July 19, 1960 A. H. LE FEBVRE ET AL 2,945,449

HYDRAULIC CONTROL PUMP

Filed June 3, 1954 3 Sheets-Sheet 1

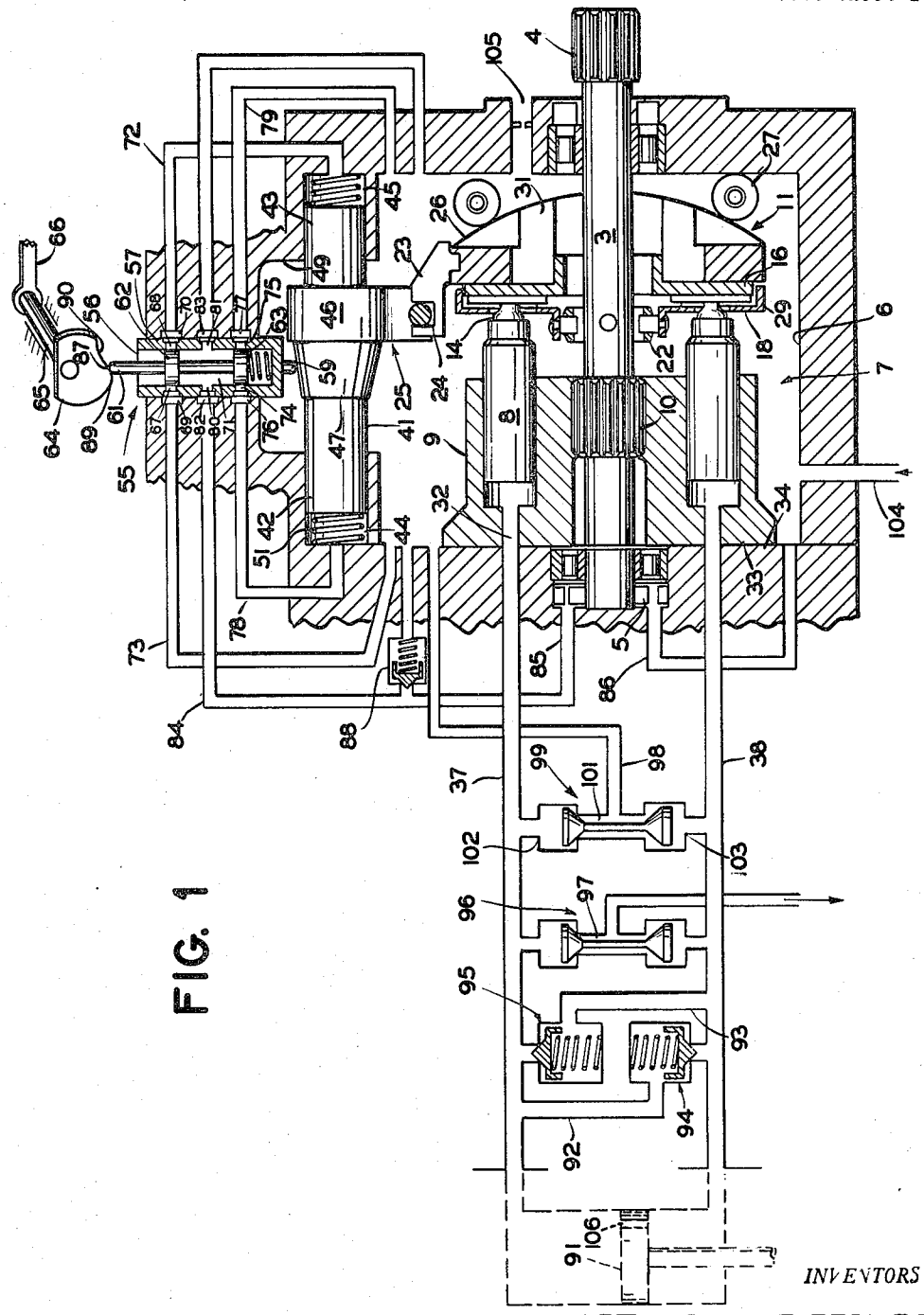

FIG. 1

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Filed June 3, 1954 3 Sheets-Sheet 2

