

July 22, 1952

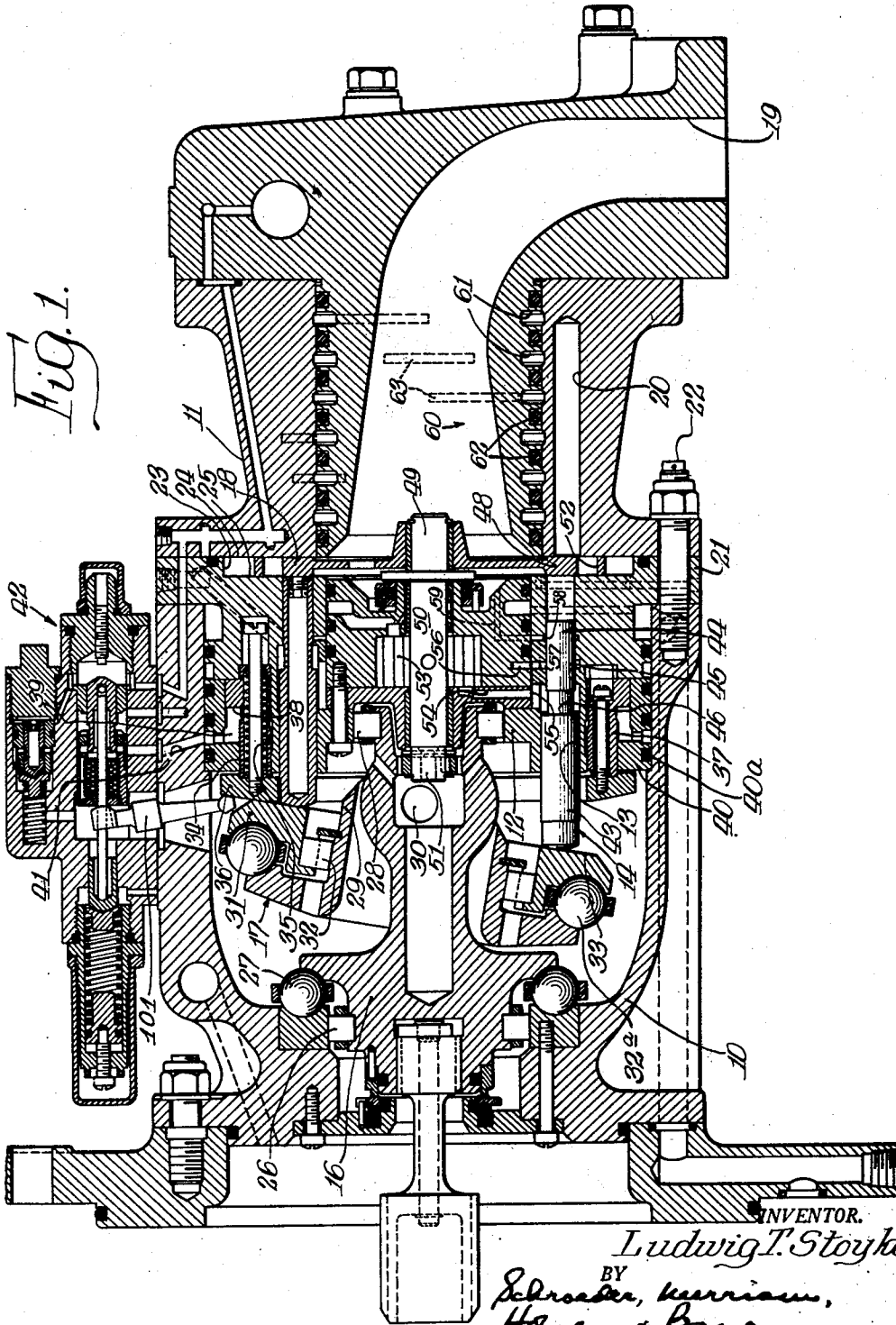
L. T. STOYKE

2,604,046

MULTIPLE OUTLET FLUID PUMP AND CONTROL

Filed Dec. 10, 1949

3 Sheets-Sheet 1



July 22, 1952

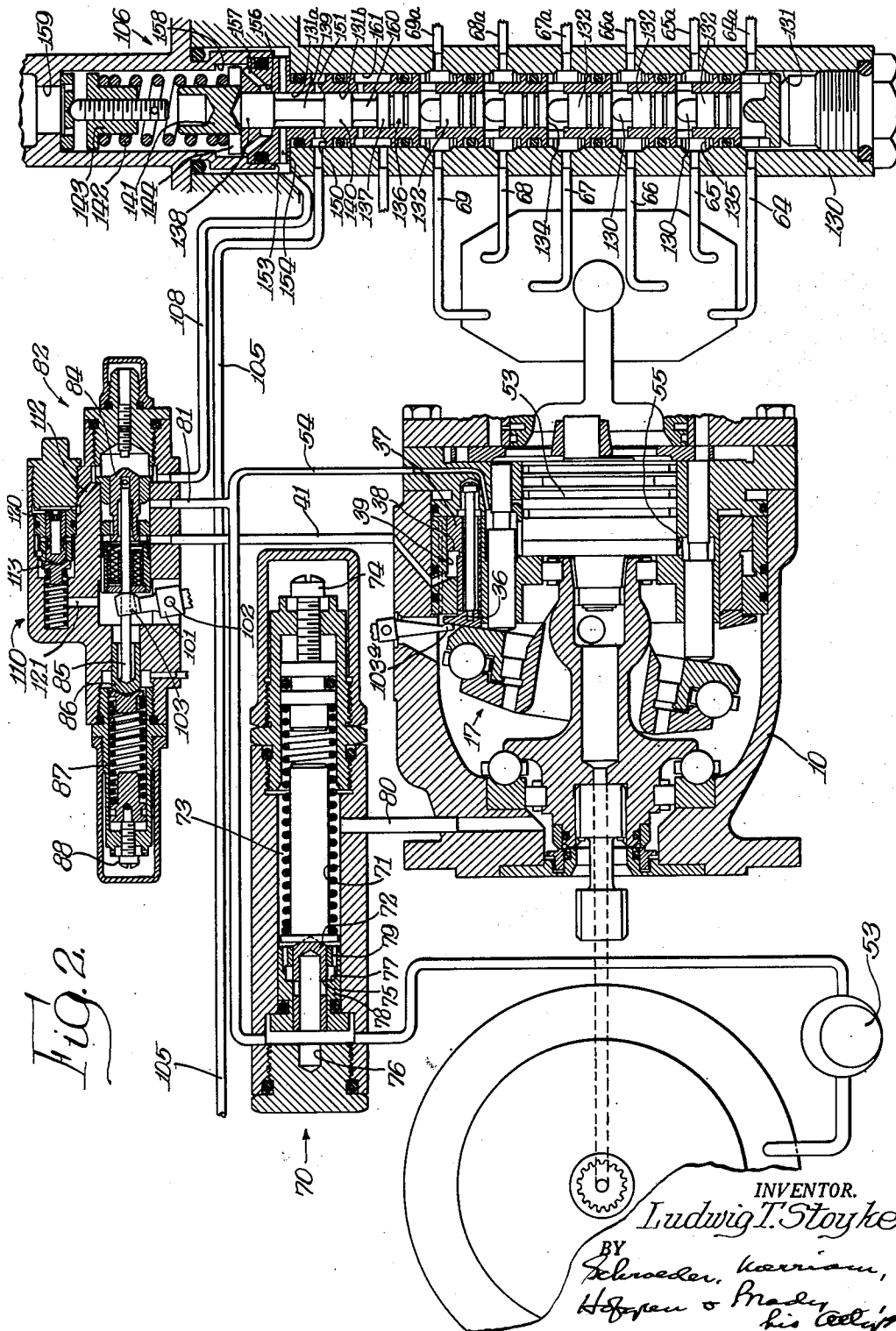
L. T. STOYKE

2,604,046

MULTIPLE OUTLET FLUID PUMP AND CONTROL

Filed Dec. 10, 1949

3 Sheets-Sheet 2



July 22, 1952

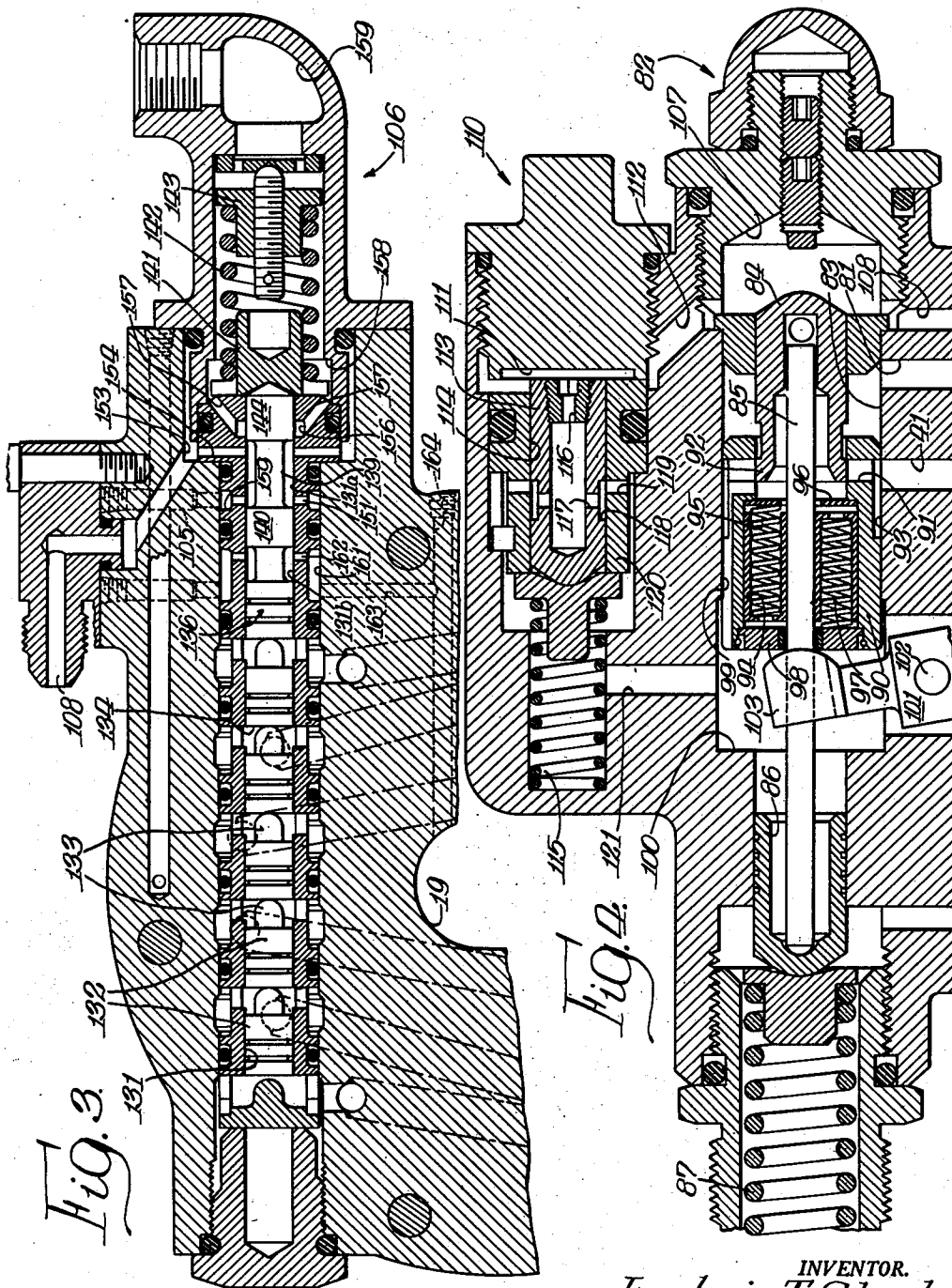
L. T. STOYKE

2,604,046

MULTIPLE OUTLET FLUID PUMP AND CONTROL

Filed Dec. 10, 1949

3 Sheets-Sheet 3



INVENTOR.
Ludwig T. Stoyke,
 BY
Schroeder, Karrison,
Hofman & Brady
his Attys.

UNITED STATES PATENT OFFICE

2,604,046

MULTIPLE OUTLET FLUID PUMP AND
CONTROLLudwig T. Stoyke, Rockford, Ill., assignor to
Sundstrand Machine Tool Co., a corporation of
Illinois

Application December 10, 1949, Serial No. 132,293

11 Claims. (Cl. 103—2)

1

This invention relates to pumps and more particularly to variable displacement multiple outlet fluid pumps.

