

Feb. 11, 1969

A. F. ANDERSON

3,426,686

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Filed April 4, 1966

Sheet 1 of 5

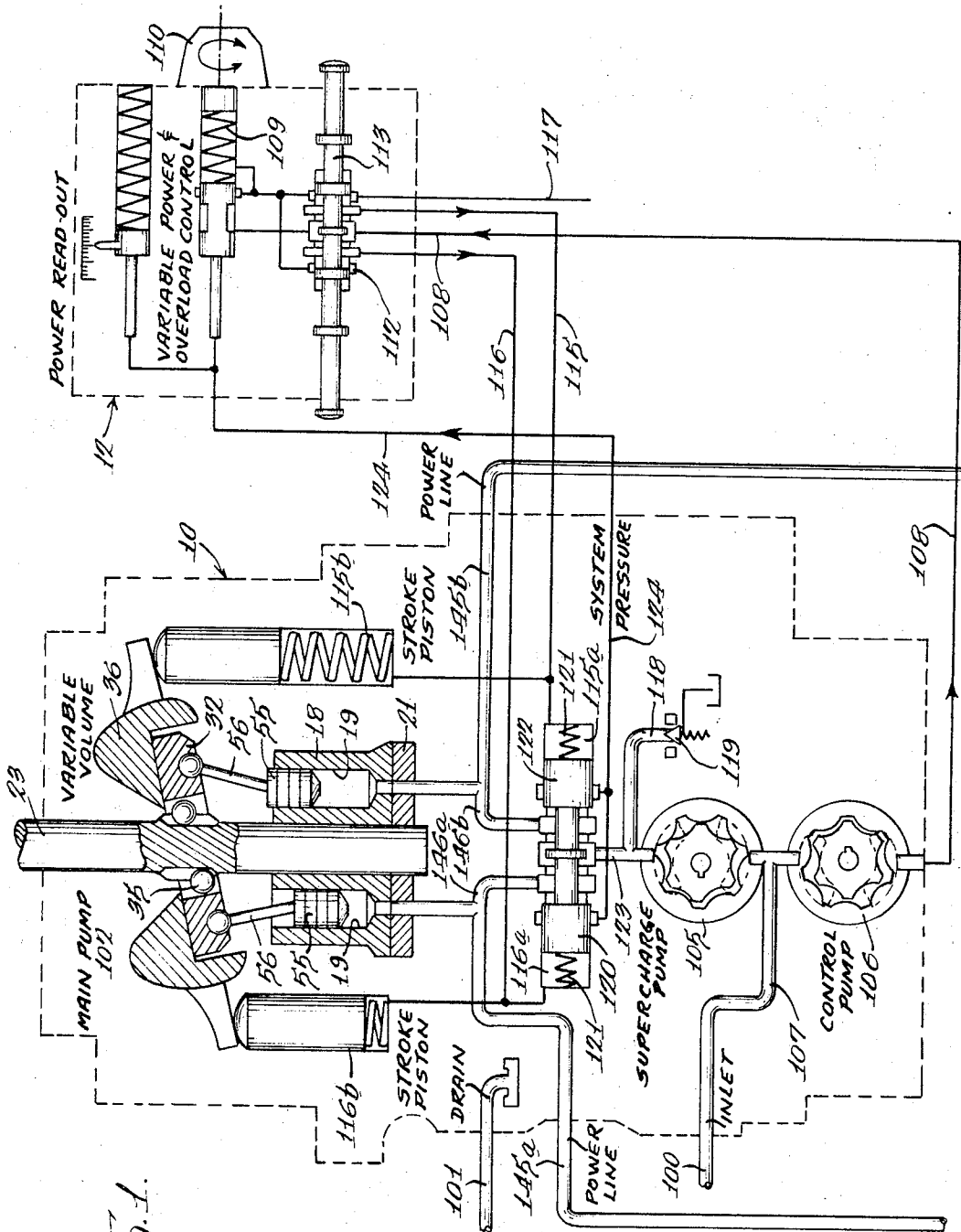


Fig. 1.

Inventor:

Arthur F. Anderson

By

Harry Parker, Jr., et al., Attorneys

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Feb. 11, 1969

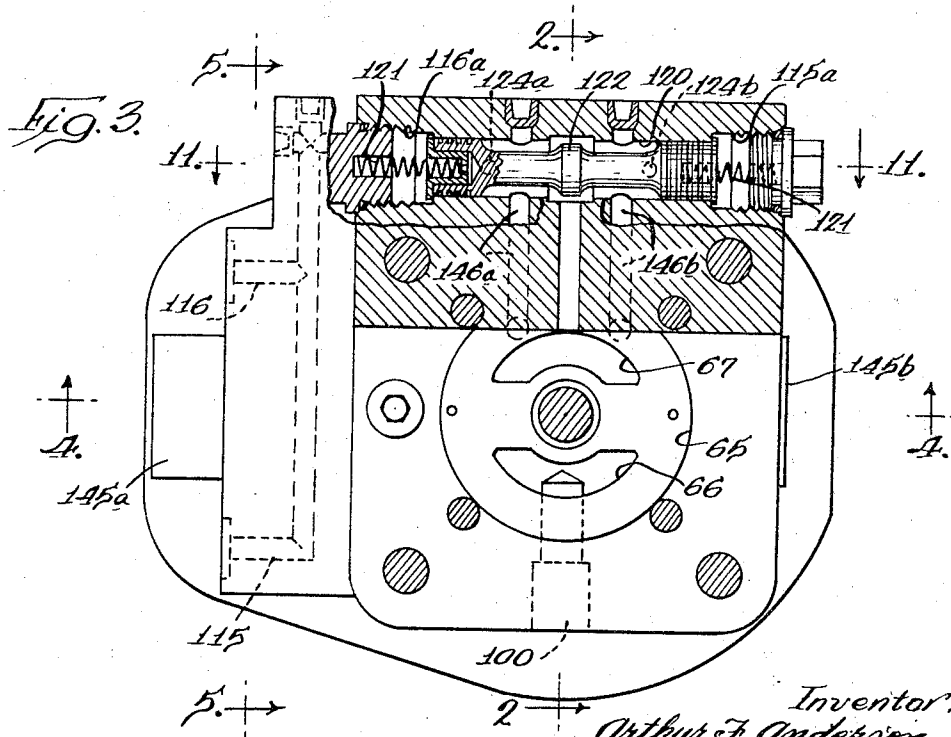
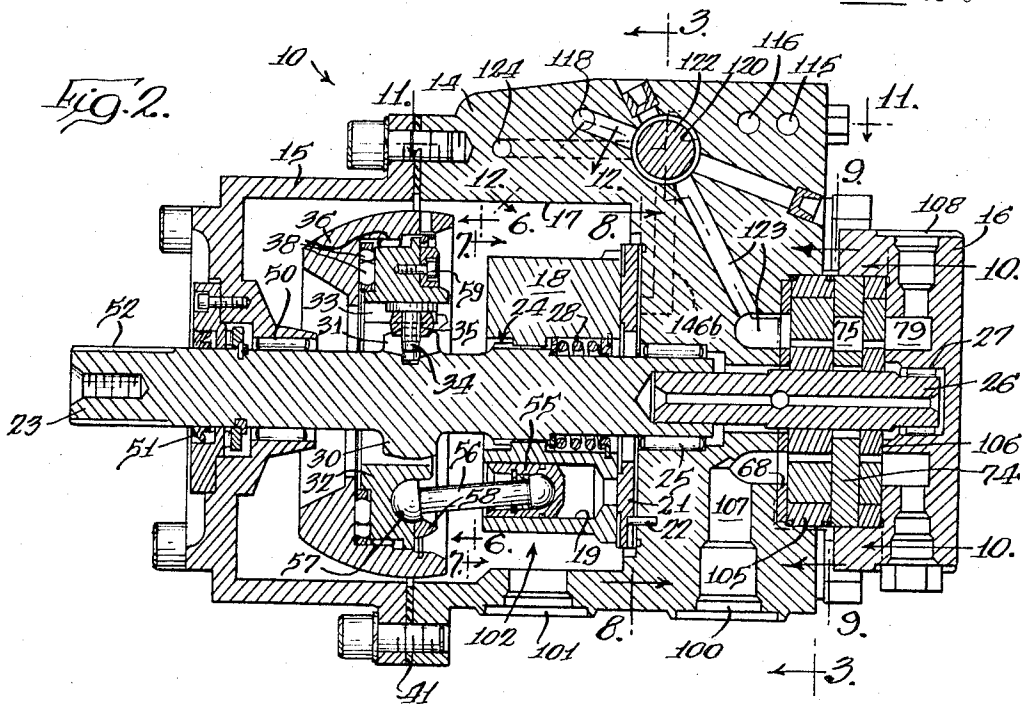
A. F. ANDERSON

