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AUTOMATIC CONTROL FOR VARIABLE DISPLACEMENT PUMP

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2 Sheets-Sheet 2

FIG. 3

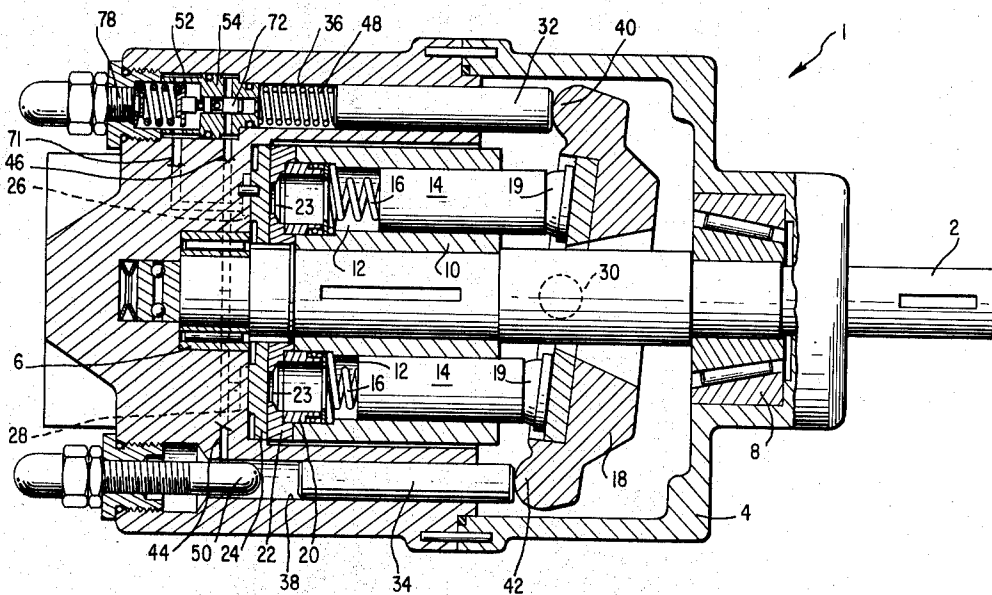
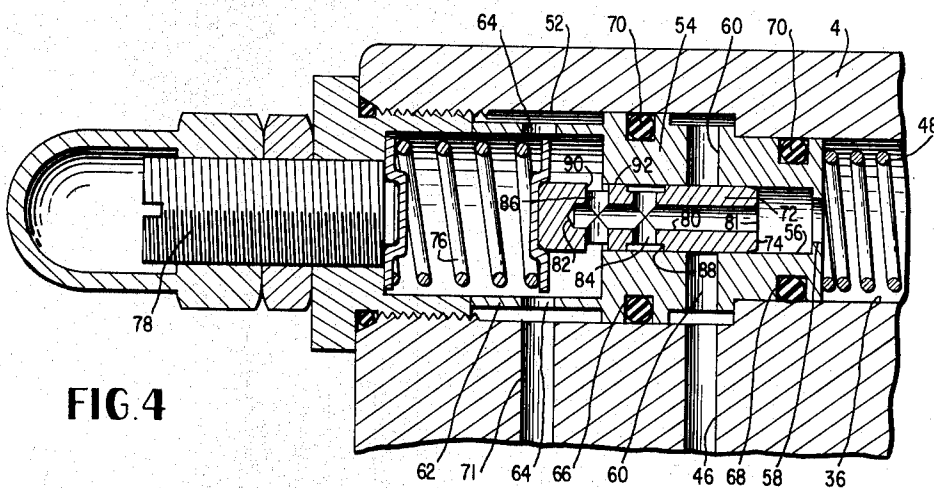


FIG. 4



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**AUTOMATIC CONTROL FOR VARIABLE
DISPLACEMENT PUMP**Michael A. D'Amato, Grand Ave. and 4th St.,
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7 Claims. (Cl. 103—38)

This invention relates to an automatic control for a variable displacement pump. More particularly, the invention concerns a pressure responsive regulator which so controls the pump that the latter delivers maximum flow until a predetermined pressure in the output of the pump is reached, and thereafter limits the delivery and hence the output pressure to the maximum desired level.