It is the general object of this invention to produce a multiple outlet variable displacement pump of new and improved design.

It is a more specific object of this invention to produce control means for a variable displacement multiple outlet pump adapted to vary the displacement of the pump in response to a variable control pressure.

A further object of the invention is to produce a control device for a multiple outlet variable displacement pump operating when the pressure in any single outlet exceeds a predetermined amount to reduce the displacement of the pump.

Still another object of the invention is to produce a control device for a pump of the type described in the preceding paragraphs in which a variable control oil pressure is employed for operating means for controlling the displacement of the pump and where means, movable in response to the build-up of excessive pressure in any outlet, is provided in the variable control oil circuit to tank control pressure.

It is a further object of the invention to produce a pump for use with a control of the type described in the preceding paragraph which is provided with means biasing the pump toward zero displacement and in which the means for controlling displacement operate in opposition to the biasing means.

Other and further objects of the invention will become apparent from the following description and drawings, in which:

Fig. 1 is a longitudinal section through a fluid pump housing and discharge manifold embodying the invention;

Fig. 2 is a schematic diagram of the hydraulic control circuit, showing in section the pump, and the relief, relay and priming valves;

Fig. 3 is a sectional view of the outlet pressure relief valve showing the details thereof; and

Fig. 4 is an enlarged view of the upper portion of Fig. 1 showing the details of the relay valve and priming valve.