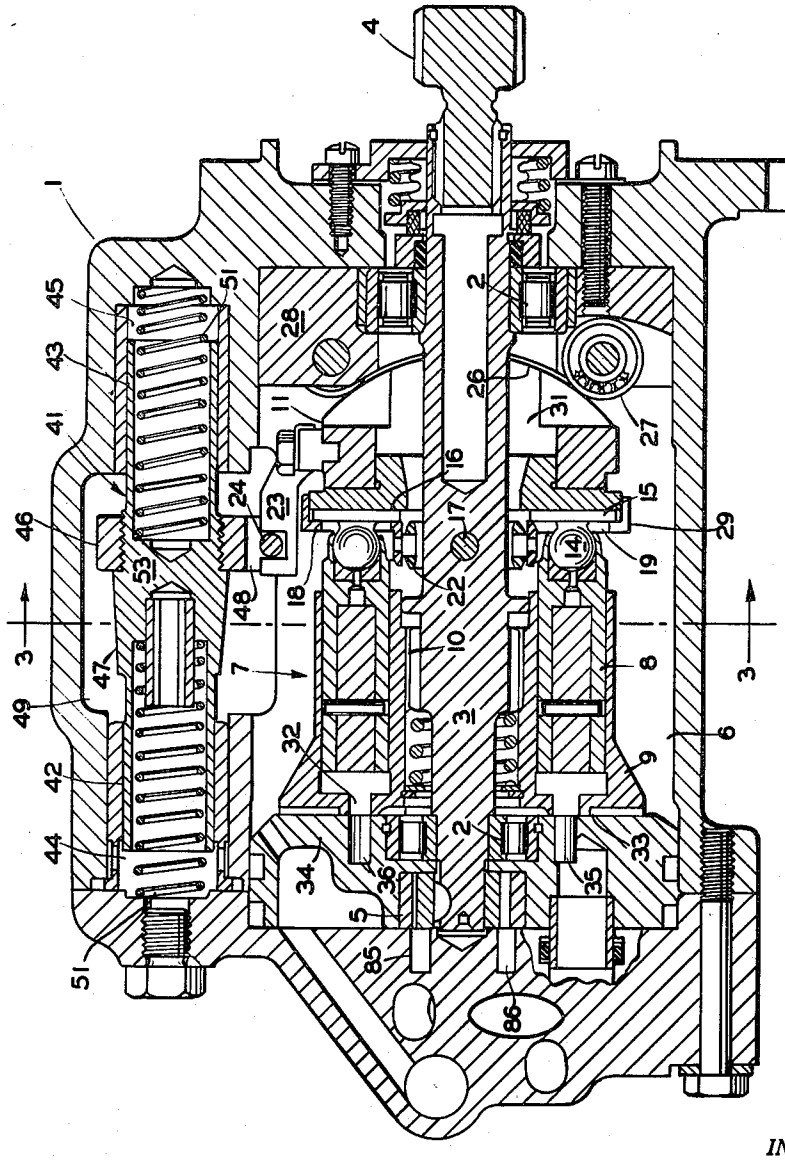

FIG. 2

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Filed June 3, 1954 3 Sheets-Sheet 3

