Nov. 9, 1948. J. K. DOUGLAS 2,453,309

VANE TYPE HYDRAULIC MOTOR

Original Filed Dec. 29, 1939 2 Sheets-Sheet 1

Fig. 1.

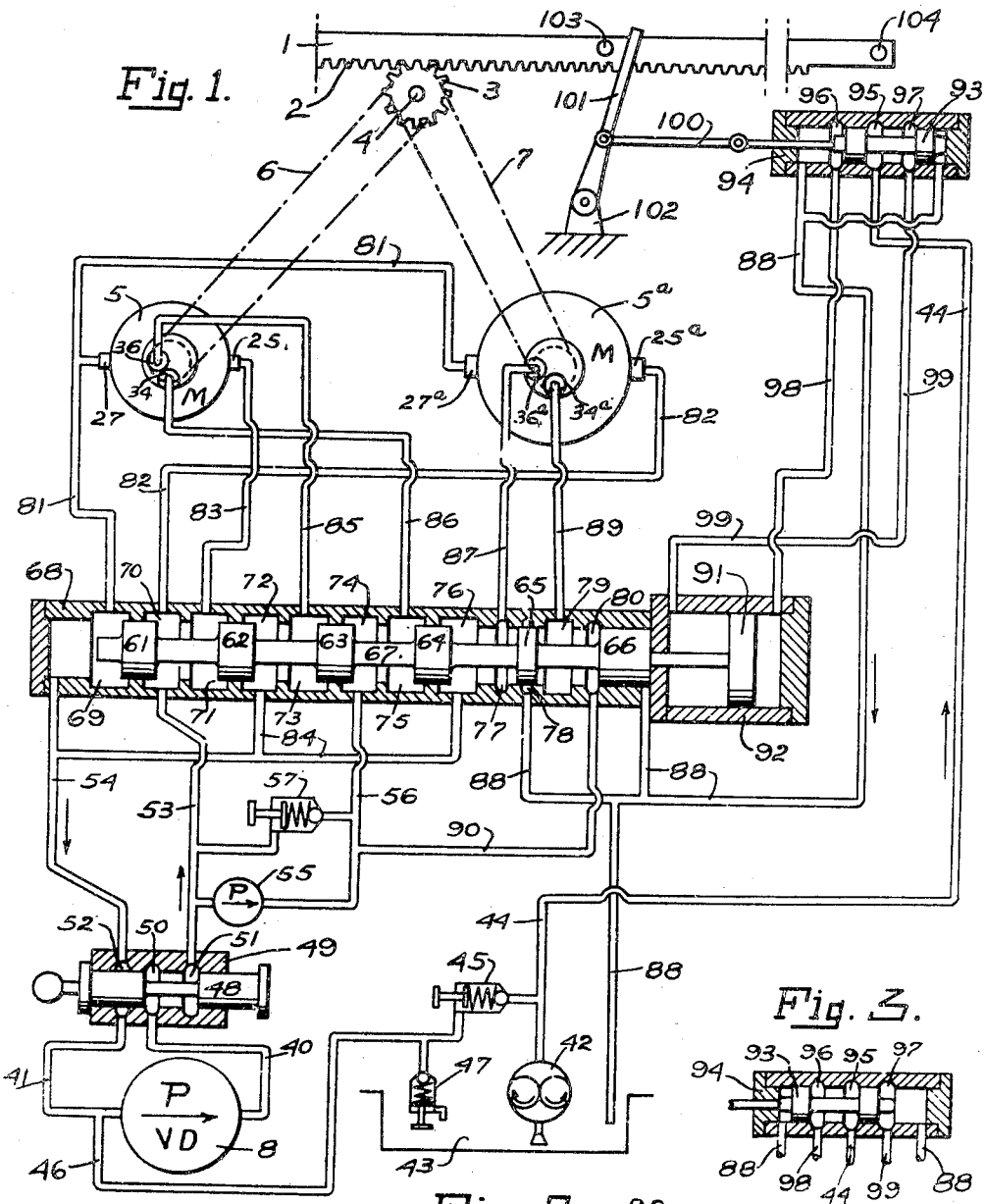
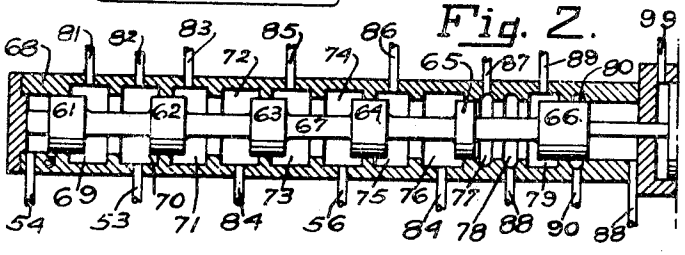


Fig. 3.