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Inventor:
Arthur F. Anderson
By
J. Parker, Juettner & Cullinan
Attys

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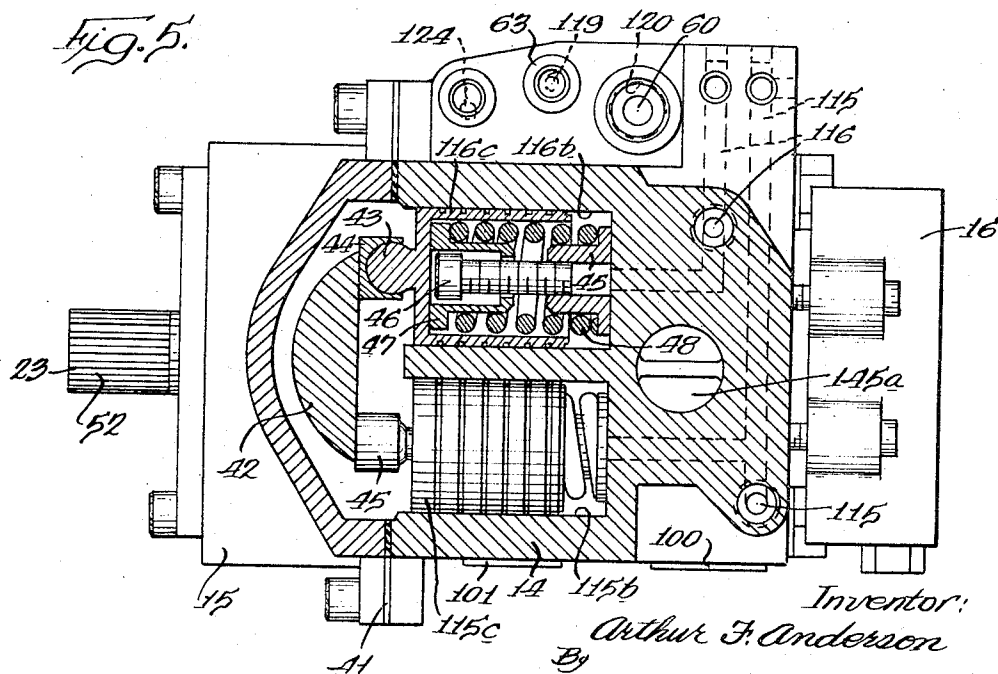
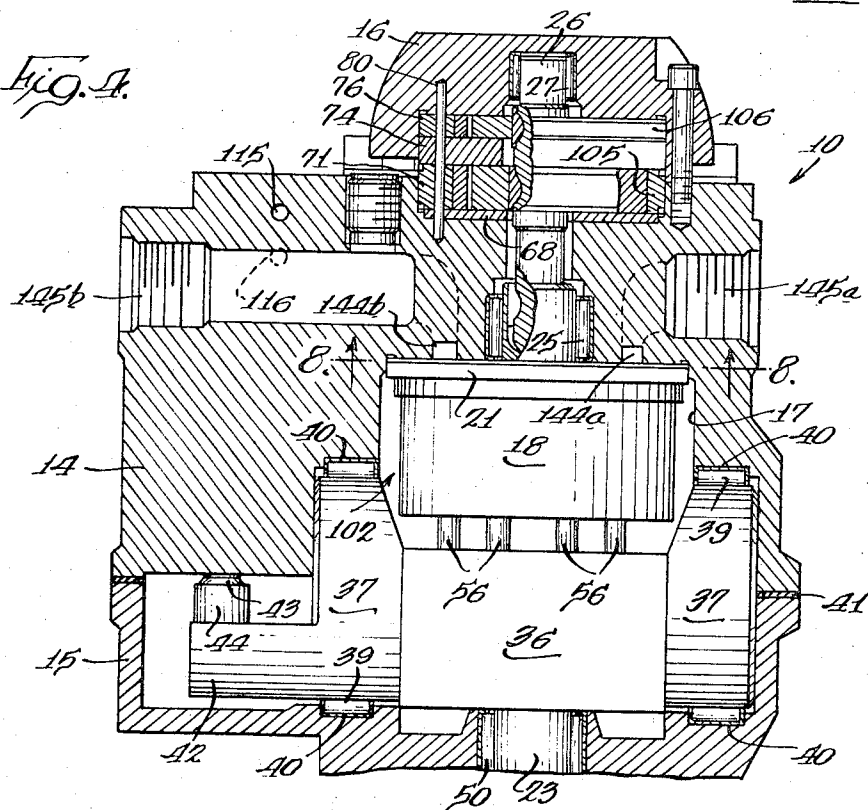
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Fig. 6.