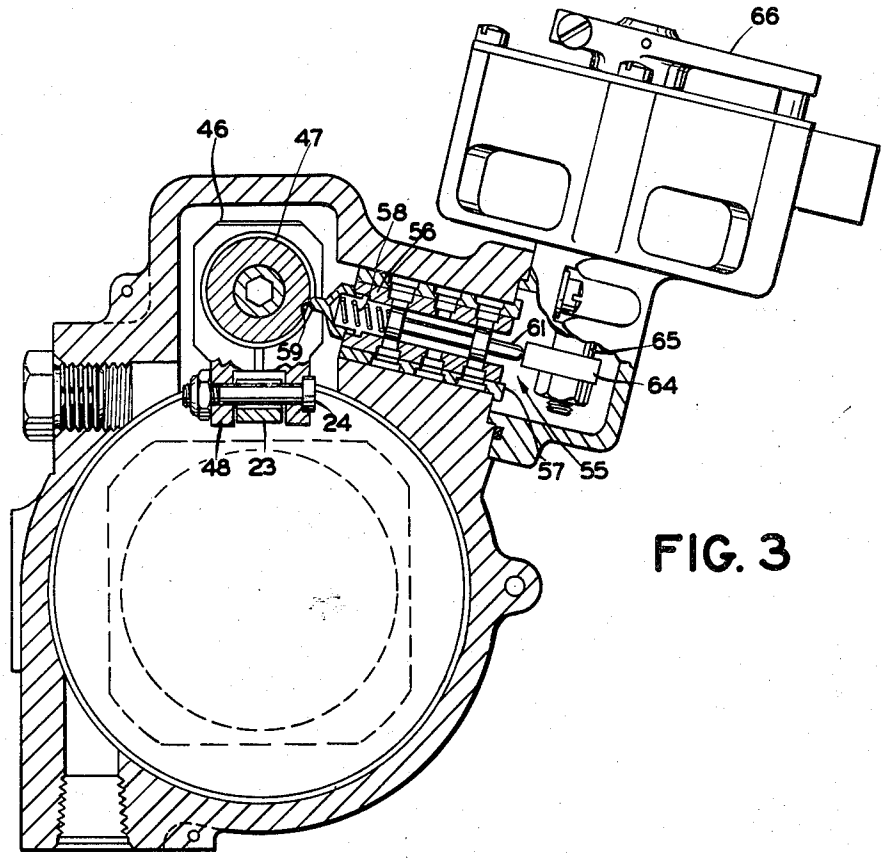

FIG. 3

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2,945,449

Patented July 19, 1960

2,945,449

HYDRAULIC CONTROL PUMP

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Filed June 3, 1954, Ser. No. 434,273

5 Claims. (Cl. 103—162)

The present invention relates to new and useful improvements in hydraulic control pumps.

An important object of the invention is to provide in a hydraulic control pump a novel arrangement of valve controls for regulating pressure flow, cooling the flow, and replenishing the flow as required.

A further object of the invention is to provide a novel piston type, variable displacement, fully reversible hydraulic control pump including a manually operated servo-powered flow control and including flow cooling and replenishing devices.

A still further object of the invention is to provide in a hydraulic pump control system a novel manually operated servo-powered pressure and directional pressure flow control device.

While the invention is subject to wide application, it finds particular use in a hydraulic circuit for powering an actuator piston and controlling the movement of the same. A feature of the invention is that this controlled movement is obtained without employing intermediate externally operated valves.

The invention further lies in the particular construction and arrangement of the various elements thereof and in their cooperative association with one another.

The foregoing and other objects and advantages of the invention will appear more fully hereinafter from a consideration of the detailed description which follows, taken together with the accompanying drawings, wherein an embodiment of the invention is illustrated. It is to be expressly understood, however, that the drawings are for purposes of illustration and description, and are not to be construed as defining the limits of the invention.

In the drawings:

Fig. 1 is a schematic view of a hydraulic pump control circuit embodying the invention;

Fig. 2 is a longitudinal section of the pump assembly; and

Fig. 3 is a cross-section of the pump assembly on line 3—3 of Fig. 2 directed to showing the stroke control mechanism.

