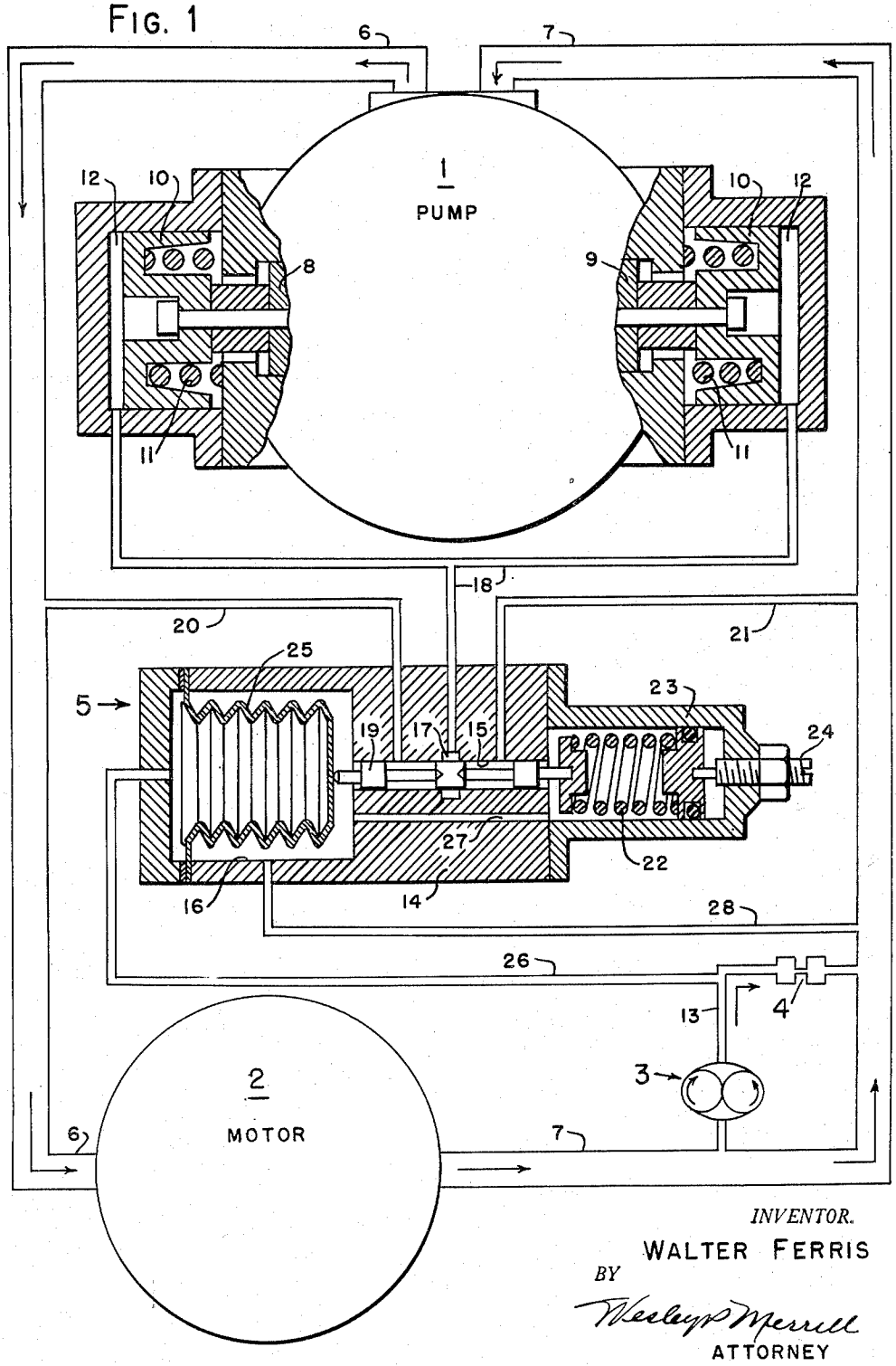
March 10, 1953 W. FERRIS 2,630,681

ROTARY PUMP AND MOTOR HYDRAULIC DRIVE HAVING A SUBSTANTIALLY CONSTANT OUTPUT SPEED

Filed Nov. 4, 1950 3 Sheets-Sheet 1

FIG. 1



INVENTOR.