Fig. 2.



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Nov. 9, 1948. J. K. DOUGLAS 2,453,309

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Original Filed Dec. 29, 1939 2 Sheets-Sheet 2

Fig. 8.

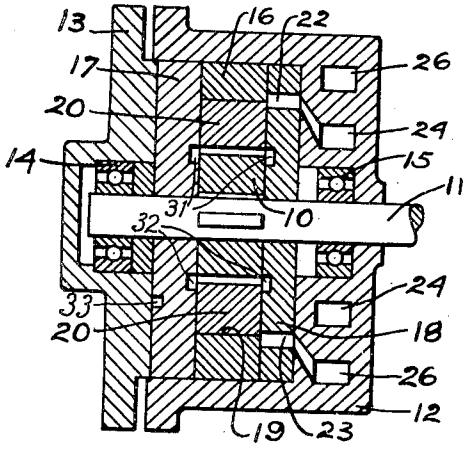


Fig. 4.

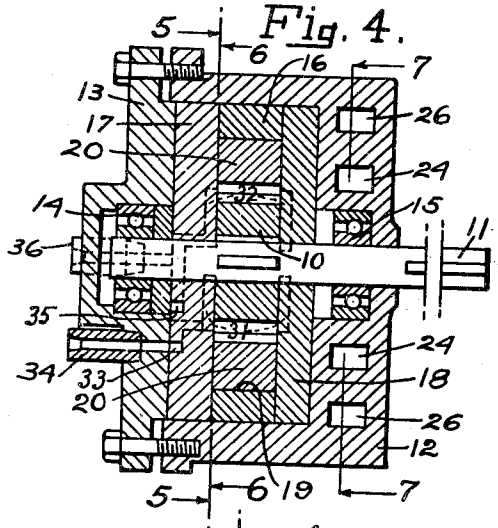


Fig. 6.

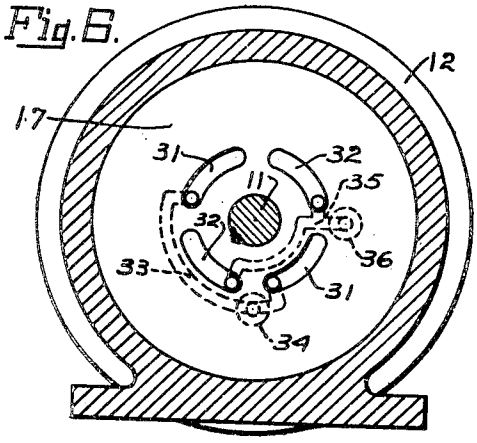


Fig. 5.

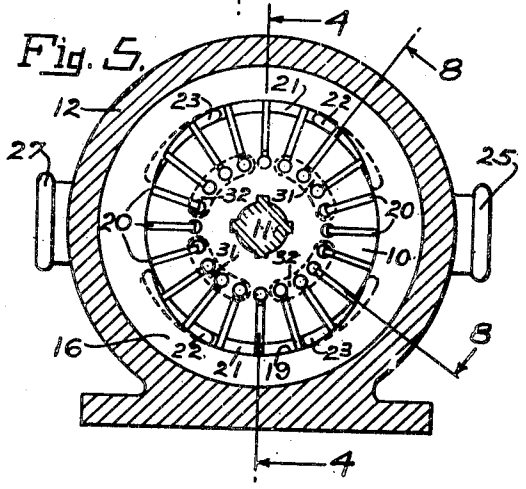
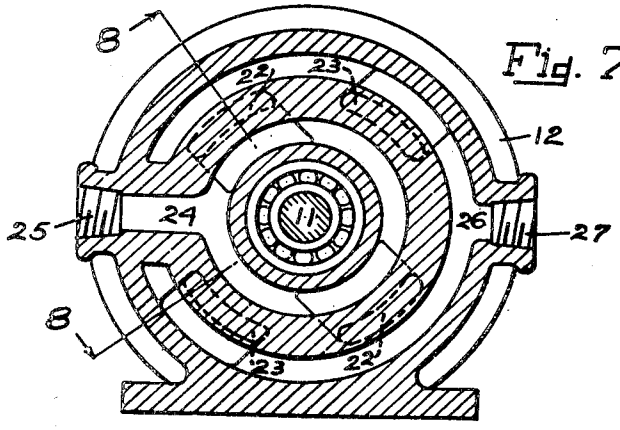


Fig. 7.