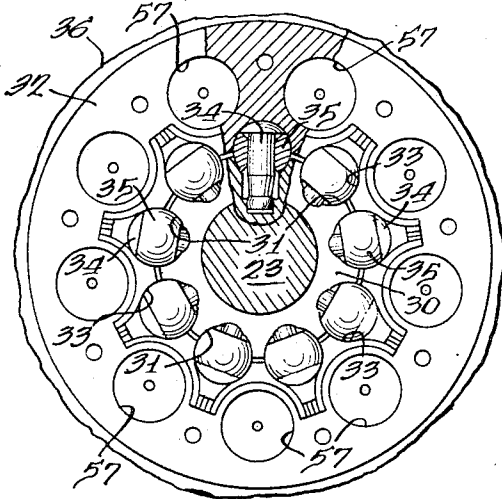


Fig. 7.

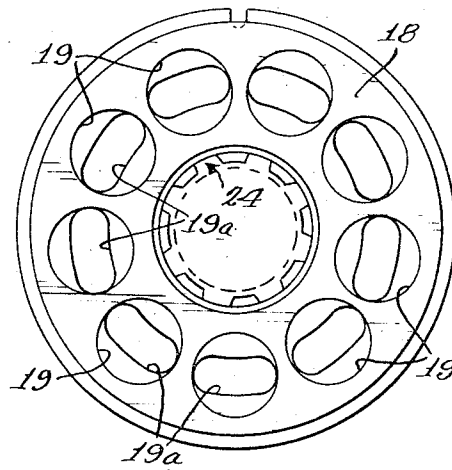


Fig. 8.

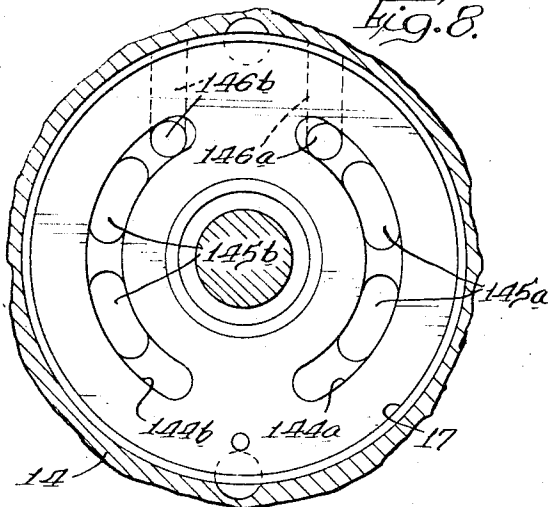


Fig. 9.

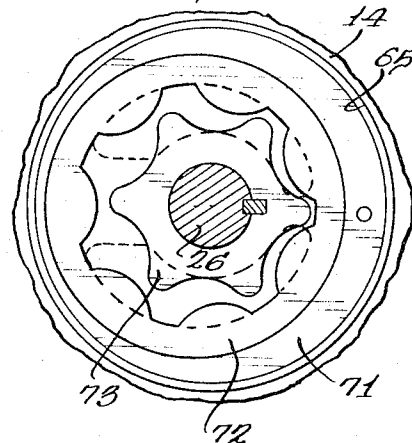
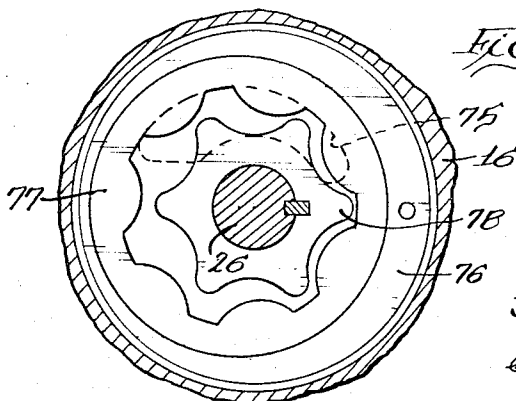


Fig. 10.



Inventor:
Arthur F. Anderson
By
Gary Parker, Juettner & Cullinan
Attys

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A. F. ANDERSON

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Fig. 11.

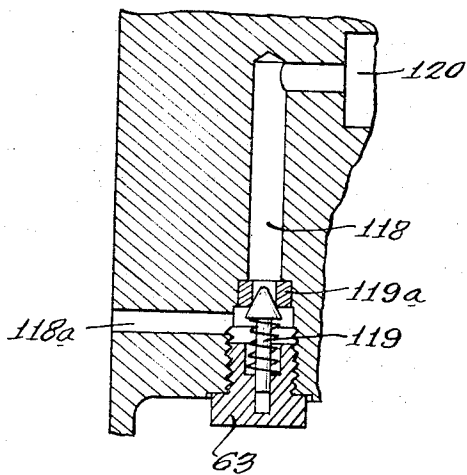
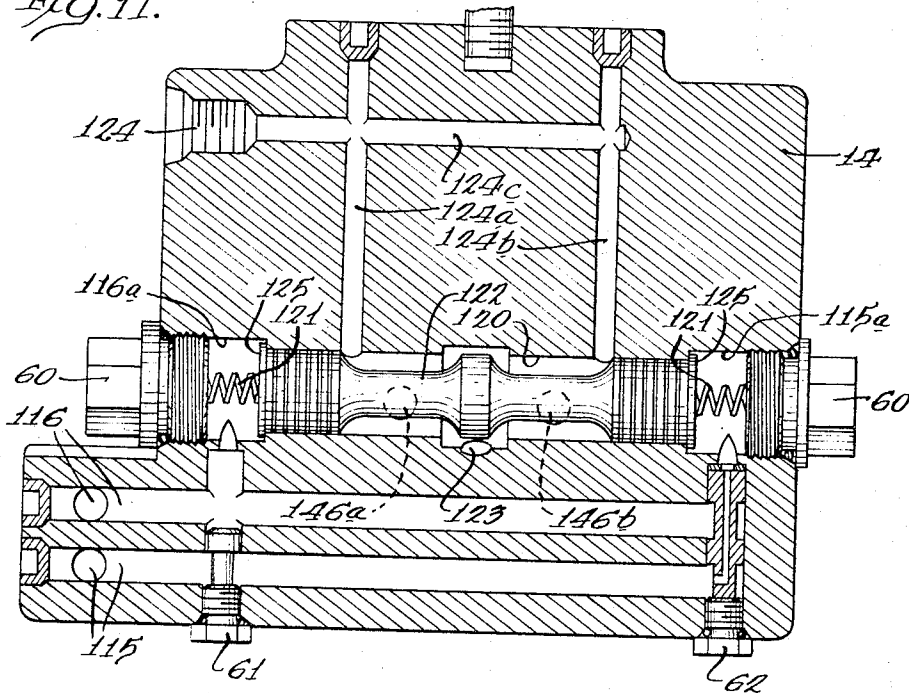


Fig. 12.