WALTER FERRIS

BY

Wesley P. Merrill

ATTORNEY

March 10, 1953 W. FERRIS 2,630,681

ROTARY PUMP AND MOTOR HYDRAULIC DRIVE HAVING A SUBSTANTIALLY CONSTANT OUTPUT SPEED

Filed Nov. 4, 1950 3 Sheets-Sheet 2

FIG. 2

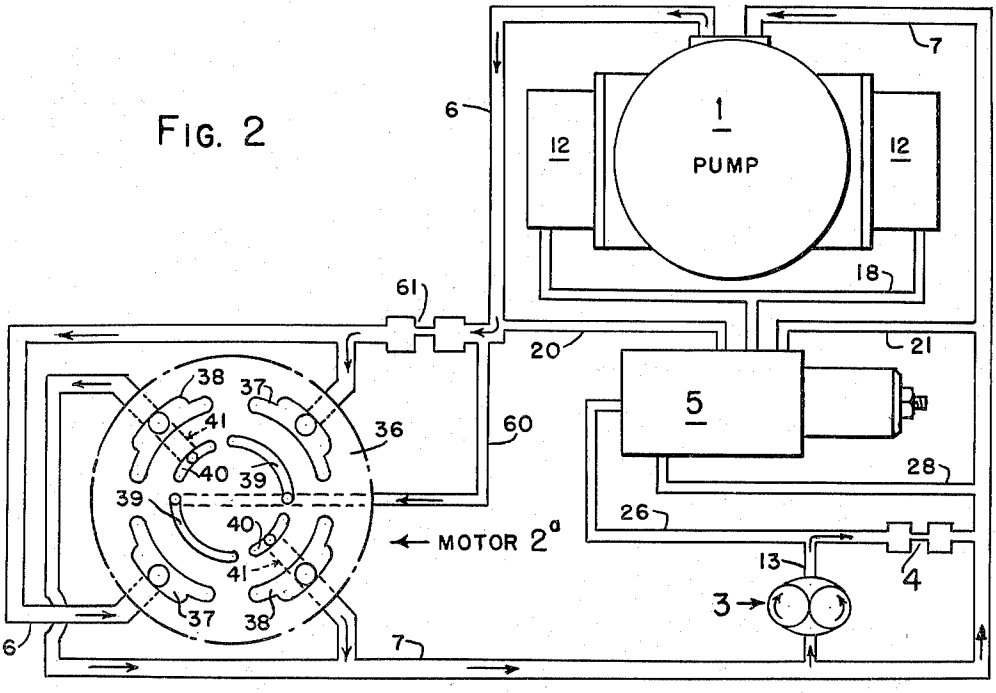
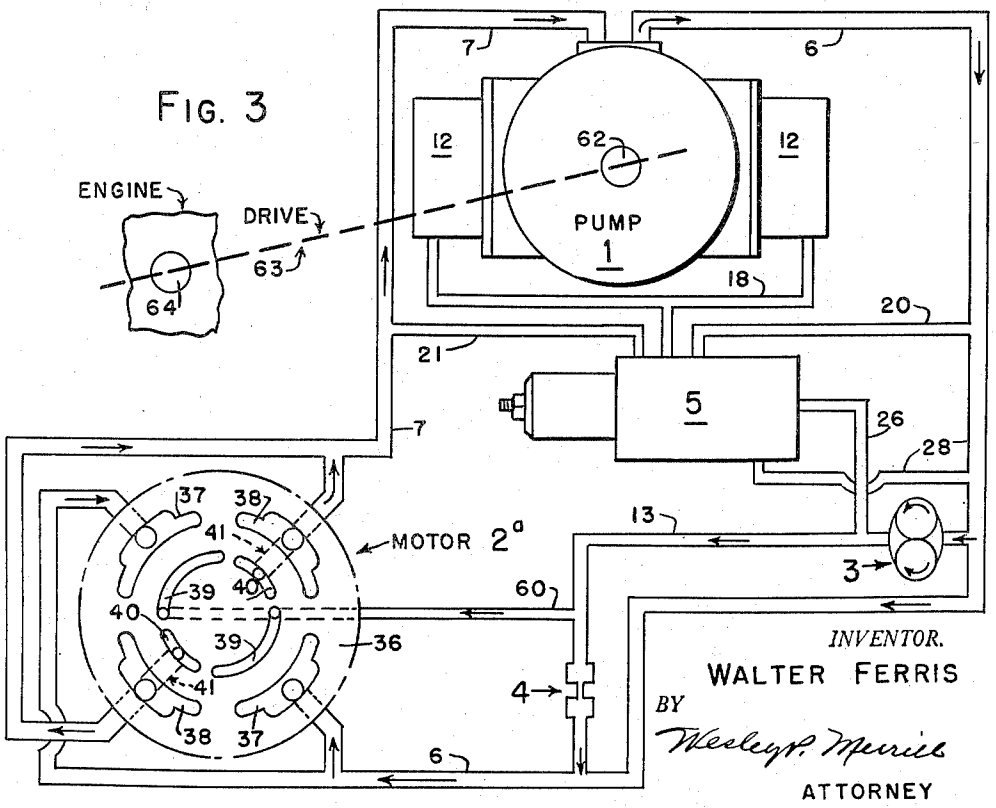