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2,453,309

UNITED STATES PATENT OFFICE

2,453,309

VANE TYPE HYDRAULIC MOTOR

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Original application December 29, 1939, Serial No. 311,479, now Patent No. 2,345,920, April 4, 1944. Divided and this application March 15, 1943, Serial No. 479,229

10 Claims. (Cl. 121—87)

1

This application is a division of application Serial No. 311,479 which was filed December 29, 1939, and has since matured into Patent 2,345,920.

The invention relates to a drive which includes a vane type hydraulic motor and a control therefor.

An object of the invention is to provide a hydraulic drive having a vane type motor, which is adapted to drive a load when supplied with motive liquid, and a control for rendering the motor ineffective to drive the load regardless of whether or not the supply of motive liquid is discontinued.

Another object is to provide a hydraulic drive having a motor for driving a load and means for rendering the motor ineffective to resist movement of the load.

Other objects and advantages will appear from the following description of an embodiment of the invention shown schematically in the accompanying drawings in which the views are as follows:

Fig. 1 is a diagram of the hydraulic circuit of a drive in which the invention is embodied.

Fig. 2 is a view showing a control valve in a position different from that shown in Fig. 1.

Fig. 3 is a view showing a pilot valve in a position different from that shown in Fig. 1.

Fig. 4 is a vertical longitudinal section through one of the motors shown in Fig. 1, the view being taken on the line 4—4 of Fig. 5.

Fig. 5 is a transverse section through the motor taken on the line 5—5 of Fig. 4.

Fig. 6 is a transverse section taken through the motor on the line 6—6 of Fig. 4.

Fig. 7 is a transverse section through the motor taken on the line 7—7 of Fig. 4.

Fig. 8 is a vertical section taken on the irregular lines 8—8 of Figs. 5 and 7.

For the purpose of illustration, the invention has been shown embodied in a drive for a machine of the type having a carriage which makes an idle stroke in one direction at high speed and a working stroke in the opposite direction at a lower speed appropriate for a tool to operate upon a work piece but it is to be understood that the invention is adapted to various other uses.

The machine includes a carriage 1 having a rack 2 fixed upon the under side thereof and in mesh with a gear 3 which is fixed upon a shaft 4 so that rotation of shaft 4 in one direction or the other will cause carriage 1 to move in one direction or the other. Since the machine per se forms no part of the present invention, all other parts thereof have been omitted from the drawing.

2

Shaft 4 is adapted to be rotated by two vane type hydraulic motors 5 and 5a which are connected thereto by suitable drives 6 and 7 respectively. Motors 5 and 5a are energized by a pump 8 which delivers liquid to both motors to cause them to move carriage 1 in one direction at a cutting speed and then delivers its entire output to motor 5 only to cause it to move carriage 1 at high speed in the opposite direction at which time motor 5a is short circuited and the vanes thereof are retracted so that its rotor spins idly as presently will be explained.

The two motors may be of the same size but motor 5a has been shown as being larger than motor 5 in order to obtain a high speed of carriage 1 during its return stroke. For example, if the displacement of motor 5a is twice that of motor 5, carriage 1 will be moved during its idle stroke at a speed three times its speed during its working stroke.

Motor 5 may be of the type shown in Figs. 4 to 8 and motor 5a may be exactly the same except that it may be of a different size if desired. As shown, the motor includes a rotor 10 keyed upon a shaft 11 and arranged within a stator consisting primarily of a casing 12 which has a removable end head 13 and rotatably supports shaft 11 by means of bearings 14 and 15, a spacer ring 16 which is arranged within casing 12 and extends around rotor 10, and two cheek plates 17 and 18 which are arranged within casing 12 upon opposite sides of spacer ring 16, the cheek plates and spacer ring being clamped in position by end head 13 and spacer ring 16 being just enough thicker than rotor 10 to permit rotor 10 to turn freely between cheek plates 17 and 18.

The inner peripheral surface of spacer ring 16 provides a track 19 for a plurality of vanes 20 which are the same width as rotor 10 and fitted in slots formed radially therein. Vane track 19 is approximately elliptical with its short diameter horizontal and just enough greater than the diameter of rotor 10 to permit rotor 10 to turn freely. The vertical diameter of track 19 is enough greater than the diameter of rotor 10 to provide a working chamber 21 of the desired size both above and below rotor 10.

Each chamber 21 communicates with two ports 22 and 23 which are arranged upon opposite sides of the vertical center line of track 19 with the two ports 22 arranged diametrically opposite each other and each port 23 spaced approximately 90° from ports 22. Each portion of track 19 between adjacent ends of adjacent ports forms a sealing arc which is ordinarily concentric with rotor 10.