In describing the invention in detail, reference is directed to the drawings, wherein there is shown a hydraulic pump control circuit system comprising a suitable housing 1, wherein the various elements of the device are incorporated, and in which is supported in suitable manner, as by bearings 2 a drive shaft 3 splined at one end 4 for association with a suitable source of driving power, not shown. At the opposite end of the shaft is carried, so as to be driven by the latter, a fixed diplacement pump 5 of the rotor type, such as a gear rotating within a gear, commonly known as a gerotor pump. Contained in an oil-filled sump chamber 6 is a pump assembly 7. The latter includes a plurality of pistons 8 in ring arrangement in a barrel or piston block 9. Here seven pistons are provided. The piston block is axially splined at 10 to the drive shaft and it rotates with the latter.

Reciprocating movement of the pistons is provided by means of the tilting of a circular tilt block member 11. Each piston reciprocates through one end of the piston block, and each includes in its outer end a spherical socket in which is contained and pivots the ball end 14 of a shoe 15. As the piston block rotates, the several shoes ride over the face of a thrust end plate 16 of tilt block 11. The several shoes are held in riding contact with the thrust end plate by means of a return plate 18 which has a plurality of openings 19 each collaring the neck of a shoe. The return plate is mounted to a universal joint 22 that is properly connected by pin 17 onto the drive shaft and rotates with the latter.

Tilt block 11 does not rotate, but is tiltable either forwardly or rearwardly from a vertical position by means of a forwardly extending arm 23 that is connected by pin and slot 24 to control means 25 for moving the arm and, as a consequence, tilting block 11 in one direction or the other accordingly as the arm is moved backwards or forwards from a null position, the null position being shown in the drawings.

The tilt block has a convexed back 26 adapted as the block is tilted to ride upon opposed pairs of rollers 27. The rollers are carried by housing blocks 28. The rollers support opposed portions of the back of the block and are always in contact with the latter as the latter block tilts from one position to another. The tilt block is supported in its forward position by the thrust plate portion 16 thereof which is at all times positioned within a peripheral flange 29 about the return plate. As the return plate rotates with the universal joint, the peripheral flange 29 is carried about the peripheral surface of the thrust plate. Tilt block 11 is further provided with an enlarged axial opening 31 of relatively larger diameter than the diameter of the drive shaft 3 that passes through it. This larger opening permits tilting of the tilt block without the latter being obstructed by the drive shaft.

The opposite ends of the pistons are each ported at 32 through the end face 33 of the piston block. End face 33 bears against a port plate 34 of the housing, which port plate has a pair of opposed semi-circular openings 35, 36. One of these communicates (Fig. 1) with a main flow line 37, and the other communicates with a second main flow line 38. Either line may be employed as an intake line to the pistons or as a pressure discharge line from the pistons. When one line serves one of these functions, the other line serves the other function. The port hole 32 of each piston cylinder is communicable with the semi-circular openings, and on rotation of the piston block each cylinder port hole successively passes over the full length of one semi-circular opening, and then over the other.

When the tilt block is in its normal or vertical position (Figs. 1 and 2), the piston shoes ride over the thrust plate face without reciprocating the pistons. When the tilt block is tilted in either direction, then, and as the piston shoes ride over the face of the thrust plate, the ported pistons successively pass over the openings 37 and 38, drawing in fluid as they pass over one, and discharging or pumping out fluid as they pass over the other.

When the upper portion of the tilt block nods forwardly, main line 37 acts as the pressure discharge line, and line 38 as the intake. When the upper portion of the tilt block tilts rearwardly, the functions of the lines are reversed.

Control means is provided for determining and setting the directional tilt of block 11 as well as the extent of the tilt. The directional tilt of the plate determines which of the main flow lines will act as a discharge line and which as the intake line. The extent of the tilt, it is

obvious, will determine the length of the piston stroke and, as a consequence, the pressure flow through the discharge line.

