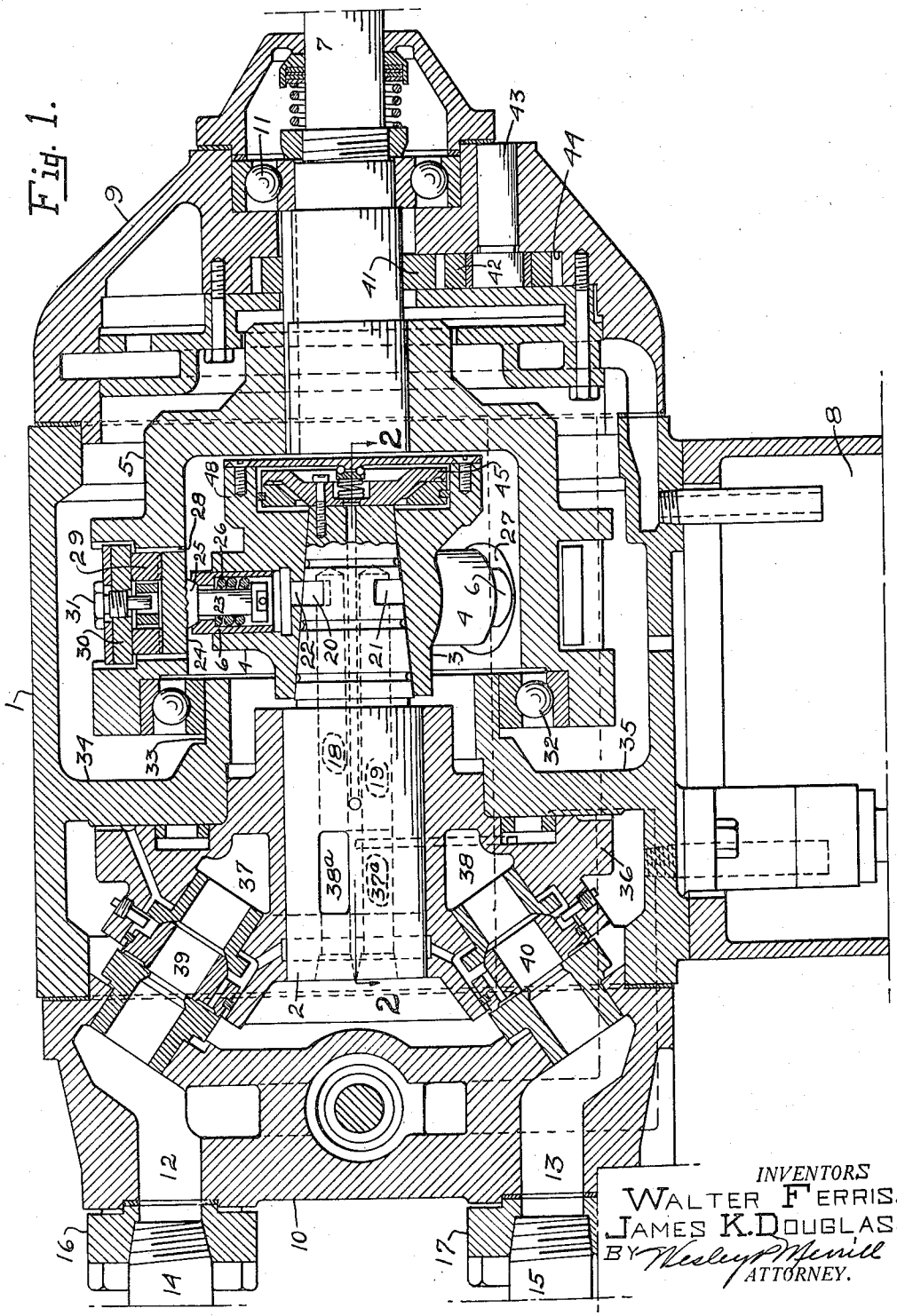
Dec. 15, 1936. W. FERRIS ET AL 2,064,299

PUMP OR MOTOR

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Fig. 1.