An object of the invention is to provide, in a variable displacement pump wherein the delivery of the pump is governed by the tilt angle of a swash plate, a pair of control plungers forced against diametrically opposite sides of the plate by the pressure of fluid from the high pressure or output side of the pump, wherein one of the plungers is slightly larger than the other so as normally to predominate and thereby tilt the swash plate to a predetermined maximum tilt angle resulting in maximum delivery. By providing a pressure-responsive control valve in the fluid connection between the high pressure side of the pump and the cylinder of the larger of the control plungers so as to switch the connection of the larger cylinder to the low-pressure side of the pump in response to the attainment of a predetermined maximum delivery pressure, the smaller of the two control plungers then overpowers a spring and decreases the tilt angle of the swash plate and thus decreases the delivery of the pump. The primary objectives are the provisions of a very fast but smooth-acting automatic control which will compensate, but not overcompensate; which will normally apply constant differential fluid forces against diametrically opposite sides of the swash plate to avoid flopping or chattering thereof; which starts and maintains the pump at maximum delivery until predetermined output pressure is reached and thereafter quickly regulates the delivery so as to maintain no more and no less than a predetermined output pressure; and which can be easily adjusted to vary the maximum delivery pressure, all without relief or bypass valves in the main fluid circuit of the pump.

The pump in which the control is incorporated is disclosed in my co-pending application Serial No. 230,940, filed October 16, 1962, entitled Variable Displacement Pump, now Patent No. 3,175,510; and the control is an improvement over the type disclosed in the patent to Ifield, No. 2,455,062.

These and other objects will be apparent from the following specification and accompanying drawings, in which:

FIG. 1 is a longitudinal cross sectional view of a pump embodying the invention, with the parts shown in start-up position;

FIG. 2 is an enlarged fragmentary view of the regulator valve and nearby parts in start-up position;

FIG. 3 is a view similar to FIG. 1, but with the parts shown in the position immediately after maximum desired delivery pressure is attained; and,

FIG. 4 is an enlarged fragmentary view of the regulator valve and nearby parts in FIG. 3 condition.

Referring now to the drawings, in which like reference numerals denote similar elements, the pump 1 in which the invention is incorporated has a drive shaft 2 rotatably mounted in casing 4 by bearings 6 and 8. Ridged with drive shaft 2 and rotating therewith is a rotor 10 having seven axial cylinders 12 in which pistons 14 reciprocate. The pistons are biased by springs 16 against a swash plate

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18, end bearing knuckles 19 being provided for sliding against the swash plate. At the port ends of cylinders 12, rotor 10 is mechanically coupled by sealing sleeves 20 to a rotating wear plate 22 having therein ports 23 which register with the port ends of cylinders 12. Wear plate 22 slides against a fixed plate 24 having a pair of arcuate kidney-shaped inlet and delivery ports 26 and 28, respectively, connecting with inlet and delivery connections (not shown). Swash plate 18 is mounted by pivots 30 in casing 4 so that it may be tilted from a position in which its working surface lies normal to the axis of the shaft 2 to the extreme angle of tilt illustrated in FIG. 1. Pump 1, when utilizing the regulator described below, is intended for unidirectional fluid flow, and it will be understood that when the working surface of swash plate 18 is normal to the axis of shaft 2, no pumping occurs when rotor 10 turns, and when the swash plate is tilted to the extreme angle illustrated in FIG. 1, the pump has maximum delivery. This invention is concerned with the automatic regulator for controlling the tilt angle of swash plate 18 and, hence, the delivery of the pump.

Disposed on opposite sides of casing 4 are plungers 32, 34 respectively sliding in cylinders 36, 38 and bearing at their ends against ears 40, 42 on diametrically opposite sides of swash plate 18. Cylinder 38 is constantly connected to the high pressure side of the pump by a duct 44 leading to delivery port 28 and, at least during start-up, so also is cylinder 36 connected to the high pressure side of the pump by a duct 46. Plunger 32 and its cylinder 36 are slightly larger in diameter than plunger 34 and cylinder 38 and plunger 32 is also biased against swash plate ear 40 by a spring 48 so that when the pump is at rest and during start-up until maximum desired pressure at delivery port 28 is reached, plunger 32 overpowers plunger 34 and pushes the latter back against the end of an adjustable stop screw 50 so that swash plate 18 assumes its maximum angle of tilt and the pump delivers maximum flow.

Referring particularly to FIGS. 2 and 3, cylinder 36 has an enlargement 52 in which a shell 54 is seated. Shell 54 has an axial bore 56 running from end to end, the forward end of the axial bore being surrounded by an inwardly flanged lip 58, and a cross bore 60 intercepts axial bore 56. At its rear end shell 54 has an axially extending skirt 62 with a cross bore 65 which intercepts the interior of the skirt. Annular grooves 66 and 68 on opposite sides of cross bore 60 accommodate rings 70 which seal the shell in cylinder 36 and enlargement 52 so that cross bore 60 communicates at its outer ends to a duct 46 leading to the high pressure side of the pump. The skirt end of shell 54 communicates with the low pressure side of the pump by a duct 71 which leads to inlet port 26.