The angular distance between adjacent ends of adjacent ports is at least twice as great as the angular distance between adjacent vanes so that each sealing arc will at all times have at least two vanes in contact therewith.

As best shown in Figs. 7 and 8, ports 22 communicate with an annular passage 24 which is formed in the end wall of casing 12 and communicates with a main port 25 by means of which the motor may be connected to one side of a hydraulic circuit, and ports 23 communicate with a passage 26 which is formed in the end wall of casing 12 outward from passage 24 and communicates with a main port 27 by means of which the motor may be connected to the other side of the hydraulic circuit.

The arrangement is such that, when main port 25 is connected to the discharge outlet of a pump or other source of motive liquid and main port 27 is connected to a return or discharge line so that ports 22 function as inlet ports and ports 23 function as discharge ports, the motive liquid entering through each port 22 will exert a force upon the outer portion of that vane which is adjacent the end of port 22 and in contact with the sealing arc of vane track 18. The force exerted by the liquid upon that vane will cause rotor 10 to rotate in a counterclockwise direction in respect to Fig. 5 and the liquid will act upon each succeeding vane as it passes the end of port 22 and comes into contact with the sealing arc so that rotor 10 is caused to rotate continuously as long as motive liquid is supplied to port 25. The liquid ahead of each vane will be discharged into the adjacent port 23 as soon as the preceding vane passes the adjacent end of that port 23. When motive liquid is supplied to port 27, the motor will operate in exactly the same manner but in the opposite direction.

It is essential that the vanes just beyond the ends of the inlet ports be held in contact with vane track 19 as otherwise the liquid could flow freely from each inlet port to a discharge port and no rotative force would be transmitted to rotor 10. These vanes may be held in contact with track 19 by subjecting the inner ends thereof to a pressure higher than the pressure prevailing at the inlet ports but, if the inner ends of the vanes were subjected to this higher pressure during a complete revolution of rotor 10, each vane would exert such an excessive force against track 19 during the time its outer end was exposed to the low or negative pressure of the discharge liquid that undue wear of the vanes or tracks might result.

In order to hold the working vanes against the vane track and at the same time to avoid excessive wear of the vanes or tracks, the vanes have the inner ends thereof subjected to a pressure higher than the pressure of the motive liquid only during the time the outer ends thereof are subjected to the pressure of the motive liquid.

As shown, cheek pates 17 and 18 are each provided with a pair of arcuate pressure grooves 31, which are arranged diametrically opposite each other and spaced radially inward from ports 22, and a pair of arcuate pressure grooves 32 which are arranged diametrically opposite each other and spaced radially inward from ports 23, the pressure grooves being spaced a predetermined distance apart and so located that the inner ends of each vane slot will register with the four grooves successively as rotor 10 rotates.

As shown in Fig. 6, the two grooves 31 in cheek plate 17 are connnected to each other by a passage 33, which is formed in cheek plate 17 and communicates with a connector 34 carried by end head 13, and the two grooves 32 in cheek plate 17 are connected to each other by a passage 35 which is formed in cheek plate 17 and communicates with a connector 36 carried by end head 13. The pressure grooves in cheek plate 18 communicate with the corresponding pressure grooves in cheek plate 17 through the inner ends of the vane slots and are provided for the purposes of hydrostatically balancing rotor 10.

As previously explained, motor 5a is exactly the same as motor 5 except that it is larger. Consequently, the main ports and the connectors of both motors have been indicated in Fig. 1 by the same reference numerals but with the exponent "a" added to the reference numerals applied to motor 5a.

The liquid for operating motors 5 and 5a is discharged by pump 8 into a channel 40 and the liquid discharged by motors 5 and 5a is returned to pump 8 through a channel 41. In order to make up for leakage losses and to supercharge pump 8, additional liquid is supplied to channel 41 by a gear pump 42 which draws liquid from a reservoir 43 and discharges it into a channel 44 through which it supplies liquid to a valve operating mechanism to be presently described.

The liquid discharged by gear pump 42 in excess of the liquid required to operate the valve mechanism is exhausted through a resistance valve 45 into one end of a channel 46 the other end of which is connected to channel 41. The liquid discharged by gear pump 42 into channel 46 in excess of the liquid required to supercharge pump 8 is exhausted through a relief valve 47 into reservoir 43. Gear pump 42 is thus enabled to maintain in channel 46 a pressure equal to the resistance of valve 47 and to maintain in channel 44 a pressure equal to the sum of the resistances of valves 45 and 47.