Inventor:
Arthur F. Anderson
By
Gary Parker, Justimer & Cullinan
Attys

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PUMP

Arthur F. Anderson, Elmhurst, Ill., assignor, by mesne assignments, to Ulrich Manufacturing Co., Roanoke, Ill., a corporation of Delaware

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U.S. Cl. 103—3

Int. Cl. F04b 23/10, 1/14; F04d 29/50

9 Claims

ABSTRACT OF THE DISCLOSURE

A variable displacement piston pump of the swash plate or tilt box type is hereby provided that is characterized by an improved, simplified and economical structural assembly, notably an in-line insertion of piston pump sub-assemblies and components into one open end of an enclosing housing without necessity for individual mounting of the sub-assemblies or components in or to the housing, and completion of the assembly by simple attachment of an end cap. A particular feature resides in the improvement wherein the housing and end cap are separated on a line co-planar with the pivot axis of the swash plate or tilt box and are provided with mating pairs of semi-circular recesses which together form two bearings or journals, and wherein the swash plate or tilt box has integral trunnions journaled in these bearings. This facilitates simple insertion of the swash plate into the housing and subsequent securement of the same by simple attachment of the cap without necessity for a separate mounting.

The assembly is further characterized by insertion into the end of the housing opposite said cap and onto a single drive shaft of a pair of compact rotary pumps, namely, a supercharger pump for pressure charging the inlet side of the piston pump and a control pump for controlling the direction and amount of fluid pumped by the piston pump.

A further feature resides in the provision of a manually adjustable overload control which automatically governs operation of the piston pump pursuant to the manual adjustment, said control sensing the output pressure of the piston pump and regulating as a function of said pressure the pressure of the fluid discharged by said control pump, thereby automatically to regulate the displacement and the output of the piston pump.

Variable displacement piston pumps of the character here include a rotary cylinder barrel which abuts a stationary valve face located at one end of the barrel. The barrel is provided with a plurality of cylinder bores which are arranged in a circle about the barrel axis and pistons are mounted for reciprocation in said cylinders. A drive flange rotated conjointly with but having universal movement relative to the barrel is connected by ball and socket joints to the ends of connecting rods which are connected by other ball and socket joints at their opposite ends to the pistons. A tilt box supports the drive flange and is adapted to be tilted by varying degrees relative to the barrel whereby to vary the angle between the drive flange and the barrel and thereby vary the stroke of the pistons and the volume of fluid delivered by the pump via inlet and outlet ports in said valve face.

The object of the present invention is provision of an improved pump of the character described, and particularly, the provision of a pump having a high capacity to size ratio, that is convenient and economical to construct, and reliable over a long service life.

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The objects and advantages of the invention will become apparent in the following detailed description.

Now, in order to acquaint those skilled in the art with the manner of making and using my improved pump, I shall describe, in connection with the accompanying drawings, the best mode presently contemplated by me for carrying out the invention.

In the drawings:

FIGURE 1 is a schematic diagram of the pump of the present invention and control means therefor;

FIGURE 2 is a vertical longitudinal section of the pump, the view being taken substantially on line 2—2 of FIGURE 3;

FIGURE 3 is a cross-sectional view of the pump taken substantially on line 3—3 of FIGURE 2;

FIGURE 4 is a horizontal longitudinal section taken substantially on line 4—4 of FIGURE 3;

FIGURE 5 is a vertical longitudinal section taken substantially on line 5—5 of FIGURE 3 showing means for variably tilting the tilt box and thus controlling the stroke of the pistons;

FIGURE 6 is a cross-sectional view taken substantially on line 6—6 of FIGURE 2 showing the piston drive flange and a constant velocity universal joint between said flange and the cylinder barrel drive shaft;

FIGURE 7 is a front elevation of the main pump cylinder block as the same would be viewed from line 7—7 of FIGURE 2, but with the pistons removed;

FIGURE 8 is a view taken substantially on line 8—8 of FIGURE 2, showing the porting of the main pump portion of my pump;

FIGURE 9 is a view taken substantially on line 9—9 of FIGURE 2 showing a supercharger portion of the pump;

FIGURE 10 is a view taken substantially on line 10—10 of FIGURE 2 showing a control pump portion of the pump;

FIGURE 11 is a horizontal longitudinal section taken on lines 11—11 of FIGURES 2 and 3; and

FIGURE 12 is a fragmentary sectional view taken on line 12—12 of FIGURE 2.

Referring first to FIGURE 1, I have depicted, schematically and diagrammatically, the preferred embodiment of my pump and control means therefor. The pump is indicated generally at 10 and the controller or regulator at 12; the main or hydraulic power system of the pump is depicted by pipes and/or passages, and the control circuit or system is indicated by relatively fine lines. The fluid supply for the entire system is maintained by a reservoir or the like (not shown) communicating with the remainder of the system by supply and drain lines 100 and 101 respectively.

The reservoir primarily supplies fluid to a main pump 102 which is driven by any suitable prime mover. In the preferred embodiment, a supercharger pump 105 and a control pump 106 are embodied in the structure 10 and are driven by the same prime mover as pump 102.

The control pump 106 draws fluid from the reservoir supply line 100 via passage 107 and pumps the same at a relatively low control pressure (e.g. 400 p.s.i.) via conduit 108 to a pressure regulator 109. The regulator 109 is manually adjustable, as by means of a handle or knob 110, thereby to cause increase or decrease in the control pressure and by virtue thereof to increase the main pump output, as will presently be described. The fluid at the regulated control pressure flows to a four-way reversing valve 112 including a reciprocable spool 113 having a

central neutral position, a forward position and a reverse position. In the neutral position, the valve ports are interconnected by the valve body and spool whereby the entire control system is at the same pressure and thus neutralized. In the forward position, the spool serves to connect line 108 to a forward control line 115 and a reverse control line 116 with a vent or drain line 117 returning to the reservoir. In its reverse position, the spool 113 reverses the connections effected in the forward position, i.e., connecting the line 108 to the reverse control line 116 and connecting the forward control line 115 to the drain line 117.