FIG. 3



INVENTOR.
WALTER FERRIS
BY
Wesley P. Morris
ATTORNEY

March 10, 1953 W. FERRIS 2,630,681

ROTARY PUMP AND MOTOR HYDRAULIC DRIVE HAVING A SUBSTANTIALLY CONSTANT OUTPUT SPEED

Filed Nov. 4, 1950 3 Sheets-Sheet 3

FIG. 5

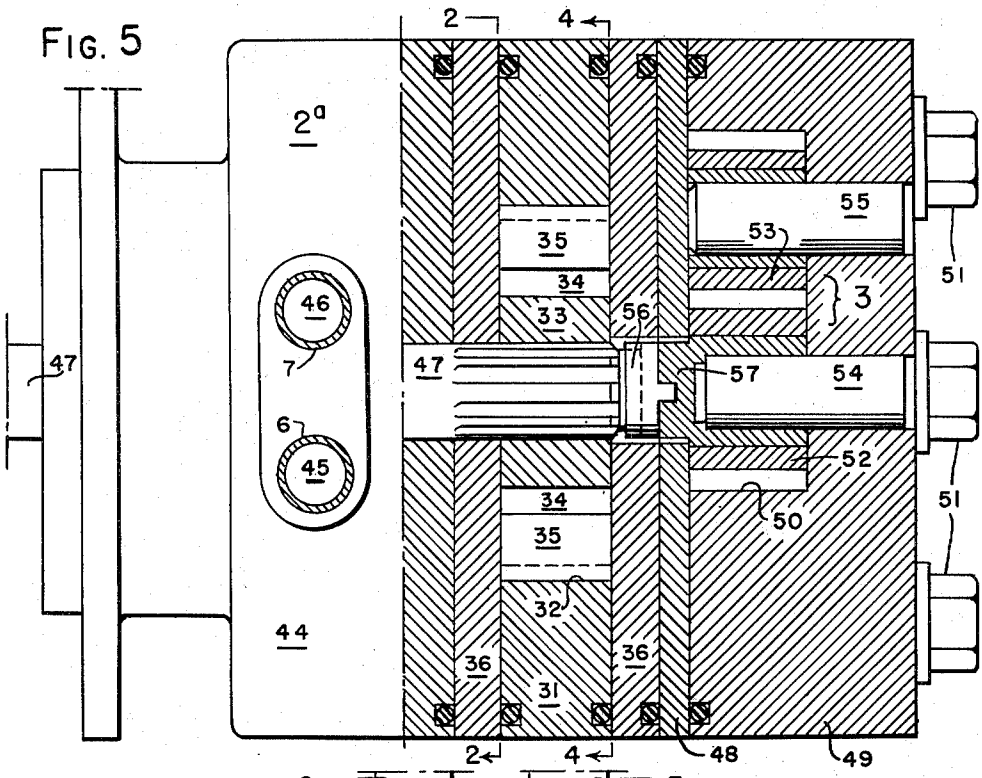
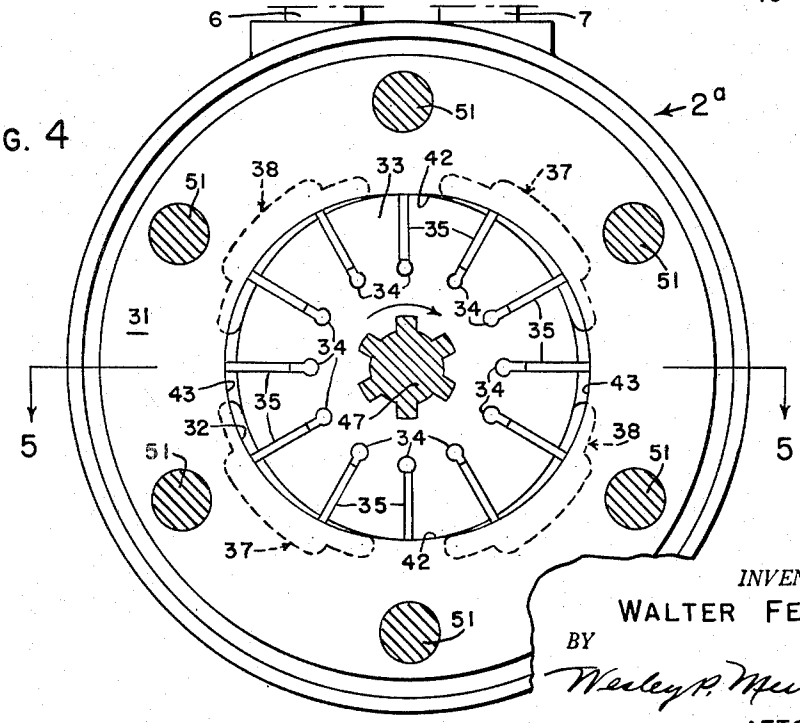


FIG. 4



INVENTOR.
WALTER FERRIS
BY
Wesley P. Murrill
ATTORNEY

Patented Mar. 10, 1953 2,630,681

UNITED STATES PATENT OFFICE

2,630,681

ROTARY PUMP AND MOTOR HYDRAULIC DRIVE HAVING A SUBSTANTIALLY CONSTANT OUTPUT SPEED

Walter Ferris, Milwaukee, Wis., assignor to The Oilgear Company, Milwaukee, Wis., a corporation of Wisconsin

Application November 4, 1950, Serial No. 194,160

12 Claims. (Cl. 60—53)

1

This invention relates to hydraulic drives of the type which includes a motor for driving a load, a pump for supplying liquid to the motor to energize the same and means for maintaining the speed of the motor within a narrow speed range regardless of wide variations in the speed at which the pump is driven.

An object of the invention is to provide a hydraulic drive of the above type which is particularly adapted for driving refrigerating apparatus, which is carried by a vehicle, from the power plant which drives the vehicle.

Another object is to provide a drive of the above type in which the pump and the motor may be of the sliding vane type.