Pump 8 is initially controlled by a start and stop valve 48 which is fitted in the bore of a valve casing 49 having three annular grooves or ports 50, 51 and 52 formed therein. Port 50 communicates with channel 40, port 51 communicates with a channel 53 through which liquid is directed to the motors, and port 52 communicates with channel 41 and with a channel 54 through which liquid is returned from the motors.

The arrangement is such that, when valve 48 is in the position shown in Fig. 1, liquid discharged by pump 8 will flow through channel 40 and valve casing 49 into channel 53 and the liquid returned from the motors through channel 54 will flow through port 52 and channel 41 to pump 8. When valve 48 is shifted to the limit of its movement toward the left, it will block port 51 and open port 52 to port 50 so that pump 8 is bypassed.

The inner and outer end of each vane may be subjected to the same pressure and each vane held in contact with track 19 by a light spring arranged in the inner end of its vane slot in the well known manner but the working vanes are preferably urged against the vane track by liquid having a pressure related to but somewhat higher than the pressure of the motive liquid.

As shown, liquid for holding the working vanes 20 of motors 5 and 5a against vane tracks 19 is supplied by a small capacity pump 55 which is

driven in unison with pump 8 and draws liquid from channel 53 and discharges it into a channel 56. The liquid discharged by pump 55 in excess of the volume required to hold the working vanes outward is exhausted through a low pressure resistance valve 57 back into channel 53 so that the pressure in channel 56 is always a few pounds higher than the pressure created by pump 8.

Motors 5 and 5a are controlled by a plurality of valves which are simultaneously operable to control the flow of liquid to and from the main ports of the motors and the flow of liquid to and from the pressure grooves of the motors. As shown, six valves or pistons 61, 62, 63, 64, 65 and 66 are fixed upon a plunger 67 and closely fitted in the bore of a control valve casing 68 having twelve annular grooves or ports 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79 and 80 formed therein.

Port 69 is connected by a channel 81 to port 27 of motor 5 and to port 27a of motor 5a, and channel 54 is connected to the left end of the bore of valve casing 68 so that ports 27 and 27a are connected to the intake of pump 8 when valve plunger 67 is in the position shown in Fig. 1. Port 70 is connected by a channel 82 to port 25a of motor 5a and it has channel 53 connected thereto so that port 25a is at all times subjected to the pressure created by pump 8.

Port 71 is connected by a channel 83 to port 25 of motor 5, ports 72 and 76 are connected by a channel 84 to channel 54 intermediate the ends thereof, port 73 is connected by a channel 85 to connector 36 on motor 5, port 74 has channel 56 connected thereto, port 75 is connected by a channel 86 to connector 34 on motor 5, port 77 is connected by a channel 87 to connector 36a on motor 5a, port 78 and the right end of the bore of valve casing 68 are connected to a drain channel 88 which discharges into reservoir 43, port 79 is connected by a channel 89 to connector 34a on motor 5a, and port 80 is connected by a channel 90 to channel 56 intermediate the ends thereof.

Valve plunger 67 is adapted to be shifted in one direction or the other by a piston 91 which is connected thereto and fitted in a cylinder 92 arranged upon the right end of valve casing 68. Liquid for operating piston 91 is supplied to cylinder 92 under the control of a pilot valve 93 which is arranged in the bore of a valve casing 94 having both ends thereof connected to drain channel 88 so that movement of valve 93 will not be hampered by entrapped liquid or gas.

Valve casing 94 has three annular grooves or ports 95, 96 and 97 formed in the wall of the bore thereof. Port 95 has gear pump channel 44 connected thereto, port 96 is connected by a channel 98 to the right end of cylinder 92, and port 97 is connected by a channel 99 to the left end of cylinder 92.

Pilot valve 93 may be shifted in any suitable manner such as in response to carriage 1 approaching the limit of its movement in each direction. Means are provided to compensate for the over run of carriage 1 but, since such means are well known and form no part of the present invention, they have been omitted from the drawing and valve 93 shown as having its stem connected by a link 100 to a lever 101 which has one of its ends pivoted upon a bracket 102 and its other end extending into the path of two dogs 103 and 104 carried by carriage 1.

Operation

Assuming that the several parts are in the positions shown in Fig. 1 and that pumps 8, 42 and 55 are running, the drive will function as follows:

Gear pump 42 will draw liquid from reservoir 43 and discharge it through channel 44 and resistance valve 45 into channel 46. The liquid discharged by gear pump 42 in excess of the liquid required to supercharge pump 8 will be exhausted through relief valve 47 into reservoir 43 so that gear pump 42 maintains a low or return pressure in channel 46 and a higher or gear pump pressure in channel 44. The gear pump pressure will extend from channel 44 through pilot valve casing 94 and channel 99 to the left end of servomotor cylinder 92 and cause piston 91 to hold control valve plunger 67 in the position shown in Fig. 1. The return pressure will extend from channel 46 through channel 41, valve casing 49 and channel 54 to the left end of valve casing 68 and from channel 54 through channel 84 to ports 72 and 76.