While the invention is susceptible of various modifications and alternative constructions, it is herein shown and will hereinafter be described in its preferred embodiment. It is not intended, however, that the invention is to be limited thereby to the specific construction disclosed. On the contrary, it is intended to cover all modifications and alternative constructions falling within the spirit and scope of the invention, as defined in the appended claims.

2

Pump construction

As illustrated in the drawings, the pump comprises a hollow casing having a somewhat tubular section 10 and an end section 11. Located within the casing is a cylinder block 12 having a plurality of cylinder bores 13 in which pistons 14 are reciprocable. A drive shaft 16 is rotatably mounted in the casing and carries a wobbler device 17 for converting rotary motion of the shaft into reciprocatory movement of the pistons. A valve device 18 is provided for controlling the flow of fluid to the cylinders from an inlet port 19 and from the cylinders to a plurality of discharge ports 20, one of which latter ports is provided for each of the cylinders 13.

The cylinder block 12 is generally annular in form and has an integral flange 21 positioned between the casing sections 10 and 11, the casing sections and flange being secured together by a plurality of bolts 22. The cylinder block is provided with a cylindrical recess in its right hand end (as shown in Fig. 1) to form a cylindrical valve chamber 23 having opposed parallel end faces 24 and 25. In this chamber and against these faces, the valve device 18 is located.

The shaft 16 is rotatably mounted within the casing and to this end there are provided a roller bearing 26 and a ball bearing 27 at the left hand end of the casing and a roller bearing 28 supported in the cylinder block 12, which bearings carry the shaft. The wobbler device 17 comprises an inner ring member 29 which is pivotally mounted on the shaft 16 by means of a pin 30 extending therethrough. The wobbler includes an outer ring 31 carried on the inner ring by means of roller bearings 32 and thrust bearing 32a and is arranged with a flat end face 33 in position to engage the adjacent convex ends of the pistons 14. As will be noted from the drawings, the pin 30 about which the wobbler pivots is off center with respect to the central longitudinal axis of the shaft 30 and with respect to the wobbler face. Thus, as shaft 16 is rotated an inertia load is applied to the wobbler, tending to rotate it about the pivot to a position imparting maximum stroke to the pistons. This inertia load is augmented by the hydraulic load applied to the pistons, as will be hereinafter described, and thus the wobbler tends to assume a position causing maximum stroke with rotation of the shaft 16.

Springs 34 are located in an annular recess 35 between the cylinder block and the casing 10, and are secured to an annular collar 36 which in turn is adapted to contact the ring 33 to urge

3

the wobbler to neutral position. By compressing the springs and thus moving the collar 36 to the right, the wobbler assumes a stroke-imparting position as described. For compressing the springs I mount them in a sleeve 37 slidable in the recess 25. The sleeve is provided with a shoulder 38 located in a chamber 39 formed between the sleeve and an annular member 40 secured in fluid-tight relationship to the casing 10 by a number of O-rings 40a. A fluid passage 41 is connected to the chamber 39 and to a main relay control valve 42 which is adapted to supply operating fluid under pressure thereto to move the sleeve to the right to compress the springs.

Each of the pistons has a relatively larger portion 43 adjacent its left hand end (as seen in Fig. 1) and a relatively smaller portion 44 adjacent its right hand end. The cylinders 13 are so proportioned as to engage each of the sections of the piston, and accordingly the right hand section 45 of each cylinder has a somewhat smaller diameter than the left hand end. The proportioning of the pistons provides an annular shoulder surface 46 on each piston to which oil pressure is applied to urge the pistons to the left on their intake strokes, as hereinafter described.

The valve 18 is positioned with its annular rim portion 48 in the valve chamber 23 between the cylinder ports and the radially aligned discharge ports 20 opposite thereto. The valve is given a gyratory movement by means of an eccentric pin 49 which is carried on a rotatable shaft 50 positioned in axial alignment with the shaft 16 and connected thereto by a spline arrangement 51.

The valve 18 is freely rotatable about the eccentric pin 49 and is provided with a perforated valving rim, the perforations taking the form of a plurality of openings 52 therethrough adapted to interconnect each of the cylinder ports with a predetermined different one of the discharge ports 20. The valve itself is more specifically described in the copending application of myself and Bruce H. Mossbaker filed on December 10, 1949, as Serial No. 132,292, now Patent No. 2,579,899.