The control means includes an elongated control piston member 41, reciprocable in the housing in a plane parallel to that of the drive shaft. The opposed end portions 42, 43 of the piston member reciprocate in opposed cylinder portions 44, 45 of the housing. Threaded onto the intermediate section of the piston is a nut 46 which abuts a shoulder of an annular tapered boss portion 47 of the control piston. Nut 46 is connected by depending lug portions 48 thereon and pin and slot means 24 to tilt block arm 23. A suitable space at 49 is provided in the housing chamber 6 to allow the nut 46 and tapered portion 47 of the control piston to be carried forwardly or rearwardly with the movement of the control piston.

The control piston has a null or normal position in which it is balanced by opposed tension forces of springs 51 that are positioned in hollow ends of the control piston. A solid central wall 53 of the control piston provides an abutment for the inner ends of spring 51. The outer projecting portions of the springs abut against the housing inner wall.

When control piston 41 is in its spring balanced position, which is its normal position, the tilt block is held by the pin and slot means 24 in its vertical null position. Block 11 tilts either forwardly or rearwardly, but does not rotate.

When the control piston is moved leftward, the upper portion of the tilt block is tilted in the same direction by arm 23; and when the control piston is moved to the right, the upper portion of the tilt block is tilted in this direction. The extent of movement of the control piston in either direction sets the extent of the tilt of the block plate and, as a consequence, the length of the stroke of pistons 8.

Hydraulic servo valve control means 55 (Figs. 1 and 3) controls the directional movement of the control piston and the extent thereof. The valve control means comprises a sleeve 56 slidable in a bore 57 of the housing. A bottom wall of the sleeve has a projection 59 which rests upon the control piston taper 47. Seated at the bottom within sleeve 56 is a coil spring. Reciprocable in the sleeve is a servo valve member having an elongated shaft 61 carrying a pair of lands 62, 63, of which land 63 is at the bottom end of the shaft and rests upon the coil spring.

Coil spring 58 constantly urges the valve member upwards; the latter is limited in this directional movement by a cam member 64. Tension of the coil spring also urges sleeve element 56 downward so as to rest it upon the control piston taper 47. Cam 64 is carried in the housing fast to a pin 65 that is pivotable by a manually operable arm 66 to present a desired cam surface to the extended end portion of valve shaft 61. The cam member has an arcuate surface including high and low points and an intermediate null point.

Sleeve 56 includes a pair of opposed openings 67 and 68 which are adapted, when the sleeve is in its normal or null position, to register with opposed openings 69 and 70 extending through the wall of the housing bore. Opening 68 communicates the sleeve chamber 71 by line 72 with the right end of the control piston; opening 67 communicates chamber 71 by line 73 with sump chamber 6. Sleeve 56 also includes a pair of lower opposed openings 74 and 75 which register, when the sleeve is in normal position, with a pair of opposed openings 76 and 77 extending through the housing bore. Opening 74 communicates sleeve chamber 71 by line 78 with the left end of the control piston; opening 75 communicates chamber 71 by line 79 to sump tank 6. Intermediately of sleeve 56 between the upper and lower openings, is a pair of opposed openings 80 and 81. In the normal position of the sleeve these openings are in register with opposed bore openings 82 and 83 through the housing. Opening 81 communicates the sleeve chamber 71 to the sump tank 6; opening 80 communicates the sleeve chamber by line 84 with the outlet end 85 of gerotor pump 5. The intake of pump 5 is connected by passage 86 with sump tank 6.

When the null point 87 of cam 64 is presented to the valve shaft end, the latter is moved down against the tension of the coil spring to bring lands 62 and 63 into register, respectively, with the upper sleeve ports 67 and 68 and with the lower ports 74 and 75. In this position of the valve, flow from the control pump 5 passes through registered openings 82 and 80 to chamber 71 and from there through openings 81 and 83 to the sump 6. Any excessive pressure built up in the pump outlet line is relieved by valve 88 to the sump.

