, said differential gear operatively connected to the driving means for rotating said crankshafts and to one of said crankshafts, and means to rotate said stroke-changing shaft a predetermined arc about its axis.

7. In a variable capacity pump as claimed in claim 6 wherein said last-mentioned means includes a quadrant gear connected to one end of said stroke-changing shaft and adapted to move said shaft through a predetermined arc about its axis, a double-acting cylinder, a slidable piston in said cylinder having a rack movable therewith, said rack adapted to engage and move said quadrant gear, and valve means to control the flow of pressure fluid towards and away from said double-acting cylinder whereby said quadrant gear will be moved a predetermined amount.

8. In a variable capacity pump as claimed in claim 7 wherein a control including an actuating arm is provided to signal the valve to an open position and lever means connected between said quadrant gear and said actuating arm to move said valve to a closed position after movement of said quadrant the desired distance.

9. The combination in a variable capacity pump including a cylinder having a reciprocatable plunger slidably mounted therein of means for reciprocating said plunger and for varying the movement thereof from absolute zero to full stroke including a linkage comprising a cross-bar pivotally connected to said plunger, a connecting rod pivotally connected to each end of the cross-bar, parallel crankshafts in said pump each positioned on opposite sides of the cross-bar and connected to the end of one of said connecting rods on the same side of said cross-bar, means operatively interconnecting said crankshafts, driving means connected to said means, said first mentioned means having adjustable means to vary the relative timing of said crankshafts with respect to one another, said adjustable means including a spur gear operatively connected to the driving means, said spur gear forming a pressure fluid chamber, a coupling connector connected to one of said crankshafts, segment elements disposed in said pressure fluid chamber, a segment element fixedly connected to said spur gear, a segment element fixedly connected to said coupling connector, and valve means including a back-pressure regulator to convey pressure fluid towards and away from said pressure fluid chamber whereby said segments will be moved arcuately relative to each other a predetermined amount and means for signalling the predetermined amount of arcuate movement desired between said segment elements.

10. In a variable capacity pump as claimed in claim 9 wherein said last mentioned means includes a control having a cam follower and lever arm to move said valve to an open position, and cam means connected to and movable with said coupling connector to coact with said cam follower and lever arm to move the valve to a closed position after the predetermined arcuate movement of said segments.

11. In a variable capacity pump as claimed in claim 9 wherein said stroke-changing shaft extends outwardly of the frame and includes an indicating member on said outer end of the stroke-changing shaft to indicate the distance of arcuate movement thereof.

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