Movement of the pistons on their return or suction stroke is accomplished by means of a gear pump 53 mounted upon the shaft 50 and connected by means of a passage 54 to a groove 55 in each of the cylinders 13. The groove 55 is located at the mean position of the shoulder portion 46 and thus the pressure generated by the pump 53 serves constantly to urge the pistons to the left, that is, on their suction or return strokes. Pump 53 also serves as the source of fluid pressure for operating the control system to be hereinafter described.

Where wobbler type pumps are used as fuel pumps for engines using crude oil as the fuel, impurities in the crude oil often cause the deposit of scale or other accumulations on the pistons. Such accumulations are apt to cause sticking of the pistons. I have found that accumulations of this nature are usually encountered only in a comparatively small area near the high pressure end of the piston. In order to remove such deposits I provide means for introducing a solvent therefor at the area most likely to be affected. To this end I provide a conduit 56 which may be connected to a source of solvent under pressure, which conduit connects with an annular groove 57 formed in the sidewalls of the smaller portion 45 of the cylinder. A second annular groove 58 is also provided in that portion of the cylinder spaced outwardly, that is, to the right as seen in

4

Fig. 1, from the groove 57. The annular groove 58 connects with a conduit 59 which empties into the inlet side of the pump. Solvent is introduced into the conduit 56 at a pressure somewhat less than the pressure of fluid from the pump 53 so that no tendency exists for the solvent to leak into the operating oil circuit. The solvent covers the area of the piston which reciprocates between the annular grooves to remove all accumulations which might otherwise foul the piston, and is removed through the conduit 59 to the intake side of the pump. The annular groove 58 and the conduit 59 also serve to return to the inlet any fuel on the high pressure side of the pump which leaks past the outer end of the piston.

In the particular embodiment shown eighteen pistons are provided in the pump which discharge into an equal number of discharge ports 20. The end cap 11 is provided with a manifold arrangement 60 designed to combine the eighteen discharge ports into six separate outlets by joining three ports equally spaced in the discharge port circle to form six groups of three discharge ports each. To this end the manifold is provided with six annular grooves 61, separated by O-rings 62. Slots 63 are milled in the manifold to connect each discharge port 20 to one of the six annular grooves 61. Six discharge outlets 64-69 are provided, each connected to one of the slots 63.

Pressure relief valve

Referring now to Fig. 2 of the drawings, I provide a pressure relief valve 70 in the operating fluid circuit between the gear pump 53 and the groove 55, which valve is provided with a bore 71 having a piston 72 reciprocable therein, and urged by means of a spring 73 toward the left, as seen in Fig. 2. Means in the form of a screw device 74 is provided for adjusting the tension of the spring to determine the pressure at which the relief valve opens. The piston 72 is provided with a plurality of openings 75 through the sidewalls thereof adapted when the piston is moved to the right under the pressure of oil in a chamber 76, to which the pump 53 is connected, to be aligned with an annular groove 77 in a sleeve 78 positioned at the left hand end of the bore. The sleeve is provided with a number of notches 79 connected to the groove 77 and opening to the interior of the bore. A conduit 80 opens at one end to the interior of the bore 71 and at the other end to the interior of the casing 10. The relief valve 70, of course, determines the upper limit of operating oil pressure in the circuit and serves to tank oil under pressure sufficiently high to compress spring 73 and cause rightward movement of the piston 72.

Main relay control valve

The conduit 54 is connected to the chamber 76 and to the space 55 and, by means of an intermediate conduit 81, to a main relay valve 82. The relay valve is provided with a bore 83 to which the conduit 81 opens and with a piston 84 slidable therein. Fixed to the piston 84 is a rod 85 which extends longitudinally of the bore and has its other end connected to a piston 86. Means in the form of a control spring 87, which bears against the end of the piston 86, is provided for urging the pistons to the right, as seen in Figure 2. Screw means 88 are provided for adjusting the tension of the spring 87 to determine the pressures at which both pistons will move. A slidable sleeve 90 is located in an intermediate

5

portion of the bore and provided with a plurality of openings 91 controlled by a land 92 located on the left hand end of the piston 84. The openings 91 extend radially through the sleeve and are connected by means of an annular groove 93 to the conduit 41 which in turn is connected to the chamber 39. Fixed to the rod 85 is a spring cage 94 carrying three springs 95 spaced approximately 120° apart, which springs bear against a stop member 96 in the form of an annulus surrounding the rod 85 and fixed in the sleeve 90. Three additional springs 97 are positioned in the member 94 between the springs 95 and bear against a second annular stop member 98 fixed in the other end of sleeve 90. As the springs extend beyond the cage 94, a dampening movement of the rod to the right or left is permitted before the cage comes into direct contact with the stop members. The sleeve 90 is provided with a longitudinal passage 99 which opens into a chamber 100, which in turn opens to the interior of the casing member 10. Thus, when the piston 84 is moved to the right, as seen in Figures 2 and 4, operating fluid pressure is cut off from the openings 91 and the sleeve is subjected to operating fluid pressure to move the sleeve to the left, compressing the dampening springs 95. When this occurs fluid in the chamber 39 is drained therefrom through the passage 41, openings 91, space 99, and chamber 100 to the interior of the casing.