Another object is to provide a drive of the above type which is light in weight, compact and economical to manufacture.

Other objects and advantages will appear from the description hereinafter given of hydraulic drives in which the invention is embodied.

According to the invention in its principal aspect, the displacement of the pump is varied in response to variations in the drop in pressure across an orifice through which liquid is discharged by an auxiliary pump which is driven in unison with the motor.

The invention is exemplified by the drives shown schematically in the accompanying drawings in which the views are as follows:

Fig. 1 is a diagram of the principal parts of the hydraulic circuit of a drive in which the invention is embodied and in which the vanes of the motor are urged outward against the vane track by springs.

Fig. 2 is a circuit diagram of a drive similar to that shown in Fig. 1 but in which the motor vanes are moved outward in response to the drop in pressure across an orifice through which liquid flows from the pump to the motor, the motor being represented by a diagram of the main ports and the vane slot ports in its cheek plate arranged in the plane indicated by the line 2—2 of Fig. 5.

Fig. 3 is a circuit diagram of a drive similar to that shown in Fig. 2 but in which the motor vanes are moved outward and the displacement of the pump is varied in response to the drop in pressure across a single orifice.

Fig. 4 is a transverse section through a hydraulic motor which may be employed in the drives shown in Figs. 2 and 3, the view being taken on the line 4—4 of Fig. 5.

Fig. 5 is in part a top plan view of the motor shown in Fig. 4 and in part a horizontal section taken on the line 5—5 of Fig. 4.

2

For the purpose of illustration, the invention will be explained as being embodied in a drive in which the motor is employed to drive a refrigerating apparatus which is carried by a motor truck and the pump is driven by the engine of the truck but it is to be understood that the invention is not limited to such use as a drive embodying the invention may be employed to drive a load and to maintain the speeds of the load within a narrow speed range regardless of variations in the speed of the pump driving means or regardless of variations in the load on the motor which tend to cause variations in the motor speed.

Figure 1

The drive includes a variable displacement pump 1 which is driven by the engine of a refrigerator truck as indicated in Fig. 3, a hydraulic motor 2 which is energized by liquid from pump 1 and drives the truck refrigerating apparatus (not shown), a small pilot pump 3 which is driven in unison with motor 2 and discharges through an orifice 4, and a pressure responsive control 5 which effects regulation of the displacement of pump 1 in response to variations in the drop in pressure across orifice 4.

Any suitable type of variable pump may be employed but, in order to keep the weight and overall dimensions of the pump at minimum, pump 1 preferably is of the sliding vane type shown in Patent No. 2,238,062. However, the pump used in practice is provided with a telescoping vane track such as that shown in Patent No. 2,538,193 instead of a track having flexible sections as shown in Patent No. 2,238,062. Pump 1 has its outlet connected to the inlet of motor 2 by a channel 6 and its inlet connected to the outlet of motor 2 by a channel 7 which is also connected to a tank (not shown) from which pump 1 may draw liquid to make up for leakage losses.

The displacement of pump 1 is determined by the positions of two diametrically opposed bridges 8 and 9 which form parts of the vane track of the pump. Pump displacement is maximum when both bridges are in their outermost positions, pump displacement is reduced when one or both bridges are moved inward, and pump displacement is zero when both bridges are in their innermost positions. Each of bridges 8 and 9 is fixed for movement with a piston 10 which is urged outward by a spring 11 and is fitted in a cylinder 12 attached to the pump casing. When the pump is operating, bridges 8 and 9 are also urged outward by pump pressure. Springs 11 normally hold bridges 8 and 9 in their outermost or maximum displacement positions.

The arrangement is such that, when liquid under pressure is supplied to cylinders 12, pistons 10 will move bridges 8 and 9 inward to reduce the displacement of pump 1, and then when liquid is permitted to escape from cylinders 12, springs 11 will move bridges 8 and 9 outward to increase the displacement of pump 1.

Motor 2 may be of any suitable type but, in order to keep its weight and dimensions at minimum, the motor used in practice is of the sliding vane type and is similar to the motor shown in Figs. 4 and 5 except that its vanes are urged outward against the vane track by springs as shown in Patent No. 2,357,333. Pilot pump 3 has been shown separate from motor 2 but in practice it is arranged within the casing thereof and driven in unison therewith as shown in Fig. 5. Also, orifice 4 is arranged within the casing of motor 2. Pump 3 has its inlet connected to discharge channel 7 and its outlet connected by channel 13 to the inlet of orifice 4 the outlet of which is connected to channel 7 so that when driven pump 3 will draw liquid from channel 7 and discharge it through orifice 4 back into channel 7.

Control 5 includes a body 14 having formed therein a small axial bore 15, a large chamber 16 at one end of bore 15 and a port 17 formed in the wall of bore 15 and connected to both of cylinders 12 by a channel 18. A valve 19 is fitted in bore 15 to control communication between channel 18 and two channels 20 and 21 which communicate with bore 15 at opposite sides of port 17 and are connected to channels 6 and 7 respectively.