Slidable lengthwise in the axial bore 56 of shell 54 is a piston valve 72 whose forward end 74 is normally forced against the inwardly flanged lip 58 on shell 54 by a compression spring 76 which engages the rear end of the piston valve. The compression of spring 76 is adjustable by an adjustment screw 78 against which spring 76 backs. Piston valve 72 has an axial bore 80 with an open front end 81 and blind rear end 82. Axially spaced cross bores 84 and 86 connect with axial bore 80 and terminate at their outer ends in annular grooves 88 and 90. Thus, when piston valve 72 is forced to its extreme forward position by spring 76, duct 46 leading from the high pressure side of the pump is connected to cylinder 36 rearwardly of piston 32 by cross bore 60 in shell 54, annular groove 88, cross bore 84 and axial bore 80 of piston valve 72. In this position (FIGS. 1 and 2) annular groove 90 is blanked by the surface 92 around the rear portion of the axial bore 56 of shell 54 and hence no fluid enters or leaves via cross bore 86. However,

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when piston valve 72 moves rearwardly (FIGS. 3 and 4) annular groove 88 is blanked by surface 92 so that communication between cylinder 36 and duct 46 to the high pressure side of the pump is cut off while communication between cylinder 36 and the low pressure side of the pump is established via axial bore 80, cross bore 86, annular groove 90 of piston valve 72, groove 90 then lying within the confines of skirt 62 on shell 54.

As previously noted, when the pump is at rest, spring 48 forces plunger 32 forwardly against the swash plate ear 40 so as to tilt swash plate 18 to the extreme angular position of FIG. 1, thereby driving piston 34 rearwardly against the end of adjustable stop screw 50. Thus, when the pump starts it delivers maximum flow. Since cylinders 36 and 38 are both connected to the high pressure side of the pump via ducts 44 and 46, swash plate 18 is clamped at its extreme tilt angle by the combined forces of spring 48 and plunger 32, which is larger than plunger 34 and hence plunger 32 applies an overpowering force against plunger 34. However, when the pressure in the delivery port 28 rises to a desired level, piston valve 72 is driven rearwardly against the bias of spring 76 so that communication between cylinder 36 and the high pressure side of the pump is cut off, and communication with the low pressure side is established. In this condition, plunger 34 needs only to overcome the opposing of spring 48 to pivot swash plate 18 to a lesser angle of tilt, thus reducing the delivery and hence the output pressure of the pump, so that a condition of equilibrium is maintained by the slight forward and rearward movements of piston valve 72. The maximum operating pressure can be predetermined by adjustment of screw 78, and the maximum delivery rate can be determined by adjustment of stop screw 50.

The invention is not limited to the details disclosed and described hereinbefore, but embraces all substitutions, modifications and equivalents within the scope of the following claims.

I claim:

1. In a variable displacement pump, including a casing having inlet and delivery ports and a tiltable swash plate, the improvement comprising first and second cylinders in said casing, said cylinders each having open and closed ends, first and second plungers respectively sliding in the open ends of said cylinders, said plungers having outer ends respectively engaging diametrically opposite sides of said swash plate and inner ends facing the closed ends of their respective cylinders whereby a force applied to the inner end of said first plunger tends to slide the same outwardly and thereby tilt the swash plate to decrease delivery and a force applied to the inner end of the second plunger tends to slide the same outwardly and tilt the swash plate to increase delivery, compression spring means in the inner end of said second cylinder engaging the inner end of said second plunger and applying an out-

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ward bias thereto, a fluid connection between the inner end of the first cylinder and said delivery port, first and second fluid conduits respectively leading from said delivery and inlet ports, and pressure responsive valve means normally connecting the inner end of the second cylinder to said first conduit and being responsive to the pressure of fluid therein for alternatively connecting the inner end of said second cylinder to said second conduit upon attainment of predetermined fluid pressure.

2. The combination claimed in claim 1, said second plunger being of larger diameter than the first plunger.

3. The combination claimed in claim 2, and adjustable stop means in the inner end of said first cylinder for limiting the inward movement of said first plunger.

4. The combination claimed in claim 1, said pressure responsive valve comprising a bushing engaging in the closed end of said second cylinder and further including a piston sliding in said bushing, and a compression spring engaging between said piston and the closed end of said second cylinder.

5. In a variable displacement fluid pressure energy translating device which includes high and low pressure fluid passages and a control member movable from a first extremity to a second extremity for continuously varying the displacement of the device from minimum to maximum, the improvement comprising first and second cylinders respectively containing first and second plungers engaging said control member in opposite senses for moving the same respectively towards said first and second extremities, spring means for biasing said control member towards said second extremity, a fluid connection between the first cylinder and said high pressure passage, and means including a valve responsive to the pressure of fluid in said high pressure passage for normally connecting the second cylinder to said high pressure and responding to pressure above a predetermined maximum for alternatively connecting said second cylinder to the low pressure passage.

6. The combination claimed in claim 5, said second cylinder and plunger being of larger effective diameter than the first cylinder and plunger.

7. The combination claimed in claim 6, said spring means comprising a compression spring in said second cylinder engaging said second plunger.

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