When the high point 89 of cam 64 is presented to the valve shaft, the latter is pressed downward to carry its lands down and out of register with the sleeve openings. With this action, fluid pumped to valve chamber 71 by pump 5 is blocked from the upper passages by the upper land 62 and, therefore, flows through ports 74, 76 to the left end of the control piston and forces the latter to the right. As a consequence, arm 23 is carried so as to tilt the tilt block rearwardly, while the low end of the control piston taper 47 is passed beneath the sleeve projection 59 causing the sleeve to descend with the decline of the taper passing below. The sleeve 56 progressively descends with this action under coil spring tension until the ports thereof are brought into register with the servo lands, whereupon fluid flow to the left end of the piston ceases and further tilting of the tilt block stops. The tilted position of block 11 is then held until the position of cam 64 is changed.

Now, should it be desired to restore the tilt block to normal null position, cam 64 is pivoted back to its null position, whereupon coil spring 58 urges the valve element 61 up to normal position. The sleeve however, until again acted upon by piston taper 47, remains in the last-moved position wherein the upper and lower sleeve ports are below their respective land. It is to be noted that the sleeve ports, though moved, are still in register with the bore ports because of the relatively larger diameter of the latter ports and the increased diameter of the outer ends of the sleeve ports as indicated. Whereupon, fluid from the control pump passes from chamber 71 through the upper ports 68 and 70 to the right end of the control piston and drives the latter to the left. This action simultaneously draws the tilt block back to normal and also moves the high end of the control piston taper 47 beneath the sleeve end. This raises the sleeve until its upper and lower ports register with the lands, whereupon further movement of the control piston ceases and the tilt block is back to its normal vertical position. As the control piston moves to the left to normal position, fluid in the left piston cylinder relieves to the sump over line 78, through sleeve chamber 71 beneath the lower land and line 79.

Now, by pivoting the cam clockwise, the low surface 90 thereof is presented to the valve shaft and causes the lands to rise above their respective sleeve ports, whereupon control pump flow is, it is clear, to the right end of the control piston and the latter is carried leftward causing the tilt block to nod to the left, the tilting action ceasing as the sleeve is elevated to register its ports with the lands.

When the lands are fully below or above their respective sleeve ports, control pump flow to the relative side of the control piston is full and the consequent movement of the control piston and tilt block is maximum, so that the maximum stroke is established for the pistons 8 and the discharge thereof is at maximum pressure. It is obvious now that the distance the tilt block will tilt and the length of the piston stroke is relative to the distance the control piston must travel to raise or lower the sleeve to register its ports with the related lands. Therefore, by con-

trolling the distance the valve lands are raised or lowered from normal will control the piston stroke. This, it is plain, may be done by the high and low positions of the cam and the points intermediately thereof.

The main flow lines **37** and **38** of the output pump, regardless of which line is employed as intake or pressure discharge, may be utilized in hydraulically driving a work load, such as an actuator piston **91**. The latter is reciprocated by fluid ported through whichever main line is used as the pressure discharge line.

A pair of lateral lines **92**, **93** from one main line connect with the other. In lateral **93** is provided a relief valve **95** which relieves excessive pressure from line **37** to line **38** when line **37** acts as the pump discharge line. In lateral **92** relief valve **94** relieves line **38** to line **37** when line **38** serves as the pump discharge line.

Suitable means is provided for cooling the work fluid of heat acquired by the latter in driving the work load. A bleed valve **96** is provided for this purpose. It bleeds from the return portion of whatever main line may be acting as the intake line a measured quantity of heated fluid which passes off to a bleed tank. Bleed valve **96** is of the shuttle type, operable in a chamber **97** connected laterally between the main flow lines. Chamber **97** connects to a bleed-off tank, not shown. When valve **96** is shuttled in one direction by discharge pressure in line **37**, it closes flow from the latter to chamber **97** and opens flow from line **38** to the chamber **97**. When valve **96** is shuttled in the opposite direction by discharge fluid pressure in line **38**, it closes the latter to chamber **97** and opens line **37** to chamber **97**.