The valve 112 may be operated manually, and is operable independently of the pressure regulator 109. Assuming the valve 112 is in forward position, control fluid at a regulated or adjusted pressure is fed via line 108 to the forward control line 115. At the same time, the line 116 is vented to the reservoir. Fluid in line 115 is fed to a hydraulic actuator 115a for a four-way valve 120 and to a main pump direction controlling an output adjusting stroke cylinder 115b. The cylinder 115b operates to cause the main pump 102 to operate in one direction, i.e., to pump fluid in one direction, and also operates upon increase and decrease in the control pressure to increase and decrease the output of the pump 102.

The valve 120 includes a spool 122 centered in a neutral position by centering springs 121, and the same in said position includes ports interconnecting and serving to put the system all at the same pressure thereby to neutralize the system. Upon actuation by the actuator 115a, the valve is shifted to a forward position which will be described in detail hereinafter. Due to simultaneous actuation of the stroke cylinder 115b, the pump will in this position of the valve be operating to supply fluid under pressure via power line or conduit 145a to one or more reversible hydrostatic motors or a like load (not shown) to operate the same. At the same time, hydraulic fluid is returned from the motors or the like via conduit 145b which at this time is connected to the pump inlet, whereby fluid is circulated in essentially a closed loop from the pump 102 via line 145a to the load and then back to the pump via line 145b.

The conduit 145a is also coupled to a conduit 146a which leads back to the valve 120 and which at this time is coupled via the valve to a conduit 124 which leads to the pressure regulator 109, whereby full system pressure is brought to bear on the regulator to the extent that if system pressure exceeds a predetermined maximum the regulator will be opened or by-passed or vented, in known manners, to relieve or decrease control pressure, whereby the stroke cylinder 115b will be automatically adjusted to decrease the output of the main pump 102 and thereby afford an automatic safety against excessive system pressures.

The conduit 145b is similarly coupled to a conduit 146b which leads to the valve 120 and which at this time (forward position) is coupled by the valve to the outlet 123 of the supercharger 105 to afford an initially pressurized supply of fluid to the main pump 102. The output pressure of the supercharger is maintained at a suitable level (e.g., 50 p.s.i.) via a by-pass 118 and a relief valve 119 coupled to a drain.

When it is desired to reverse the direction of the power fluid, it is only necessary to operate the reversing valve 112 to its reverse position, whereupon control fluid is supplied via reverse line 116 to a hydraulic actuator 116a for the valve 120 and a second pump direction and stroke adjusting cylinder 116b. At the same time, the actuator 115a and cylinder 115b are vented to the reservoir via line 117, whereupon the actuator 116a may shift the valve 120 to reverse position and the cylinder 116b may take over control of the main pump. Fluid under pressure is then supplied from pump 102 via conduit 145b to the load, the fluid being returned to the pump via conduit 145a. At the same time, the valve 120 has been shifted

so that system pressure is transmitted to the regulator 109 via conduit 146b, the valve 120 and the conduit 124; and the conduit 146b is connected to the supercharger 105.

The main pump 102 is thus operable under the control of the pumps 105 and 106, the valve 120 and the controller or regulator 12, whereby to supply fluid under regulated pressure, in varying amounts and in opposite directions to any suitable load, such as one or more hydrostatic motors.

Referring now to FIGURES 2 to 12, the preferred physical structure of the pump 10 is illustrated as enclosed within a three-part housing of bolted assembly including a main pump housing 14 having an end cap 15, and an auxiliary pump housing 16. The housing 14 has a cylindrical bore 17 in one end thereof receiving a rotary cylinder barrel 18 which is provided therein with nine axially extending cylinder bores 19 arranged equidistantly in a circle concentric with an axial bore through the barrel. Confined between the bottom of the bore 17 and the inner end of the barrel 18 is an annular valve plate 21 which is retained stationary relative to the housing by a pin 22 secured to the housing and extending into a slot or recess in the valve plate.

Extending axially through the barrel and plate is a drive shaft 23, aligned portions of the shaft and the barrel being complementarily splined, as indicated at 24, whereby the two are interconnected for joint rotation. The shaft extends inwardly beyond the valve plate 21 into an axial bore in the housing 14, where it is journaled on bearings 25 and united with a shaft extension 26. The extension 26 projects through the main housing 14 and into the auxiliary housing 16 to drive the auxiliary pumps 105 and 106 as will presently appear. At its end, the extension is journaled on bearings 27 supported in a bore in the housing 16. A compression spring 28 is confined between opposed abutments on the shaft 23 and the barrel 18 whereby to bias the barrel into engagement with the valve plate.

Outwardly of the barrel 18, and preferably in the plane of the juncture between the housing 14 and the end cap 15, the shaft 23 is provided with a toothed portion 30 comprising part of a constant velocity universal joint which is illustrated in FIGURES 2 and 6. As shown, the portion 30 of shaft 23 is provided with nine equally spaced axially extending slots 31, the same number as there are cylinders in the barrel 18. Each slot is comprised of a semi-cylindrical outer portion, a radially inner portion of any desired configuration, and a radially inwardly extending recess or socket substantially centrally of said inner portion.

Encircling the toothed or slotted portion 30 of the shaft is a drive flange 32, the radially inner surface of which is provided with axially extending semi-cylindrical slots 33 of the same number as and respectively aligned with the slots 31. Mounted within each aligned pair of slots 31-33 is a constant velocity power transmission assembly comprised in this case of a stem or stem pilot 34 and a ball element 35. Each stem 34 comprises a radially extending rod having a spherical inner end fitting within the socket part of the respective slot 31 and forming therewith a ball and socket joint. At its outer end, each stem is provided with an elongated parti-cylindrical head conformably and slidably received in the respective slot 33. Each ball element 35 comprises a hollow spherical segment journaled on the rod portion of the respective stem immediately below the head thereof, the spherical surfaces of the ball element together with the cylindrical surface of the head defining, in effect, a ball substantially completely filling the cross sectional area of the respective pair of slots 31-33 (see FIGURE 6). In use, as will presently appear, the stems 34 guide the ball elements 35 in such manner that as the flange 32 is tilted relative to the shaft the balls are guided to and retained in substantially the homokinetic plane, i.e., the

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plane bisecting the angle between the axis of the shaft and the plane of the flange, whereby to provide a constant velocity universal joint therebetween.