Valve 19 is urged toward the left by a spring 22 arranged in a cap 23 which is fastened to the end of body 14 and is provided in its outer end with a screw 24 for adjusting the resistance of spring 22. Valve 19 is adapted to be moved toward the right in response to an increase in the drop in pressure across orifice 4 such as by means of a piston having one of its ends in contact with the end of valve 19 and its opposite ends subjected to the pressures prevailing at opposite sides of orifice 4. Preferably however, the end of valve 19 engages the closed end of a bellows type actuator or "sylphon" 25 which is arranged in chamber 16 and has its interior connected by a channel 26 to channel 13.

The interior of cap 23 is connected to chamber 16 by a channel 27, so that both ends of valve 19 are subjected to the same pressure, and chamber 16 is connected by a channel 28 to the same part of the circuit to which the outlet of orifice 4 is connected so that, when pilot pump 3 is running, the force exerted by "sylphon" 25 upon valve 19 is proportional to the drop in pressure across orifice 4. In the present instance, channel 28 and the outlet of orifice 4 are connected to channel 7 in which the pressure is substantially zero so that the force exerted by "sylphon" 25 upon valve 19 is substantially proportional to the pressure created by pump 3 in discharging liquid through orifice 4.

Spring 22 and "sylphon" 25 are so proportioned and spring 22 is initially so adjusted by turning screw 24 that the pressure in sylphon 25 need exceed the pressure in chamber 16 by only a small amount, such as 25 p. s. i., to enable "sylphon" 25 to hold valve 19 in its central or neutral position in which it blocks communication between channel 18 and channels 20 and 21.

When the drive is idle, there is no pressure in "sylphon" 25. Therefore, spring 22 will hold valve 19 to the left of its neutral position so that channel 18 is open to channel 21 and springs 11 will hold pump 1 at its maximum displacement because there is no pressure in cylinders 12.

When pump 1 is started, it will deliver liquid through channel 6 to motor 2 and cause motor 2 to operate and to return liquid to pump 1 through channel 7. If pump 1 is driven from the engine of a refrigerator truck, as indicated in Fig. 3, and if motor 2 is employed to drive the refrigerating apparatus of the truck, the truck engine is so adjusted that when running at its idling speed it will drive pump 1 fast enough to enable pump 1 to discharge liquid at the rate required to drive motor 2 at the desired speed, that is, the speed at which motor 2 will drive the refrigerating apparatus at the correct speed.

Since pilot pump 3 is driven in unison with motor 2, it will draw liquid from channel 7 and discharge it through channel 13 and orifice 4 back into channel 7 and the pressure created by pump 3 in forcing liquid through orifice 4 will extend through channel 26 into "sylphon" 25. Orifice 4 is so proportioned that, when motor 2 is running at the desired speed, pump 3 will create the pressure, such as 25 p. s. i., required to enable "sylphon" 25 to move valve 19 into its neutral position against the resistance of spring 22.

Then when the truck engine is accelerated and drives pump 1 at a faster speed, pump 1 will momentarily discharge liquid at a faster rate and thereby momentarily increase the speed of motor 2 and pump 3. Increasing its speed causes pump 3 to force liquid through orifice 4 at a faster rate and, since the drop in pressure across an orifice is substantially proportional to the square of the velocity of the liquid flowing therethrough, the pressure created by pump 3 will increase and enable "sylphon" 25 to move valve 19 toward the right to partially uncover port 17. Then high pressure liquid will flow from channel 6 through channel 20, control 5 and channel 18 into cylinders 12 and cause pistons 10 to reduce the displacement of pump 1 and thereby reduce the speed of motor 2 and pump 3 until the pressure drop across orifice 4 is reduced to its initial value, such as 25 p. s. i., at which time motor 2 is again running at the desired speed. Decreasing the pressure drop across orifice 4 to its initial value reduces the force exerted by "sylphon" 25 and enables spring 22 to return valve 19 to its neutral position where it will remain until the speed of motor 2 again varies from the desired speed.

When the truck engine is decelerated, pump 1 will be driven at a slower speed and will momentarily discharge liquid at a slower rate, thereby momentarily decreasing the speed of motor 2 and pump 3. Decreasing the speed of pump 3 causes the pressure in "slyphon" 25 to drop and enable spring 22 to move valve 19 toward the left to partially uncover port 17. Then liquid can flow from cylinders 12 through channel 18, control 5 and channel 21 into return channel 7, thereby permitting springs 11 to increase the displacement of pump 1 which will increase the speed of motor 2 and pump 3 until the pressure drop across orifice 4 is increased to its initial value, such as 25 p. s. i., at which time motor 2 is again running at the desired speed. Increasing the pressure drop across orifice 4 to its initial value enables "sylphon" 25 to return valve 19 to its initial position where it will remain until

the speed of motor 2 varies again from the desired speed.

Each time the speed of pump 1 varies and causes a variation in the speed of motor 2, the control will function in the above described manner to vary the displacement of pump 1 just enough to effect correction of the variation in motor speed. If the load on motor 2 should vary and cause a variation in the speed of motor 2, there would be a corresponding variation in the speed of pilot pump 3 and, consequently, a variation in the drop in pressure across orifice 4 which would cause control 5 to effect adjustment of pump 1 to correct the variation in the speed of motor 2 in the same manner as when the variation in motor speed is due to a variation in the speed of pump 1. The control will thus maintain the speed of motor 2 within a narrow speed range regardless of whether the speed of pump 1 is constant or variable and regardless of whether the load on motor 2 is constant or variable.