With the exception of fluid bled off and whatever fluid may be lost in the hydraulic circuit, the fluid pumped out to the work load is returned to the intake line. This lost and bled off fluid is replenished by a pressure flow over line **98** from sump **6** through a shuttle valve **99** to whichever of the two main lines is serving as the intake line. The shuttle valve operates in a chamber **101** connected at one end to a lateral **102** off line **37**, and at the other, to a lateral **103** off line **38**. Pressure in line **37** shuttles the valve to close lateral passage **102** and to open passage **103**. Pressure in line **38** has the reverse effect. The sump tank **6** is constantly replenished by fluid pumped therein through the replenishing oil inlet **104**.

A small amount of fluid from the supply sump bleeds off through a narrow orifice **105** to a gear case, not shown.

In the operation of the device, let it be assumed cam **64** is pivoted from normal position to its low position **90** whereupon the valve lands **62**, **63** rise above their related sleeve ports. Thereupon fluid from the control pump **5** is discharged under pressure over line **84** to the valve chamber **71** and passed over line **72** to the right end of the control piston to move the latter leftward. This action simultaneously nods the tilt block plate and restores the valve sleeve. The shoes **15** of the rotating pistons **8** move over the tilted block face **16** taking in fluid over line **38** and discharging it under pressure over line **37** to the work load **91**. Fluid traveling to the work load shuttles both valves **96** and **102** to close to the pressure line and to open to the intake line. The work fluid drives the actuator piston **91**. Some of the work fluid is forced through a bleed hole **106** of the actuator piston head to the return portion of the intake line **37**. On building up of pressure in the discharge line **38** with the reciprocation of the work load, the excessive fluid pressure is relieved through valve **95** to the intake line. As the fluid flows in the return circuit to the intake pistons, some of it passes through the slight opening in bleed valve **96** to the bleed-off tank. The bled-off fluid and fluid lost in circuit are replenished by fluid from the sump through shuttle valve **99** to the intake line. Pumping continues at the stroke set by the manually operated cam **64** and it ceases when the cam is restored to null position.

Although an embodiment of the invention has been illustrated and described in detail, it is to be expressly understood that the invention is not limited thereto. Various changes can be made in the design and arrangement of the parts without departing from the spirit and scope of the invention, as the same will now be understood by those skilled in the art.

We claim:

1. In a hydraulic control pump of the character described including a piston block rotatable by a drive shaft and including a plurality of pistons successively discharging fluid from one end of the block into a common outlet and successively intaking fluid at said end from a common inlet, a circular block plate having an axial opening about the drive shaft of a diameter greater than the latter and including a thrust face at one end and a convexed back at the other, each piston including in the opposite end a spherical socket containing a ball pivotable therein and connected by a relatively short neck portion to a shoe adapted to ride over the thrust face, a retaining plate joined universally directly to the shaft and adapted to be carried about with the latter, the retaining plate including a plurality of apertures, each freely collaring a neck of a shoe, a peripheral flange about the retaining plate in which the peripheral portion of the thrust end of the circular plate is freely received, whereby the retaining plate serves to hold the shoes in riding contact with the thrust face of the plate and is rotatable relative to the plate, roller means continuously supporting opposed portions of the convexed back end of the circular plate whereby the circular plate is supported for tilting movement thereon and the thrust face of the tilt plate is retained in the flange of the retaining plate, and hydraulically operated control means for tilting the circular plate whereby the stroke of the pistons is controlled.