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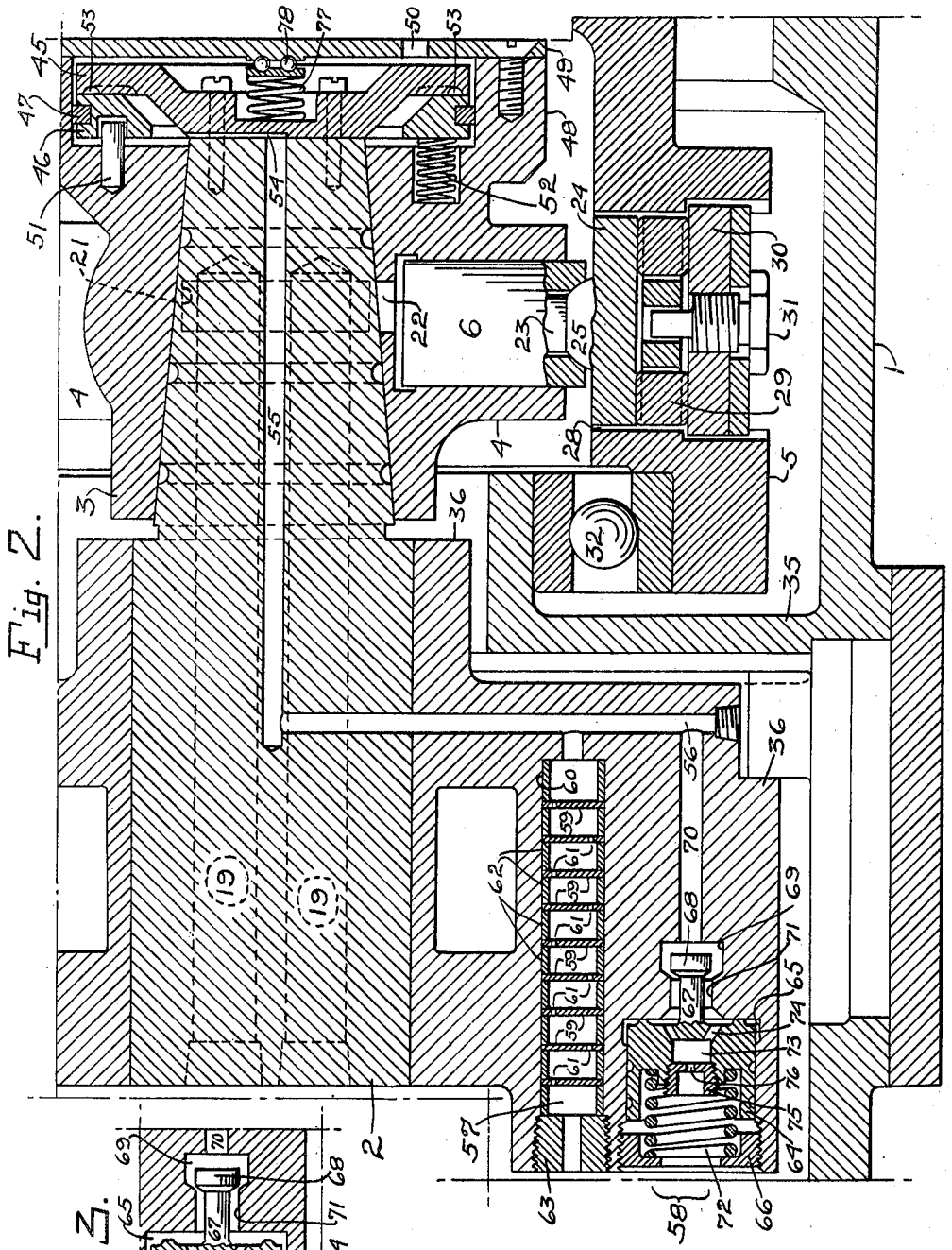


Fig. 2.

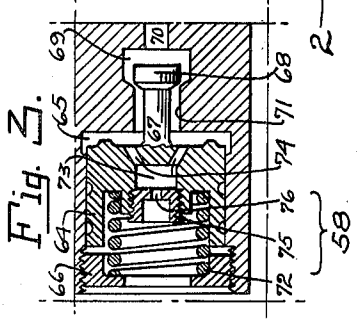


Fig. 3.