Figures 4 and 5

The motor shown in these figures, which has been indicated in its entirety by the reference numeral 2^a, includes a spacer ring 31 having an approximately elliptical vane track 32 formed upon its inner periphery, a rotor 33 arranged within spacer ring 31 and provided with a plurality of radial vane slots 34, and a vane 35 slidably fitted in each slot and having its outer end held against vane track 32 when the motor is operating as will presently be explained.

Spacer ring 31 and rotor 33 are arranged between two identical cheek plates 36 each of which is provided with two diametrically opposed inlet ports 37 and two outlet ports 38 which are spaced 90° from ports 37. Each cheek plate 36 also has a vane slot port 39 formed therein radially inward from each inlet port 37 and a vane slot port 40 formed therein radially inward from each outlet port 38 as indicated in Fig. 2 in which motor 2^a has been represented by a face view of one of the cheek plates 36, the view being taken on the line 2—2 of Fig. 5 but drawn to a smaller scale and with the outer peripheral portion of the cheek plate broken away.

Main ports 37 and 38 extend completely through each cheek plate but the vane slot ports 39 and 40 are formed only in the inner faces of the cheek plates. Each vane slot port 39 is supplied with liquid at a pressure higher than the pressure in inlet port 37 as will presently be explained. Each vane slot port 40 is connected to the radially outward outlet port 38 by a groove 41 formed in the outer face of the cheek plate. Vane slot ports 39 and 40 are on the same radius as the inner ends of vane slots 34 so that each vane slot registers with ports 39 and 40 alternately as rotor 3 rotates.

Vane track 32 differs from the vane track of pump 1 in that it is rigid and has a fixed length while the vane track of pump 1 is extensible and has a variable length. As previously explained, vane track 32 is approximately elliptical. The portion of vane track 32 between the adjacent ends of ports 37 and 38 at the smallest diameter of the ellipse constitute "sealing bridges" 42 and the portion of vane track 32 between the adjacent ends of ports 37 and 38 at the greatest diameter of the ellipse constitute "working bridges" 43 which correspond to the bridges 8 and 9 of pump 1 but are stationary.

When the motor is operated, at least one vane 35 is always in contact with each of bridges 42 and 43 and is positively held thereagainst due to its inner edge being subjected to the pressure in a vane slot port 39. The vanes in contact with the bridges provide seals between ports 37 and 38 so that no liquid can flow from a port 37 into a port 38 without rotating rotor 33.

One of the two cheek plates 36 has its outer face in engagement with a front head 44 having an inlet 45 and an outlet 46 formed therein. Front head 44 contains passages (not shown) which connect inlet 45 to both inlet ports 37 and other passages (not shown) which connect outlet 46 to outlet ports 38. Rotor 33 is splined upon a drive shaft 47 which is rotatably supported within front head 44 by means of bearings not shown.

The outer face of the other cheek plate 36 engages one face of a plate 48 the other face of which engages a rear head 49 having formed therein a pump chamber 50 the front end of which is closed by plate 48. Spacer ring 31, cheek plates 36, plate 48 and heads 44 and 49 are rigidly secured together by a plurality of stud bolts 51.

Pump chamber 50 has closely fitted therein two intermeshing gears 52 and 53 which constitute the pumping elements of a pilot pump 3 and which are journaled, respectively, upon two stub shafts 54 and 55 fixed in rear head 49. Gear 52 drives gear 53 and it is driven in unison with motor 2^a through a coupling 56 which connects shaft 47 to the hub 57 of gear 52.

The arrangement is such that, when motive liquid is supplied to inlet 45, it will flow through ports 37 into the spaces between rotor 33 and vane track 32 and will act upon the outer portions of the vanes 35 in contact with bridges 43, thereby causing rotor 33 to rotate in a clockwise direction in respect to Fig. 4 as indicated by the arrow. Rotor 33 will drive shaft 47 which will drive pilot pump 3.

Figure 2

The drive shown in this figure is substantially the same as the drive shown in Fig. 1 except that the motor vanes are urged outward by fluid pressure instead of by springs. Consequently, like parts have been indicated by like reference numerals and further description thereof is not necessary. The drive includes a motor 2^a which may be the same as the motor shown in Figs. 4 and 5. In order to illustrate how the motor vanes are urged outward by fluid pressure, motor 2^a has been represented by a view taken across the face of a cheek plate 36 as indicated by the line 2—2 of Fig. 5.

Pressure for urging the vanes of motor 2^a outward is provided by means of a channel 60 through which pump 1 delivers liquid to the vane slot ports 39 of motor 2^a at substantially full pump pressure and by means of an orifice 61 through which pump 1 delivers liquid to the inlet ports 37 of motor 2^a and which causes a small drop in pressure, such as 25 p. s. i., between pump 1 and ports 37 so that the pressure in vane slot ports 39 exceeds the pressure in inlet ports 37 by a small amount such as 25 p. s. i. Orifice 61 has been shown separate from motor 2^a and channel 60 has been shown connected to channel 6 at a point between orifice 61 and pump 1 but in practice channel 60 and orifice 61 are arranged inside the casing of motor 2^a.