2. In a hydraulic control pump including a rotary piston block having a plurality of circumferentially spaced pistons axially reciprocable by a circular tilt plate tiltable from a vertical position to a plurality of forward or rearward positions, a shoe pivoted in an end socket of each piston in close relation to the end of the piston and rideable over an end face of the tilt plate as the piston block rotates, means for holding the piston shoes in continuous contact with the end face of the tilt plate, the tilted position of the plate serving to determine the length of the stroke of the pistons, manually operable means for selectively setting the tilt position of the tilt plate including an arm connected to the plate, hydraulically operated piston means for drawing the arm in either a forward or rearward direction and as a consequence tilting the plate accordingly, valve means for effecting the hydraulic operation of the piston means, complementary valve means operable by the piston means in a reverse sense for terminating the hydraulic operation of the latter at the end of a predetermined distance of travel of the piston means, and manually settable means for controlling the functioning of the first-mentioned valve means and for predetermining the action of the complementary valve means.

3. A hydraulic control pump of the character described including a rotary piston block having a plurality of circumferentially spaced pistons axially reciprocable therein by the angular disposition of a tilt-plate, wherein the length of the piston stroke is relative to the tilt angle of the plate and wherein the plate is tilable from a null vertical position in either of two opposed angular directions; hydraulically operated means for selectively tilting the plate in either of the two directions and for predetermining the degree of the angular tilt of the plate in the selected direction; an axially movable hydraulically operated elongated piston member; spring means at opposite ends of the piston member balancing it in a normal null position; an arm projecting from the tilt plate; means operatively connecting the arm to the piston member,

whereby axial movement of the piston member in one direction from null position tilts the plate angularly in such direction, and whereby reverse movement of the piston member from null position reverses the directional tilt of the plate; means for hydraulically operating the piston member in either of the two said directions including first servo valve means operable from a null position in a selected particular direction for communicating pressure fluid from a source to a selected end of the piston member to drive it in a particular direction, second servo valve means complementary to the first valve means and operable in a reverse direction to cut off the communication of pressure fluid to the selected end of the piston upon the latter reaching a predetermined position, control means for selectively actuating the servo valve means in a particular direction and for a predetermined distance, other means carried by the piston member cooperable as the piston member travels in its selected direction to actuate the second servo valve means a distance complementary to the moved distance of the first valve means so as to cut off the communication of pressure fluid to the selected end of the piston.

4. A hydraulic control pump comprised of a housing having a drive shaft mounted therein, first means within said housing connected to said shaft for increasing the pressure of a work liquid, second means within said housing connected to one end of said shaft for increasing the pressure of a control liquid, said housing having a sump chamber, third means within said housing arranged to control said first means for increasing the pressure of a work liquid, a servo valve within said housing for controlling said third means, means external of said housing arranged to control said servo valve, first passage means within said housing connecting said sump chamber to said second means for increasing the pressure of a control liquid and said second means to said servo valve, second passage means within said housing arranged so that control liquid passes from said servo valve through said third means to said sump chamber, a relief valve in a conduit within said housing connecting said first passage connecting said second means to said servo valve to said sump chamber, first and second main flow passages within said housing connected to said first means for admitting and receiving work fluid and adapted to be operably connected to an actuating piston, said first and second main flow passages being connected to said sump chamber by bleed means including bleed valve within said housing, said bleed means being arranged to bleed hot pressurized work liquid to said sump chamber, and replenishing means including a shuttle valve within said housing arranged to pass work liquid from said sump chamber to said first and second main flow passages.

5. A hydraulic control pump comprised of a housing having a drive shaft mounted therein, first means within said housing connected to said shaft for increasing the pressure of a work liquid, said housing having a sump chamber, third means arranged to control said first means for increasing the pressure of a work liquid, first and second main flow passages within said housing connected to said first means for admitting and receiving work fluid and adapted to be operably connected to an actuating piston, said first and second main flow passages being connected to said sump chamber by bleed means including bleed valve within said housing, said bleed means being arranged to bleed hot pressurized work liquid to said sump chamber, and replenishing means including a shuttle valve within said housing arranged to pass work liquid from said sump chamber to said first and second main flow passages.

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