A follow-up member 101 is pivotally mounted at 102 in the relief valve casing and has its lower end 103a bearing against the annular ring 35 of the wobbler while its upper bifurcated end 103 bears against the stop member 38.

Variable control oil pressure is supplied from a control source (not shown) by means of a conduit 105 through an outlet pressure relief valve 106 in a manner to be hereinafter explained and directed to a chamber 107 at the right hand end of the bore 83 through the medium of conduit 108. Variable control oil pressure in the chamber 107 serves to move the piston 84 to the left, as shown, uncovering the openings 91 and placing them in communication with operating oil pressure in the conduit 81 to increase the displacement of the pump. The dampening springs become compressed with movement of the piston 84 to the left and add their resistance to that of the control spring 87 to terminate the movement of the piston 84. As the wobbler increases its angle with increase in pressure in the chamber 39, the lower end 103a of the follow-up member also moves to the right to pivot the upper end to the left, allowing the sleeve 90 to shift in a follow-up manner under the tension of the springs 97. Similarly, should the wobbler angle increase without decrease in operating fluid pressure in the chamber 39, the follow-up member 101 will be pivoted in the direction just described further to decrease the tension of the springs 97 and to increase the tension of springs 95 and thus to shift the sleeve 90 slightly to the left to tank operating fluid.

Mounted on the relay valve is a priming valve 110 having a chamber 111 connected to the chamber 107 by means of a passage 112. A piston 113 is reciprocally mounted in the bore 114 of the priming valve and urged to the position shown by spring 115. The closed end of the piston 113 is provided with an orifice 116 in communication with the chamber 111 and the interior of the piston. A plurality of openings 117 is provided in the sidewalls of the piston, the openings being

6

connected to an annular groove 118 which in turn is in communication with a plurality of openings 119 formed in a sleeve 120 in which the piston reciprocates. The openings 119 are in communication with the left hand end of the bore 114, which in turn is in communication with the chamber 100 through passage 121. The tension of the spring is such as to permit air in the variable control oil circuit to pass through the orifice 116, the opening 117, the annular grooves and bore and into the passage 121. After air has been exhausted from the variable control oil system and only oil is flowing into the chamber 96, the differential pressure across the orifice 116 increases with the change in the density of the fluid to a point sufficient to overcome the tension of the spring 115 to move the piston 113 to the left, closing off communication between the annular groove 118 and the openings 119. Once pressure is established in the variable control oil circuit the priming valve remains closed during operation of the pump and control.

Outlet pressure relief valve

The outlet pressure relief valve 106 comprises a casing 130 having a bore 131 therein in which are slidable a plurality of pistonlike members 132. As seen from the drawings, each of the pistonlike members is provided with a first portion in sliding contact with the bore and with a reduced portion 133 at one end in contact with the first portion of the next adjoining member. The reduced portions 133 provide a space 134 between each pair of pistons, which space is in communication with an annular groove 135 formed in the bore and connected at one side to each outlet 64-69 and at the other side to outlets 64a-69a. As the particular embodiment of my invention shown in the drawings was designed for use with a turbine engine having six jets, each of the outlets 64a-69a is connected to an individual jet to supply fuel thereto. In order to safeguard the pump and fuel system of such an engine it is desirable to incorporate an outlet pressure relief valve to limit the maximum pressure in any outlet and to decrease fuel delivery to all nozzles equally, should pressure exceed maximum in any outlet. Thus, the device of this invention serves to limit engine output when a nozzle becomes inoperative and without subjecting the turbine structure to a condition of non-uniform heat distribution.

To this end, the rightmost piston member 132 bears against a spool valve 136 which is provided with two end portions 137 and 138 and a central portion 140 in sliding fluid-tight engagement with the bore 131 and with a reduced portion 139 between the end portion 138 and the central portion 140. The end portion 138 bears against a stop member 141 resiliently urged thereagainst by means of a spring 142 bearing against a member 143 in the right hand end of the bore and against a shoulder portion 144 secured to the member 141. The tension of the spring 142 is sufficient to maintain all of the members in the bore 131 in the position shown in Figure 2 under normal pressures in the outlets 64-69. With the members in this position, the conduit 105, which is connected to the source of variable control oil pressure, connects to an annular groove 150 formed in the casing 130, which in turn is connected by means of a plurality of passages 151 to the portion of the bore 131a in which the reduced portion 139 is located. Another annular groove 153 is also connected to the portion 131a through

a plurality of passages 154 and connects with the conduit 108 connected to the control chamber 107 in the relay valve. With the valve in the position shown in Fig. 2 variations in the control oil pressure are conducted directly through the outlet pressure relief valve to the chamber 107 to shift the piston 84 therein to control the displacement of the pump.