For purposes of controlling the tilting movement of the drive flange, the same is journaled in or on a tilt box 36 comprising an annular bearing portion receiving the joint 30-35 and a pair of radially oppositely extending trunnions 37. Preferably, anti-friction bearings 38 are provided between the drive flange and the tilt box to assure free rotation of the flange. The trunnions 37 are journaled by bearings 39 in respective cylindrical bores formed by complementary semi-cylindrical recesses 40 in the mating faces of the main housing 14 and the end cap 15. By virtue of this construction, i.e., the housing 14 and the end cap 16 and location of the universal joint in the plane of the juncture therebetween, the tilt box is very conveniently mounted in the housing and the assembly of the trunnions and the two bearing parts is readily and easily effected. Moreover, this construction accommodates fabrication of the trunnion supports or bearings entirely interiorly of the housing assembly and interiorly of the end cap gasket 41, whereby all problems of hydraulic leakage and the need for complex seal arrangements at the trunnions are eliminated.

At the outer side thereof, one of the trunnions 37 includes an eccentric extension 42 extending into a recess in the end cap 15 and aligning itself therein with the outer ends of a pair of pistons 115c and 116c reciprocally mounted respectively in the stroke adjusting cylinders 115b and 116b previously referred to. These cylinders are formed in the outer end face of the main housing 14 in spaced parallel relation to one another, in perpendicular relation to the plane of the housing end face and to opposite sides of the tilt axis (the axis of the trunnions) of the tilt box 36. Consequently, the pistons 115c and 116c are operable, upon admission of fluid under pressure to the respective ones of ports 115 and 116 (FIGURES 1 and 5) to tilt the box 36 and thus the flange 32 in opposite directions about a neutral position wherein the box 36 and flange 32 are perpendicular to the shaft 23.

Each of the pistons 115c and 116c preferably comprises a cup-shaped piston having an axially protruding spherical head 43 universally mounting thereon a bearing shoe 44 disposed for engagement with the trunnion extension 42. Interiorly of each piston, there is provided a compression spring assembly which is operable to normally bias the respective piston outwardly, but only to a limited extent. Each such assembly preferably comprises an inner abutment 45 engaging the bottom wall of the respective cylinder, a screw 46 adjustably threaded into the abutment, a collar 47 slidably mounted on the screw for the limited movement accommodated by the screw head, and a compression spring 48 confined between the abutment and the collar for normally biasing the collar and the piston outwardly.

A further advantage of the described assembly of the housing 14, end cap 15 and trunnions 37 is the ease and facility with which the pistons 115c and 116c may be mounted in and adjusted relative to the housing 14. Thus, this assembly is seen to be an important feature of the invention leading to particular facility and economy of construction and to pump compactness.

Outwardly of the tilt box assembly, the end cap 15 includes an end closure portion having a tubular central section mounting bearings 50 and seals 51 for the outer end portion of the drive shaft 23, the shaft extending through the cap and having a splined end 52 for connection with any selected prime mover. When driven by such prime mover, the shaft rotates the constant velocity joint 30-35 and the barrel 18 conjointly with one another, and also conjointly drives the pumps 105 and 106.

The constant velocity joint and the barrel 18 conjointly rotate with themselves nine piston and piston rod assemblies comprising the principal fluid impelling means of

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the pump. As shown in FIGURE 2, each such assembly comprises a cup-shaped piston 55 reciprocable in a respective barrel cylinder 19 and a connecting rod 56 having a spherical head at each end thereof respectively engaging in a spherical socket in the interior of the piston and an axially aligned spherical socket 57 in the opposed face of the drive flange 32. As shown in FIGURE 6, the sockets 57 alternate with and are preferably located on a longer radius than ball slots 33. Each connecting rod is secured to its piston by a C-ring or the like fitted within the piston and all of the connecting rods are retained in association with the drive flange by a retainer ring 58 secured, as by bolts 59, to the face of the drive flange.

The shaft, drive flange, barrel and pistons thus rotate as a unit in the housing. When the tilt box 36 is perpendicular to the shaft, and thus parallel to the barrel, the pistons simply rotate and do not reciprocate and no pumping pressure is applied to the fluid. However, when the box 36 is tilted relative to the shaft, the drive flange assumes a position wherein the distance between it and the barrel varies around the circle of rotation whereby the pistons and connecting rods are made to reciprocate relative to the cylinders 19. The stroke of the pistons will depend upon the degree of tilt of the box 36, which is controlled by the pistons 115c and 116c (whereby the latter derive the name "stroke pistons"). Also, the stroke pistons control the direction of fluid flow since when the upper one (FIGURE 5) is energized (forced outward), the pump pistons 55 will move into their cylinders as they rotate toward the bottom of the housing (FIGURE 2) and will move outward as they rotate toward the top of the housing; whereas when the lower one of the stroke pistons is energized the pump pistons will have the opposite movement.

In accordance with the pump piston movements, the housing 14 is provided at the inner wall of the bore 17 thereof with two substantially semi-circular ports 144a and 144b extending in opposite directions from adjacent the top to adjacent the bottom of the housing, as is shown in FIGURE 8. The valve plate 21 has complementary ports and serves as a wear plate between the barrel and the housing. For cooperation with the ports, the inner or pump ends of the cylinders 19 are formed with arcuate ports 19a (FIGURE 7) complementing the ports 144a and 144b. Communicating with the latter are passages extending inwardly from opposite sides of the housing and constituting the previously described conduits 145a and 145b, respectively.

Also communicating with ports 144a and 144b are holes or passages drilled in the body or housing 14 and constituting the previously described conduits 146a and 146b, respectively. These extend upwardly in spaced parallel relation to one another and at their upper ends communicate with a cross bore in the housing, which corresponds to and is numbered the same as the body of the previously described four-way valve 120 (see FIGURE 3). The bore 120 includes a central enlarged area intermediate the ports 146a and 146b, and the supply duct 123 from the supercharger 105 communicates with this area. The spool 122 of the valve includes enlarged lands at its ends and at its center, the latter one of which is sufficiently small to fit within the enlarged central area of the bore 120 normally to maintain the ports 146a and 146b in open communication. The conduit means 124 for accommodating supply of hydraulic fluid at system pressure to the controller 12 comprises a pair of spaced parallel drill holes 124a and 124b extending longitudinally through the housing 14 from respective locations in the bore 120 (FIGURES 3 and 11) and a horizontal cross bore 124 connecting the two drill holes and opening to one side of the housing 14.