Main pump 8 will discharge liquid through channel 40, valve casing 49 and channel 53 to port 70 in control valve casing 68 and maintain therein at all times a pressure proportional to the load on pump 8.

Pump 55 will draw liquid from channel 53 and discharge a part of it through resistance valve 57 back into channel 53 so that pump 55 is caused to maintain in channels 56 and 90 and in ports 74 and 80 a superpressure which is always greater than the main pump pressure by an amount equal to the resistance of valve 57.

With control valve plunger 67 in the position shown in Fig. 1, port 75 is open to port 74 and port 79 is open to port 80 so that superpressure can extend from port 74 through port 75, channel 86, connector 34 and passage 33 (Fig. 6) to the pressure grooves 31 in motor 5 and from port 80 through port 79, channel 89, connector 34a and passage 33 to the pressure grooves 31 of motor 5a.

Port 73 is open to port 72 and port 77 is open to port 76 so that return pressure can extend from port 72 through port 73, channel 85, connector 36 and passage 35 (Fig. 6) to the pressure grooves 32 of motor 5 and from port 76 through port 77, channel 87, connector 36a and passage 35 to the pressure grooves 32 of motor 5a.

Port 69 is open to return channel 54 so that return channel 54 is connected through valve casing 68, channel 81, main ports 27 and 27a and passages 26 (Fig. 7) to the ports 23 of both motors.

Port 71 is open to port 70 so that motive liquid will flow through channels 83 and 82, main ports 25 and 25a, passages 24 and ports 22 to the pressure sides of the chambers 21 (Fig. 5) of both motors.

The pressure of the motive liquid tends to move inward the vanes 20 whose outer ends extend into the pressure sides of the chambers 21 but the inner ends of those vanes are subjected to the superpressure in grooves 31 which holds them firmly against vane track 19 so that the motive liquid may act upon the outer end portions thereof and cause rotors 10 to rotate in a counterclockwise direction, the liquid carried across the sealing arcs of track 19 by the vanes being discharged into ports 23 and returned through the above described channels to the intake of pump 8.

Each vane 20 is held by the superpressure firmly against track 19 until the inner end of its slot moves out of registry with groove 31 at which time it has moved part way across the sealing arc, then the liquid in the inner end of the vane slot is trapped therein during movement of the vane through a slight angular distance and then the inner end of the slot registers with a groove 32 which contains liquid at the return pressure, as previously explained, so that the vane is hydrostatically balanced and is held against the vane track solely by centrifugal force.

Rotation of rotors 10 in a counterclockwise direction causes drives 6 and 7 to rotate shaft 4 in a counterclockwise direction and thereby cause gear 3 to move rack 2 and carriage 1 toward the left at a speed proportional to the displacement of pump 8 relative to the combined displacements of motors 5 and 5a.

As carriage 1 approaches the limit of its movement toward the left, dog 104 will engage lever 101 and cause it to shift pilot valve 93 to the position shown in Fig. 3, provision being made for over run of carriage 1 as mentioned above. Liquid from gear pump 42 will then flow through channel 44, valve casing 94 and channel 98 to the right end of cylinder 92 and cause piston 91 to shift control valve plunger 67 to the position shown in Fig. 2, the liquid expelled from cylinder 92 by piston 91 being conducted through channel 99, valve casing 94 and drain channel 88 into reservoir 43.

Shifting control valve plunger 67 to the position shown in Fig. 2 connects port 69 to port 70 and pump pressure will extend from port 70 through port 69 and channel 81 to main port 27 of motor 5 and to main port 27a of motor 5a, and pressure will extend from port 70 through channel 82 to main port 25a of motor 5a so that motor 5a is short circuited and the outer ends of all of the vanes thereof are subjected to pump pressure. Also, port 80 is blocked and ports 77 and 79 are open to port 78 so that all of the pressure grooves 31 and 32 of motor 5a are connected to drain channel 88 through the previously described channels. Since all of the vanes of motor 5a have their outer ends subjected to pump pressure and their inner ends to zero pressure, they will be moved inward so that, when motor 5a is driven by motor 5 as will presently be explained, rotor 10 of motor 5a will spin idly and without displacing any liquid.