Should the pressure in any outlet exceed the maximum desired value, such pressure in any space 134 will serve to overcome the tension of the spring 142 and to shift all of the members in the bore located between such space 134 and the spring, including the valve 136. Movement of the valve causes the enlarged portion 140 to cover the openings 151 while simultaneously causing enlarged portion 138 to uncover an annular groove 156 in the right hand portion of the bore. The annular groove 156 is connected by means of a plurality of passages 157 to the interior 158 of that portion of the bore in which the spring 142 is located. The portion 158 is in turn connected by means of a drain 159 to the gear case, and thus variable control pressure in the chamber 107 is drained to the tank and the piston valve 84 moves to the right under the action of the control spring 87. Obviously, the effect of movement of the piston valve 84 to the right is to tank the hydraulic fluid under pressure from the cylinder 39 to permit the springs 34 to shift the wobbler to neutral position.

If desired, of course, the outlet pressure relief valve may be connected in series with the relay valve to tank the operating fluid directly through movement of the spool valve 136 rather than indirectly through reduction in variable control oil pressure.

Control oil leaking past the portion 140 enters the portion 131b of the bore to the left of the portion 140 and enters an annular groove 161 which is in communication with said portion 131b through a plurality of openings 162. As best seen in Fig. 3, the annular groove 161 is connected to the inlet 19 through the medium of passages 163 and 164.

I claim:

1. Control means for a multiple outlet wobbler type pump comprising means biasing the wobbler toward neutral position, fluid operated means opposing the biasing means and operating to increase the wobbler angle to increase the displacement of the pump, an outlet pressure relief valve having a bore, a plurality of piston-like members with each member having a portion in fluid-tight sliding engagement with the bore and a reduced portion in contact with another member to provide a space between the first portions of adjacent members, means connecting each outlet with the bore at said spaces to subject each member to the opposed pressure in two outlets, a spring holding the members against movement in the bore under normal operating outlet pressure and yieldable under excessive pressure in any outlet to permit sliding movement of a member subjected thereto, a source of control fluid under pressure, a relay valve connected to the source of operating fluid, said relay valve having a control fluid chamber and a valving member movable in response to increasing control fluid pressure in the chamber to direct operating fluid to the opposing means to increase pump displacement and said valving member being movable in response to decreasing control fluid pressure in the chamber to tank operating fluid from

the opposing means, a passage connecting the source of control fluid to one end of the relief valve bore, a second passage connecting said end of the bore to the control chamber, a third passage connecting said end of the bore to a drain, and a control valve in said end of the bore, said control valve being in contact with a piston-like member and movable therewith to control the passages.

2. A control for a multiple outlet wobbler type pump comprising a source of control fluid, means biasing the wobbler toward neutral position, a source of actuating fluid, control means connected to the source of actuating fluid to be operated thereby in opposition to the biasing means to increase the wobbler angle to increase the displacement of the pump, a member movable in response to changes in control fluid pressure to control the connection between the source of actuating fluid and the control means, an outlet pressure relief valve having a bore, a plurality of piston-like members with each member having a portion in fluid-tight sliding engagement with the bore and a reduced portion in contact with another member to provide a space between the first portions of adjacent members, means connecting each outlet with the bore at said spaces to subject each member to the opposed pressure in two outlets, a spring holding the members against movement in the bore under normal operating outlet pressure and yieldable under excessive pressure in any outlet to permit sliding movement of a member subjected thereto, a passage connecting the source of control fluid to one end of the bore, a second passage connecting said end of the bore to the member, and a control valve in said end of the bore, said control valve being movable with movement of a member to control the passages.

3. A control for a multiple outlet wobbler type pump comprising means biasing the wobbler toward neutral position, a source of actuating fluid under pressure control means connected to the source to be actuated thereby in opposition to the biasing means to increase the wobbler angle to increase the displacement of the pump, an outlet pressure relief valve having a bore, a plurality of piston-like members in the bore with each member having a portion in fluid-tight sliding engagement with the bore and a reduced portion in contact with another member to provide a space between the first portions of adjacent members, means connecting each outlet with the bore at said spaces to subject each member to the opposed pressure in two outlets, a spring holding the members against movement in the bore under normal operating outlet pressure and yieldable under excessive pressure in any outlet to permit sliding movement of a member subjected thereto, and valve means controlling the connection between the source and the control means operating in response to movement of a member to divert actuating fluid from the control means to permit the biasing means to shift the wobbler to neutral position.