The valve bore 120 is closed at its opposite ends by threaded plugs 60 which serve as abutments for the spool centering springs 121. Each spring is preferably guided

at its opposite ends within a bore in the respective plug and a retainer 125 slidably engaged with the respective end of the spool 122. The movement of each retainer is preferably limited by engagement with a shoulder in the bore whereby each spring serves only to retain the spool in or return it to its centered position and is not itself capable of forcing the spool to an overcenter position. Each retainer is perforate, whereby the respective end of the spool is maintained in open communication with the chamber formed between a respective end plug retainer. These chambers respectively comprise the actuators 115a and 116a previously described and are placed in communication with the respective control lines 115 and 116 by appropriate drill passages in the housing bearing the latter numbers (FIGURES 3, 5 and 11).

The control lines 115 and 116 are defined by spaced parallel holes drilled both vertically and transversely of the body at the auxiliary pump side of the four-way valve 120, and by longitudinal holes opening into the chambers 115a and 116a from the auxiliary pump end of the housing 14. To facilitate economic formation of the pump, the latter holes are simply drilled through both of the transverse holes and selective control over fluid flow is gained by simple plug inserts 61 and 62 (FIGURE 11). Insert 61 is relatively short and serves essentially to plug the outer end of the respective hole and to reclose the wall between the two transverse holes. Insert 62 is of a length equal substantially to that of the respective longitudinal hole and includes spaced lands sealing the wall between the longitudinal holes and sealing within the entry to chamber 115a. Ports are provided within the insert 62 to establish communication between the hole 115 and the chamber 115a, and the sealing portions of the two inserts serve to define a sealed path of communication between hole 116 and chamber 116a.

When control fluid is fed from the regulator 12 to the line 115, fluid pressure is applied to the stroke piston 115c and to the chamber 115a. Fluid in the latter chamber causes the spool 122 to shift to the left as shown in FIGURES 3 and 11, whereupon ports 124b is closed by the right end of the spool and communication is established between ports 146a and 124a and between ports 123 and 146b. Similarly, when pressure fluid is fed to line 116, the spool is shifted to the right to block off the ports 124a and to establish communication between ports 123 and 146a and ports 146b and 124b. When fluid pressure is relieved, the springs 121 automatically center the spool 122 in the bore 120.

As previously explained, the ports 124 are provided for conducting fluid at main pump pressure to the regulator, and the port 123 is provided to accommodate a pressurized source of fluid at the main pump inlet. To insure that the latter is not supplied at an excessive pressure, the safety valve 119 previously described is embodied directly in the pump. Specifically, as shown in FIGURES 2 and 12, the port 123 communicates via the enlarged central area of the bore 120 with a port leading to a cross bore 118 in the body 14. The outer end of the bore 118 is counterbored for reception of a valve seat 119a and a spring pressed valve member 119 held in place by a threaded plug 63 inserted in the counterbore. Communicating with the space between the seat 119a and the plug 63 is an inclined bore 118a leading into the main pump bore 17, whereby the pressure fluid at the pump inlet may be automatically vented into the latter bore when the pressure is excessive.

The components of the piston pump 102 will inherently have a small degree of fluid leakage, and it is intended that the fluid resulting from leakage and inlet fluid relief be accumulated in the bore 17 to provide lubrication for the physical parts of the piston pump. Excess fluid is drained from the housing to the reservoir via a radial drain port 101 in the housing 14.

To the extent thus far described, the apparatus comprises in essence the main pump 102, and in particular

a high pressure variable displacement piston pump of special economy and compactness and long service life. The valves 119 and 120 are not necessary to operation of the pump per se, as the pump operates essentially via the main or power ports 145a and 145b under the variable volume and flow reversing control of the stroke pistons 115c and 116c. However, the valves 119 and 120 are embodied compactly and expeditiously within the housing 14 and facilitate (a) pressurized supply of fluid to the inlet side of the pump, whether the inlet be the port 145a or the port 145b, and (b) transmission of outlet pressure to the control system whether the outlet be port 145a or port 145b.

While the pressurized fluid inlet supply and the fluid for the control system could be furnished from other sources independent of the pump 10, it is a particular feature of this invention to incorporate the supercharger 105 and the control pump 106 directly in the housing 14 of the main pump, whereby to provide an especially compact and economical complete pump and control system.

As previously noted, the main pump shaft 23 is equipped with an extension 26 which is utilized to drive the pumps 105 and 106 conjointly with the pump 102. Specifically, the extension 26 is keyed directly to the rotors of the two pumps, which are both preferably gerotor pumps.

Referring to FIGURES 2, 3, 4 and 9, the supercharger pump 105 is housed within a counterbore 65 at the rearward end of the housing 14, the housing being provided at the end wall of the counterbore with an inlet port 66 communicating with a radial port constituting the previously described inlet 100 from the fluid reservoir, and an outlet port 67 communicating with the port or passage 123. Preferably, a wearplate 68 having complementary inlet and outlet ports is abutted against this surface of the housing.

Mounted within the counterbore 65 is a first gerotor pump comprising an outer eccentric locator ring 71 retained against rotation relative to the housing, a rotary and eccentrically shiftable gerotor ring 72, and a rotary gerotor hub 73 keyed to the shaft extension 26 for rotation therewith. The gerotor hub 73 is smaller than the ring 72 and the two have complementary radially extending protuberances thereon meshed at the point of closest approach of the eccentric ring 70 to the shaft extension 26, whereby the hub rotates and slides the ring 72 thereby causing the same to perform a pumping function. Thus, fluid is delivered from the inlet 100 to the port 123 at a predetermined pressure.

Next outwardly from the pump 105 is the wearplate 74 having a port 75 therein complementary to and aligned with the port 67, whereby the port 75 serves as a second outlet from the pump 105 and an inlet for the control pump 106. The pump 106 is constructed essentially the same as the pump 105, but with such dimensioning as to develop the appropriate control pressure. Specifically, the control pump comprises (FIGURE 10) an eccentric locator ring 76 retained against movement in a bore in the auxiliary housing 16, a gerotor ring 77 rotatable and shiftable within the ring 76 and a gerotor hub 78 keyed to the shaft extension 26. An annular control pump outlet 79 is formed in the housing 16 and the same communicates with a radial port constituting part of the previously described control fluid supply 108. As shown in FIGURE 4, the stationary components of the two auxiliary pump assemblies are commonly secured to the housing 14 and 16 by a single longitudinally extending pin 80.