While motor 5a has been shown as having both of its main ports connected to the pressure side of the main circuit and all of its pressure grooves connected to drain for the purpose of forcing the vanes inward, the vanes could be forced inward by connecting both main ports to the return side of the circuit and all of the pressure grooves to drain or by connecting both main ports to the pressure side of the circuit and all of the pressure grooves to the return side of the circuit.

When control valve plunger is in the position shown in Fig. 2, port 73 is open to port 74 instead of to port 72 and port 75 is open to port 76 instead of to port 74, so that the pressures in the pressure grooves of motor 5 are reversed, and port 71 is open to port 72 instead of to port 70 and port 69 is open to port 70 instead of to return channel 54 so that the flow of motive liquid to motor 5 is reversed. Consequently, motor 5 will operate in the previously described manner but in the opposite direction and move carriage 1 toward the right at a high speed which is proportional to the displacement of motor 5 relative to the displacement of pump 8. During movement of carriage 1 toward the right, drive 7 will rotate rotor 10 of motor 5a which will spin idly since its vanes are fully retracted as previously explained.

As carriage 1 approaches the limit of its movement toward the right, dog 103 will engage lever 101 and cause it to shift pilot valve 93 to the position shown in Fig. 1, provision being made for over run of carriage 1 as mentioned above. Liquid from gear pump 42 will then flow through channel 44, valve casing 94 and channel 99 to the left end of cylinder 92 and cause piston 91 to shift control valve plunger 67 to the position shown in Fig. 1, the liquid expelled from cylinder 92 by piston 91 being conducted through channel 98, valve casing 94 and drain channel 88 to reservoir 43.

Shifting control valve plunger to the position shown in Fig. 1 completes a cycle of operation and starts a second cycle of operation as explained above.

The drive described herein is susceptible of various modifications and adaptations without departing from the scope of the invention which is hereby claimed as follows:

1. The combination, with a hydraulic motor having a vane track and a rotor arranged within said track and provided with a plurality of vanes for engaging said track, of means for directing motive liquid between said track and said rotor, means for causing each of said vanes to engage said track during at least a part of each revolution of said rotor to thereby enable said liquid to act upon said vanes and rotate said rotor, and means for causing all of said vanes to move inward out of engagement with said track and thereby prevent liquid directed between said track and said rotor from rotating said rotor.

2. The combination, with a hydraulic motor having a vane track and a rotor arranged within said track and provided with a plurality of vanes for engaging said track, of means for directing motive liquid between said track and said rotor, the pressure of said liquid acting upon the outer ends of said vanes and tending to move them inward away from said track, means for supplying to the inner end of each vane during at least a part of each revolution of said rotor liquid at a pressure greater than the pressure of said motive liquid to thereby hold said vanes against said track and enable said motive liquid to rotate said rotor, and means for reducing the pressure at the inner ends of said vanes below the pressure of said motive liquid to thereby cause said vanes to move inward out of engagement with said track and prevent said motive liquid from rotating said rotor.

3. In a drive, the combination of a hydraulic motor having a vane track and a rotor arranged within said track and provided with a plurality of vanes for engaging said track, said motor having an inlet for directing liquid between said track and said rotor and an outlet for the discharge of liquid therefrom, means for supplying motive liquid to said motor to energize the same, the pressure of said liquid acting upon the outer ends of said vanes and tending to move them inward, means for supplying to the inner end of each vane during at least a part of each revolution of said rotor liquid at a pressure related to and greater than the pressure of said motive liquid to thereby hold said vanes against said track and enable said motive liquid to rotate said rotor, and means for reducing the pressure at the inner end of each vane below the pressure at the outer

end thereof to thereby cause said vanes to be moved inward away from said track and prevent any liquid delivered to said inlet or said outlet from rotating said rotor.

4. The combination, with a hydraulic motor including an endless vane track and a rotor arranged within said track and provided with radial slidable vanes adapted to ride upon said track during rotation of said rotor, of means for supplying motive liquid from an external source to said motor to act upon the outer portions of said vanes and effect rotation of said rotor, and means for causing said vanes to move out of contact with said track and out of the path of said liquid to thereby prevent said rotor from being rotated by the liquid supplied to said motor.

5. In a hydrodynamic machine, the combination of a cylindrical rotor, a stationary endless vane track arranged around said rotor and forming spaces of varying widths between it and the periphery of said rotor, casing means enclosing said rotor and said track and providing ports which communicate with said spaces, a plurality of approximately radial vanes slidable in said rotor and adapted during rotation of said rotor to continuously engage said track and provide seals between said ports so that rotation of said rotor will cause liquid to be transferred from one to another of said ports and motive liquid supplied to a port will cause rotation of said rotor, and means for preventing transfer of liquid from one port to another in response to rotation of said rotor and for preventing rotation of said rotor in response to motive liquid being supplied to a port.