4. A control for a multiple outlet variable displacement pump comprising means for controlling pump displacement, an outlet pressure relief valve having a bore, a plurality of piston-like members in the bore with each member having a portion in fluid-tight sliding engagement with the bore and a reduced portion in contact with another member to provide a space between the first portions of adjacent members, means connecting each outlet with the bore at said spaces

to subject each member to the opposed pressure in two outlets, a spring holding the members against movement in the bore under normal operating outlet pressure and yieldable under excessive pressure in any outlet to permit sliding movement of a member subjected thereto, and means operating in response to movement of a member to actuate the control means to reduce pump displacement.

5. A control for a multiple outlet wobbler type pump comprising means biasing the wobbler toward neutral position, a source of actuating fluid under pressure, control means connected to the source to be actuated thereby in opposition to the biasing means to shift the wobbler to a stroke-imparting position, a plurality of members each subject to the pressure in two outlets and movable in response to differences in pressure between said outlets, and means controlling the connection between the source and the control means and operating in response to movement of a member to divert actuating fluid from the control means to permit the biasing means to shift the wobbler to neutral position.

6. A control for a multiple outlet variable displacement pump comprising means for controlling pump displacement, means sensing the pressure in each outlet and movable in response to excessive pressure in any one of the outlets and means operating in response to movement of the movable means to actuate the control means to reduce pump displacement.

7. A control for a wobbler type pump comprising a wobbler biased toward maximum stroke position, an annular cylinder, an annular piston in the cylinder and contacting the wobbler, spring means urging the piston toward movement in a direction to shift the wobbler to neutral position, a relay valve having a bore, a first passageway in the bore communicating with a source of operating fluid under pressure, a second passageway in the bore communicating with the annular cylinder, a drain outlet from the bore, a first valve member movable in the bore and having a port in constant communication with the second passageway, a second valve member controlling the port and movable in the bore in response to a variable control force to direct operating fluid to said cylinder to move the piston against the tension of the springs, a follow-up member movable with changes in wobbler position and dampening means resiliently connecting said valve members to each other and to the follow-up member for movement together.

8. A control for a wobbler type pump comprising a wobbler biased towards maximum stroke position, an annular cylinder, an annular piston in the cylinder and contacting the wobbler, spring means urging the piston toward movement in a direction to shift the wobbler to neutral position, a relay valve having a bore, a first passageway in the bore communicating with a source of operating fluid under pressure, a second passageway in the bore communicating with the annular cylinder, a drain outlet from the bore, a sleeve valve member movable in the bore and having a port in constant communication with the second pas-

sageway, a piston valve member controlling the port and movable in the bore in response to a variable control force to direct operating fluid to said cylinder to move the annular piston against the tension of the springs, a follow-up member bearing against the sleeve valve and movable with changes in wobbler position, and a plurality of dampening springs resiliently connecting said valve members to each other and to the follow-up member for movement together.

9. A servo type control valve for a wobbler type fluid pump comprising fluid operated means for controlling the wobbler angle, a valve having a bore, a piston valve having a valving land slidable in the bore, means for applying a variable control force to the piston valve to slide the piston valve in the bore, a sleeve valve slidable in the bore and having a valving port controlled by the land, fluid passageways controlled by the land and connecting the control means with a source of operating fluid under pressure and a drain, an arm movable with changes in wobbler angle and bearing against the sleeve valve, and a plurality of dampening springs having both ends bearing against the sleeve valve and being connected to the piston valve resiliently to connect said sleeve valve and the piston valve together for movement with the arm in a follow-up manner.

10. A servo type control valve comprising a valve casing having a bore, a piston valve having a valving land slidably mounted in the bore, means for applying a variable control force to the piston valve to slide the piston valve in the bore, a sleeve valve slidable in the bore and having a valving port controlled by the land, a control spring, a control rod connecting the spring to the piston valve for operation in opposition to the control force, a dampening spring secured to the rod, an arm movable in response to changes in position of the member to be controlled, a first stop secured to the sleeve valve and located intermediate one end of the dampening spring and the arm, and a second stop secured to the sleeve valve and located at the other end of the dampening spring.

11. A servo type control valve comprising a member movable in response to a variable control force to move a member to be controlled, a second member movable in a follow-up manner with the first member in response to movement of the member to be controlled, resilient means operating against the first member in opposition to the control force, and a dampening spring connecting the first member to the second member, said spring operating against the first member in opposition to increases in the control force and movable in a follow-up manner with movement of the member to be controlled.

LUDWIG T. STOYKE.

REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
1,137,877	Manly et al.	May 4, 1915