Since the pressure in vane slot ports 39 is higher than the pressure in inlet ports 37, it

will be obvious from a comparison of Fig. 4 with the face view of cheek plate 36 shown in Fig. 2 that the vanes in contact with bridges 42 and 43 are held thereagainst by the pressure in vane slot ports 39 and that each vane as it moves from a bridge 42 to the adjacent bridge 43 will be moved outward and held against the vane track by the liquid delivered by pump 1 to vane slot ports 39. As each vane moves from a bridge 43 to the adjacent bridge 42, it will be moved inward by the vane track and will be hydrostatically balanced due to vane slot ports 40 being connected to outlet ports 38 by grooves 41.

The drive will function in exactly the same way that the drive shown in Fig. 1 functions. That is, pump 1 when driven will energize motor 2^a and control 5 will function in the previously described manner to maintain the speed of motor 2^a within a narrow speed range.

Figure 3

The drive shown in this figure differs primarily from the drive shown in Fig. 2 in that the motor vanes are moved outward and the pump displacement is varied in response to the drop in pressure across the same orifice. Also, in order to simplify the view and to indicate that the shaft 62 of the main pump is connected by a drive 63 to the shaft 64 of a truck engine so that the pump will be driven by the engine, the circuit has been shown as being reversed in respect to the circuit shown in Fig. 2. That is, the pump, the motor and the pump control have been shown turned end for end in respect to Fig. 2.

Since the drive is otherwise the same as the drive shown in Fig. 2, like parts have been indicated by like reference numerals so that only a brief description of the drive is necessary. As shown, the drive includes a main pump 1, a motor 2^a, a pump 3, an orifice 4, a pump control 5, a channel 6 which connects the outlet of pump 1 to the inlet of motor 2^a, a channel 7 which connects the outlet of motor 2^a to the inlet of pump 1, a channel 13 which connects pilot pump 3 to orifice 4, a channel 18 which connects the port 17 (Fig. 1) in control 5 to the control cylinders 12 of pump 1, a channel 28 which connects high pressure channel 6 to control 5 at one side of port 17, a channel 21 which connects return channel 7 to control 5 at the other side of port 17 and a channel 26 which connects the interior of "sylphon" 25 (Fig. 1) in control 5 to channel 13, all of which are the same as in the circuit shown in Fig. 2.

The circuit shown in Fig. 3 differs primarily from the circuit shown in Fig. 2 in that the inlet of pump 3 and the outlet of orifice 4 are connected to channel 6 instead of being connected to channel 7, in that channel 28 is connected to channel 6 instead of to channel 7, because the pressure on the outside of "sylphon" 25 (Fig. 1) must be substantially the same as the pressure at the outlet of orifice 4, and in that channel 60 is connected to channel 13 instead of to high pressure channel 6.

When pilot pump 3 is driven, it will draw liquid from channel 6 and will discharge it through channel 13 and orifice 4 back into channel 6. The resistance of orifice 4 will cause pump 3 to raise the pressure in channel 13 above the pressure in channel 6 and in motor ports 37 by a small amount, such as 25 p. s. i., and that increased pressure will extend through channel 26 into "sylphon" 25 and through channel 60 into vane slot ports 39. While the pressure in channel 13 is higher than the pressure in channel 6, the energy consumed by pump 3 is small because it creates only the small difference between the two pressures.

The motor vanes in contact with bridges 42 and 43 and the vanes moving from each bridge 42 to the adjacent bridge 43 are positively held against the vane track by the pressure in vane slot ports 39 and the vanes moving from each bridge 42 to the adjacent bridges 43 are moved outward by liquid supplied by pump 3 through channels 13 and 60 and vane slot ports 39 to the inner ends of the slots containing those vanes.

The pressure within "sylphon" 25 of the drive shown in Fig. 3 is higher than in the "sylphon" 25 of either of the drives shown in Figs. 1 and 2 but the difference between the pressures on the inside of the "sylphon" and the pressure on the outside thereof is determined by the drop in pressure across orifice 4 the same as in the other two drives. Consequently, a variation in the drop in pressure across orifice 4, due to a variation in the speed of motor 2^a and the resultant variation in the speed and rate of discharge of pump 3, will cause control 5 to effect adjustment of pump 1 to correct the variation in motor speed in exactly the same manner as in the drives shown in Figs. 1 and 2.

The hydraulic drive illustrated and described herein may be modified in various other ways and adapted to various uses without departing from the scope of the invention which is hereby claimed as follows:

1. A hydraulic drive comprising a hydraulic motor, a main pump for supplying liquid to said motor to energize the same and provided with hydraulic servo-motor means for varying its displacement, fluid channels connecting said pump to said motor and forming therewith a hydraulic circuit, a restricted orifice, a pilot pump, a fluid channel connecting said pilot pump to said orifice to enable said pilot pump when driven to discharge liquid through said orifice and thereby cause a drop in pressure across said orifice, means for driving said pilot pump at a speed proportional to the speed of said motor so that a variation in the speed of said motor will cause a corresponding variation in the speed and rate of delivery of said pilot pump and a resultant variation in the drop in pressure across said orifice, and means for supplying operating liquid to said displacement varying means including a control which controls the flow of said operating liquid and is responsive to variations in the drop in pressure across said orifice for causing said displacement varying means to vary the displacement of said main pump inversely to variations in the speed of said motor to thereby maintain the speed of said motor within a narrow speed range.