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2,064,299

PUMP OR MOTOR

Walter Ferris and James K. Douglas, Milwaukee, Wis., assignors to The Oilgear Company, Milwaukee, Wis., a corporation of Wisconsin

Application August 9, 1933, Serial No. 684,309

21 Claims. (Cl. 103—161)

This invention relates to pumps and hydraulic motors of the type in which the cylinders are arranged in a cylinder barrel and revolve about a central shaft or pintle upon which the cylinder barrel is journaled to rotate thereon and through which liquid flows to and from the cylinders, such as the pump described and claimed in Patent No. 1,930,163 which issued October 10, 1933 on the copending application of Walter Ferris, Serial No. 508,103, filed January 12, 1931.

Pumps and motors of this character have as an inherent characteristic thereof a certain amount of internal leakage or slip which varies in accordance with variations in the clearance between the cylinder barrel and the pintle, variations in the fluid pressure, and variations in the temperature of the motive fluid which is ordinarily a good grade of lubricating oil and varies in viscosity in accordance with variations in its temperature.

It has heretofore been proposed to compensate for variations in the slip of a pump by varying pump displacement in response to variations in the temperature and the pressure of the oil, by bypassing a part of the pump output and varying this bypassed volume inversely to variations in the slip of the pump, and by varying the clearance between the cylinder barrel and the pintle.

The latter method is employed in the hydraulic machine disclosed in the above application, but it is not readily applicable to a pump or motor in which the pintle is moved in a direction transverse to its axis to vary pump displacement. Further, if this machine were employed as a motor and should stall under a heavy load, the pressure in the end cylinders might urge the cylinder barrel along the pintle until the lubricating film was squeezed from between the same and thereby cause the motor to have a low starting torque. Also, the cylinder barrel might seize upon the pintle.

The present invention has as an object to provide a pump or motor in which the slip is maintained substantially constant under all operating conditions.

Another object is to provide a pump or motor the displacement of which may be varied by adjusting the pintle and in which the clearance between the cylinder barrel and the pintle is automatically varied in response to variations in the pressure and/or the viscosity of the motive liquid.

Another object is to provide a pump or motor with slip controlling mechanism which is positive and precise in operation.

Other objects and advantages will be apparent from the description hereinafter given of a pump or motor in which the invention is embodied.

According to the invention in its general aspect and as ordinarily embodied in practice, the pump or motor is provided with a tapered pintle having a cylinder barrel journaled thereon and with a fluid motor which urges the cylinder barrel toward the large end of the pintle and is energized by liquid which escapes from between the cylinder barrel and the pintle.

According to the invention in another aspect, the pump or motor is provided with a tapered pintle, a cylinder barrel is journaled upon the pintle and urged toward the large end thereof by a fluid motor which is movable with the pintle.

The invention is exemplified by the hydraulic machine illustrated in the accompanying drawings in which the views are as follows:

Fig. 1 is a longitudinal vertical central section through the machine.

Fig. 2 is a sectional plan view taken on the line 2—2 of Fig. 1.

Fig. 3 is a detail view showing a valve in a different position from that occupied by it in Fig. 2.

The hydraulic machine shown in the drawings is identical to the machine shown in Patent No. 2,033,464 which issued March 10, 1936 on the copending application of Walter Ferris, Serial No. 669,861, filed May 8, 1933. Hence, it has not been completely illustrated nor will it be described in detail herein.

The machine comprises, in general, a closed casing 1, a pintle 2 arranged within the casing, a cylinder barrel 3 journaled upon the pintle and provided with a plurality of radial cylinders 4, a thrust member or driver 5 arranged around the cylinder barrel, a piston 6 arranged in each cylinder and coacting with the thrust member to transmit forces between it and the liquid in the cylinder, and a shaft 7 connected to the thrust member and extending through one end of the casing.

When the shaft 7 is driven from an outside source of power, the thrust member will reciprocate the pistons in the cylinders and rotate the cylinder barrel upon the pintle and thereby cause the machine to function as a pump and, when liquid under pressure is delivered to the cylinders, it will reciprocate the pistons in the cylinders and thereby rotate the thrust member and the shaft and cause the machine to function as a motor.