Thus, it is seen that the invention provides an extremely compact and economical apparatus embodying in a single structure a high pressure variable volume piston pump, a supercharger, a control pump, control means for the piston pump, and automatically operating valve means for correlating the functions of the several pumps.

While I have shown and described what I regard to be the preferred embodiment of my invention, it is to be appreciated that various changes, rearrangements and modifications may be made therein without departing from the scope of the invention, as defined by the appended claims.

I claim:

1. In a variable displacement piston pump having trunnion supported tilt box means operatively guiding a plurality of pistons reciprocable in the cylinders of a rotatable cylinder barrel and tiltable relative to the barrel to cause variable stroking of the pistons in the cylinders, the improvement comprising a pump housing having an end face substantially coplanar with the pivot axis of the tilt box trunnions, and end cap having an end face complementary to and abutting against the first-named end face, complementary pairs of substantially semicircular recesses in said end faces conjointly comprising journals for the tilt box trunnions, said recesses being located inwardly of the margins of said end faces and said end faces including abutting planar marginal portions substantially coplanar with the pivot axis of said trunnions and completely circumscribing said tilt box and its trunnions, and a flat gasket between said marginal portions sealing the pump housing and sealingly enclosing said trunnions in said housing, said pump housing and end cap and one of the tilt box trunnions having extensions within the confines of said marginal portions generally paralleling the trunnion axis, the trunnion extension having a flat face substantially coplanar with the trunnion axis and facing toward the pump housing, cylinder means formed in the extension of the pump housing and opening at said end face of said housing, stroke piston means in said cylinder means projecting from said end face and engaging said flat face of said trunnion extension transversely and eccentrically of the axis thereof, and means for supplying fluid under pressure to said cylinder means to cause said piston means to rotate said trunnion extension and thereby tilt the tilt box.

2. In a pump as set forth in claim 1, a pair of said cylinder means and piston means disposed transversely and to opposite sides of the axis of said face of said trunnion extension, and means for selectively supplying fluid under pressure to said cylinder means to cause said piston means to reversely rotate said extension and thereby tilt the tilt box in opposite directions from a central portion perpendicular to the cylinder barrel.

3. In a variable displacement pump, a housing, a piston pump comprising a cylinder barrel rotatable in the housing, pistons reciprocable in the cylinders in the barrel, ports in said housing communicating with the cylinders in the barrel as it rotates to conduct fluid to and from said cylinders, a tilt box operatively guiding said pistons and variably tiltable to control fluid flow through said ports, fluid pressure operated piston means for variable tilting said tilt box, auxiliary pump means in said housing coupled to and rotated conjointly with said barrel for supplying pump controlling fluid under pressure to said fluid pressure operated piston means, and overload control means connected to and operable by the fluid pressure in the outlet of the piston pump and having connection with the outlet of said auxiliary pump means for relieving the pressure on the pump controlling fluid thereby to control the piston pump as a function of its outlet pressure, said fluid pressure operated piston means comprising a pair of fluid operated stroke pistons in said housing operatively connected to said tilt box, said stroke pistons normally positioning the tilt box in a neutral position and being selectively operable to tilt the same in opposite directions to varying degrees to control the amount and the direction of fluid flow through said ports, said overload control means comprising manually operable valve means for supplying control fluid from said auxiliary pump means selectively to said stroke pistons at selectively variable pressures.

4. In a pump as set forth in claim 3, a four-way valve reciprocably mounted in said housing and communicating at its ends respectively with said stroke pistons for reciprocation in accord with the selective operation of said stroke pistons, port means in said housing leading from each of the ports of said piston pump to said four-way valve, said manually operable valve means including pressure regulator means, and conduits leading from said four-way valve and said auxiliary pump means to said regulator means, said four-way valve including port means establishing communication between the port of said piston pump then serving as the outlet port thereof and said regulator means, said regulator means correlating the piston pump output and the pressure of the control fluid.

5. In a pump as set forth in claim 4, said auxiliary pump means also including a supercharger pump and port means in said housing leading from its outlet to said four-way valve, said four-way valve including port means establishing communication between the last-named port means and the port means leading from the port of said piston pump then serving as the inlet port thereof.

6. A variable displacement pump, comprising, in combination, a main housing having a bore therein and a hole extending coaxially inwardly from the bottom of said bore, a piston pump including a barrel rotatable in said bore and having a circular array of cylinders therein parallel to its axis, said barrel and said housing having engaging end faces at the bottom of said bore normal to said cylinders, said housing having in said face a pair of separated but substantially semi-circular ports complementary to and aligned with the circle of said cylinders and communicating with the cylinders, pistons and said cylinders reciprocable toward and away from said ports, tilt box means at the opposite end of said bore operatively guiding said pistons and variably tiltable relative to said barrel about an axis generally parallel to a line joining the mid-points of said ports to vary the stroke of said pistons, said tilt box means including trunnions extending outwardly from opposite sides thereof along said axis, said housing having an end face substantially coplanar with said axis and having semicircular recesses therein complementary to and receiving said trunnions, an end cap for said housing having an end face complementary to and abutting said end face of said housing and having semi-circular recesses therein complementary to the recesses in said housing and complementary to and receiving said trunnions whereby said trunnions are journaled between said housing and said end cap, said recesses being located inwardly of the margins of said end faces and said end faces including abutting planar marginal portions substantially coplanar with the pivot axis of said trunnions and completely circumscribing said trunnions, a flat gasket between said marginal portions sealing the pump housing and end cap and sealingly enclosing said trunnions in said housing, a drive shaft extending through said end cap and said tilt box and coupled to said barrel, said shaft extending axially through said barrel and into said hole, and bearing means in said hole and in said end cap rotatably supporting said shaft.

7. In a pump as set forth in claim 6, said housing at its opposite end having a second bore therein communicating with said hole, auxiliary pump means in said second bore, and an end cap closing said second bore and enclosing said auxiliary pump means, said shaft extending through said hole and into said second bore and being coupled to said auxiliary pump means for driving the same.

8. In a pump as set forth in claim 7, said auxiliary pump means comprising a pair of gerotor pumps closely coupled to one another and said barrel.

9. In a pump as set forth in claim 7, a valve bore in said housing intermediate said barrel and said auxiliary pump means, ports in said housing leading from each of the first-named ports and from said auxiliary pump

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means to said valve bore, and a valve in said valve bore selectively movable to establish communication between said auxiliary pump and each of said first-named ports.

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WILLIAM L. FREEH, *Primary Examiner.*

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