2. A hydraulic drive according to claim 1 including fluid channels which connect said control to said hydraulic circuit and to said servo-motor means so that said servo-motor means is adapted to be energized by liquid supplied thereto from said main pump and said control controls the flow of liquid to and from said servo-motor means.

3. A hydraulic drive according to claim 2 in which said motor is of the type having vanes which are moved inward and outward during operation of the motor and which includes fluid channels which connect said pilot pump to said motor at the inner edges of said vanes to cause said vanes to be moved outward by liquid deliv-

ered to the inner edges thereof by said pilot pump.

4. A hydraulic drive according to claim 1 in which said motor is of the type having vanes which are moved inward and outward during operation of the motor and which includes fluid channels which connect said pilot pump to said motor at the inner edges of said vanes to cause said vanes to be moved outward by liquid delivered to the inner edges thereof by said pilot pump.

5. A hydraulic drive according to claim 1 in which said control includes a pressure responsive element which has one face thereof subjected to the pressure at the inlet of said orifice and the other face thereof subjected to the pressure at the outlet of said orifice and which effects operation of said control in response to variations in the drop in pressure across said orifice.

6. A hydraulic drive according to claim 5 in which said pressure responsive element comprises a bellows having its interior subjected to the pressure at the inlet of said orifice and its exterior subjected to the pressure at the outlet of said orifice.

7. A hydraulic drive comprising a main pump having hydraulic servo-motor means for varying its displacement, a hydraulic motor energized by liquid delivered thereto by said pump, fluid channels connecting said pump and said motor and forming therewith a hydraulic circuit, a pilot pump for discharging liquid at limited rates, a restricted orifice connected to said pilot pump to resist the discharge of liquid therefrom and thereby cause said pilot pump to create pressure and to vary said pressure in response to variations in the rate at which it discharges liquid through said orifice, means for driving said pilot pump at a speed proportional to the speed of said motor so that a variation in the speed of said motor will cause a corresponding variation in the speed and rate of delivery of said pilot pump and a resultant variation in the pressure created by said pilot pump, and means for supplying operating liquid from said circuit to said displacement varying means including a control which controls the flow of said operating liquid and is responsive to variations in the pressure created by said pilot pump for causing said displacement varying means to decrease the displacement of said main pump in response to an increase in said pilot pump pressure and to increase the displacement of said main pump in response to a decrease in said pilot pump pressure.

8. A hydraulic drive according to claim 7 in which said motor is of the type having vanes which are moved inward and outward during operation of the motor and which includes fluid channels which connect said pilot pump to said motor at the inner edges of said vanes to cause said vanes to be moved outward by liquid delivered to the inner edges thereof by said pilot pump.

9. A hydraulic drive according to claim 7 in which said control includes a pressure responsive element which has one face thereof subjected to the pressure at the inlet of said orifice and an opposite face thereof subjected to the pressure at the outlet of said orifice and which effects operation of said control in response to variations in the drop in pressure across said orifice.

10. A hydraulic drive comprising a hydraulic motor, a main pump for supplying liquid to said motor to energize the same and provided with hydraulic servo-motor means for varying its displacement, fluid channels connecting said pump to said motor and forming therewith a hydraulic circuit, a restricted orifice, a pilot pump, a fluid channel connecting said pilot pump to said orifice to enable said pilot pump when driven to discharge liquid through said orifice and thereby cause a drop in pressure across said orifice, means for driving said pilot pump at a speed proportional to the speed of said motor so that a variation in the speed of said motor will cause a corresponding variation in the speed and rate of delivery of said pilot pump and a resultant variation in the drop in pressure across said orifice, means for supplying liquid to said servo-motor means including a valve normally occupying a neutral position and shiftable in one direction or the other to direct liquid to or from said servo-motor means to cause the same to decrease or increase the displacement of said main pump, and pressure responsive means associated with said valve and connected to opposite sides of said orifice for causing said valve to shift in a direction to effect a decrease in the displacement of said main pump in response to an increase in the pressure drop across said orifice or to shift in a direction to effect an increase in the displacement of said main pump in response to a decrease in the pressure drop across said orifice and thereby correct the variation in motor speed which caused the variation in the pressure drop across said orifice.

11. A hydraulic drive according to claim 10 in which said pressure responsive element comprises a bellows having its interior subjected to the pressure at the inlet of said orifice and its exterior subjected to the pressure at the outlet of said orifice.

12. A hydraulic drive according to claim 10 in which said motor is of the type having vanes which are moved inward and outward during operation of the motor and which includes fluid channels which connect said pilot pump to said motor at the inner edges of said vanes to cause said vanes to be moved outward by liquid delivered to the inner edges thereof by said pilot pump.

WALTER FERRIS.

REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
2,161,439	Thoma	June 6, 1939
2,291,011	Vickers	July 28, 1942
2,320,727	Herman et al.	June 1, 1943