The machine will thus function as either a

pump or a motor but, for the purpose of explanation, it will be described herein as a pump, and it is to be understood that the terms "pump" and "motor" as employed herein are substantially synonymous within the purview of the present invention.

When the machine is employed as a pump, it is provided with a reservoir 8 which contains a supply of liquid and is shown arranged beneath the casing 1 and connected thereto to support the same.

The casing 1 is provided at its front end with a removable head 9 and at its rear end with a removable head 10.

The head 9 closes the front end of the casing 1 and carries an antifriction bearing 11 in which the shaft 7 is supported.

The head 10 closes the rear end of the casing and has formed therein two main fluid passages 12 and 13 which may be connected, respectively, to two pipes 14 and 15 of an external circuit by two pipe fittings 16 and 17 which are fastened to the rear head 10.

The passages 12 and 13 communicate, in the manner described in Patent No. 2,033,464, with fluid passages formed in the pintle 2 longitudinally thereof, the passage 13 communicating with two upper pintle passages 18 and the passage 12 communicating with two lower pintle passages 19.

The passages 18 and 19 communicate, respectively, at the front ends thereof with two pintle ports 20 and 21 formed diametrically opposite each other in the front part of the pintle 2 which is tapered as shown in Fig. 1.

The cylinder barrel 3 is fitted upon the tapered part of the pintle and provided with a cylinder port 22 for each of the cylinders 4. Each port 22 registers with the pintle ports 20 and 21 alternately as the cylinder barrel rotates to permit liquid to flow into its cylinder during one part of a revolution of the cylinder barrel and to enable the piston 6 in that cylinder to eject liquid therefrom through the other pintle port during another part of a revolution of the cylinder barrel.

Each of the pistons 6 is tubular and provided with a piston pin 23 which is connected at its outer end to a crosshead 24 and provided with a spherical head 25 which is ordinarily formed integral with the crosshead and engages a concave seat formed in the outer end of the piston.

The piston is closed at its outer end by the head 25 which is retained in firm engagement with its seat by a helical compression spring 26 arranged around the pin 23 between an annular shoulder formed in the piston near the outer end thereof and a collar fixed on the inner end of the pin 23.

Each piston head 25 extends through an opening 27 which is formed in the inner wall of the driver 5 midway between the ends of a tangential slot 28 which is formed in the driver 5 and in which the crosshead 24 is arranged to reciprocate.

Each crosshead 24 has its inner face in contact with the inner face of its slot 28 and its outer face in contact with a roller bearing 29 which is arranged in the slot and bears against a hardened bearing plate 30 fixed in the slot. The bearing plate 30 is restrained from movement lengthwise of the slot by a screw 31 which also limits the movement of the roller bearing 29 along the slot.

Each piston is thus positively retained at a fixed distance from the axis of the driver and, when the axis of the driver is offset from the axis of the pintle and the driver is rotated, the pistons will be reciprocated in the cylinders and the cylinder barrel will be rotated upon the pintle.

The driver 5 is supported at its front end by the shaft 7 and at its rear end by a ball bearing 32 carried by a hollow hub 33 which surrounds the pintle 2 and is formed upon an upper transverse way or pintle guide 34 and a lower transverse way or pintle guide 35 upon the front faces thereof.

The guides 34 and 35 are ordinarily formed integral, respectively, with the upper and lower walls of the casing 1 and have arranged therebetween a pintle block 36 which may be formed integral with the pintle 2 but which is ordinarily made separate and rigidly secured thereon to form substantially a part thereof and to provide an oil-tight joint therewith.

The pintle block 36 is shaped to fit between the opposing parallel faces of the guides 34 and 35 and to bear against the rear faces thereof against which it is normally pressed by hydrostatic pressure so that it and the pintle 2 are restrained by the guides from axial or vertical movement, but it may be moved along the guides to change the stroke of the pump.

The pintle block 36 is provided with two arcuate main fluid channels 37 and 38 which extend part way around the pintle 2 and communicate, respectively, with the passages 19 and 18 through slots 37^a and 38^a formed in the pintle 2 at the rear ends, respectively, of the passages 19 and 18.