6. The combination, with a hydraulic motor having a vane track and a rotor arranged within said track and provided with a plurality of vanes for engaging said track, of means for directing motive liquid between said track and said rotor including a valve for controlling the delivery of said liquid, means for supplying to the inner end of each vane during at least a part of each revolution of said rotor liquid at a pressure greater than the pressure of said motive liquid to thereby hold said vanes against said track and enable said motive liquid to rotate said rotor including a valve operable to discontinue the supply of high pressure liquid to the inner ends of said vanes and to connect said inner ends to exhaust to cause said vanes to be moved inward by the pressure of the motive liquid and thereby prevent said motive liquid from rotating said rotor, and means for simultaneously operating said valves.

7. In a hydraulic drive for driving an element, the combination of a hydraulic motor having a vane track and a rotor adapted to be connected to said element and arranged within said track and provided with a plurality of substantially radial vane slots having vanes fitted therein and adapted to engage said track, said motor having formed therein a passage with which the inner end of each vane slot communicates during a part of each revolution of said rotor, means for directing motive liquid to the outer ends of said vanes to rotate said rotor and thereby drive said element, the pressure of said motive liquid acting upon said vanes at the outer ends thereof and tending to move them inward, a source of liquid having a pressure higher than the pressure of said motive liquid, channel means for directing liquid from said source to said passage to thereby hold said vanes against said track and enable said motive liquid to rotate said rotor, and valve means associated with said channel means for reducing the pressure in said passage below the pressure of said motive liquid to cause said vanes to be moved inward by the pressure at the outer ends thereof and thereby prevent said motive liquid from rotating said rotor.

8. In a hydraulic drive for driving an element, the combination of a hydraulic motor having a vane track and a rotor adapted to be connected to said element and arranged within said track and provided with a plurality of substantially radial vane slots having vanes fitted therein and adapted to engage said track, said motor having formed therein a passage with which the inner end of each vane slot communicates during a part of each revolution of said rotor, means for directing motive liquid to the outer ends of said vanes to rotate said rotor and thereby drive said element, the pressure of said motive liquid acting upon said vanes at the outer ends thereof and tending to move them inward, a source of liquid having a pressure higher than and varying in accordance with variations in the pressure of said motive liquid, channel means for directing liquid from said source to said passage to thereby hold said vanes against said track and enable said motive liquid to rotate said rotor, and valve means associated with said channel means for reducing the pressure in said passage below the pressure of said motive liquid to cause said vanes to be moved inward by the pressure at the outer ends thereof and thereby prevent said motive liquid from rotating said rotor.

9. In a hydraulic drive for driving an element, the combination of a hydraulic motor having a vane track and a rotor adapted to be connected to said element and arranged within said track and provided with a plurality of substantially radial vane slots having vanes fitted therein and adapted to engage said track, said motor having formed therein a passage with which the inner end of each vane slot communicates during a part of each revolution of said rotor, means for directing motive liquid to the outer ends of said vanes to rotate said rotor and thereby drive said element, the pressure of said motive liquid acting upon said vanes at the outer ends thereof and tending to move them inward, a source of liquid having a pressure higher than the pressure of said motive liquid, channel means for directing liquid from said source to said passage to thereby hold said vanes against said track and enable said motive liquid to rotate said rotor, valve means associated with said channel means for reducing the pressure in said passage below the pressure of said motive liquid to cause said vanes to be moved inward by the pressure at the outer ends thereof and thereby prevent said motive liquid from rotating said rotor, and means responsive to said element reaching a given point in its movement for operating said valve means.

10. In a drive, the combination with a hydraulic motor having a vane track and a rotor arranged within said track and provided with a plurality of vanes to engage said track, of pressure channels for directing motive liquid to said motor at the outer ends of said vanes to energize said motor, said motive liquid acting upon the outer ends of said vanes and tending to move said vanes inward away from said track, a booster pump having its inlet connected to said pressure channel, a resistance valve connected between the outlet of said booster pump and said pressure channel, said booster pump being adapted to draw liquid from said pressure channel and deliver a part thereof to the inner ends of said

vanes and to discharge the remainder thereof through said resistance valve so that the pressure of the liquid delivered to the inner ends of said vanes is a given amount higher than the pressure at the outer ends of said vanes, a low pressure channel, and valve means for connecting the inner ends of said vanes to said booster pump and to said low pressure channel selectively.

JAMES K. DOUGLAS.

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