The channels 37 and 38 communicate, respectively, at the other ends thereof with the passages 12 and 13 through sliding joints 39 and 40 so that the liquid flowing through the pintle passages at one side of the pintle axis flows through the sliding joints at the other side of the pintle axis, thereby hydrostatically balancing the pintle block as fully explained in Patent No. 2,033,464.

If the machine is to be employed as a pump, it is ordinarily provided with an auxiliary gear pump the output of which may be employed for control and other auxiliary purposes, to compensate for leakage losses, to enable the variable pump to operate differential motors, and/or to supercharge the variable pump.

The gear pump is of ordinary construction and consists of a driving gear 41, which is fixed upon the shaft 7 to rotate therewith, and a driven gear 42 which meshes with the gear 41 and is carried by a stub shaft 43 supported in the front head 9. The gears 41 and 42 are fitted in a pump chamber 44 which is formed in the front head 9 in communication with suitable intake and discharge channels also formed therein.

The machine thus far described forms, of itself, no part of the present invention as it is fully illustrated and described and the patentable characteristics thereof claimed in Patent No. 2,033,464.

When the pump is in operation, liquid from the pintle discharge port seeps between the cylinder barrel and the pintle and spreads over that area of the pintle which is covered by the cylinder barrel. This liquid forms a lubricating film between the cylinder barrel and the pintle and then a part of this liquid escapes into the intake port and another part thereof escapes from the ends of the cylinder barrel.

The total volume of liquid thus escaping from the pressure port of the pump together with such liquid as may escape past the pistons and

from between the two parts of the sliding joints 39 and 40 is generally designated as the real slip of the pump, and this slip varies in accordance with the variations in the clearance between the cylinder barrel and the pintle, variations in pump pressure, and variations in the viscosity of the liquid.

The pump also has what is known as "apparent slip" which is a variation in its output due to a variation in pump pressure and is caused by the compressibility of the motive liquid and the deflection of the pump parts. The present invention compensates for the entire pump slip, that is, both the real and the apparent slip.

The lubricating film between the cylinder barrel and the pintle is under a pressure which, in a pump having a balanced pintle, is substantially equal to pump pressure at the edges of the pressure port and diminishes as the distance from this port increases, the pressure on the opposite side of the pintle being lower and the pressure at the ends of the cylinder barrel being substantially zero.

The pressure in the lubricating film acts upon the tapered inner surface of the cylinder barrel and the tapered outer surface of the pintle and urges the cylinder barrel toward the small end of the pintle with a force which is substantially proportional to pump pressure, thereby tending to increase the clearance between the cylinder barrel and the pintle with a resultant increase in the slip of the pump.

In order to overcome this tendency and to maintain the slip of the pump substantially constant under all normal operating conditions, the present invention provides mechanism for urging the cylinder barrel toward the large end of the pintle with a force which varies in accordance with variations in pump pressure.

This mechanism includes a piston which is carried by the pintle and consists primarily of a circular plate or flange 45, which is fastened to the end of the pintle, and a floating ring 46 which bears against the rear face of the plate 45 and ordinarily has an expansible piston ring 47 inserted in its outer annular face.

This two-part piston is enclosed within a cylinder 48 which is fastened to or formed integral with the cylinder barrel, extends beyond the end of the pintle, and is closed at its outer end by a cap plate 49 having one or more drainage holes 50 formed therein to permit the escape of any liquid which may seep past the piston ring 47.

If the floating ring 46 and the cylinder 48 had the same coefficient of expansion and if the several parts were made with micrometric accuracy, the piston ring 47 would not be necessary.

The floating ring 46 is rotated by and with the cylinder barrel through one or more driving pins 51, and it is retained in contact with the rear face of the plate 45 by a number of equally spaced compression springs 52 which are arranged in suitable recesses formed in the cylinder barrel.

The piston ring 47 rotates in unison with the floating ring 46 and the cylinder 48 and, consequently, there is no appreciable wear of either the piston ring or the inner wall of the cylinder 48.

The floating ring 46 thus rotates in contact with the rear face of the plate 45, and the contact faces thereof are lubricated by liquid which enters through a number of lubricating grooves 53 which are formed in the plate 45.

Of the liquid which constitutes the internal leakage or slip of the pump, that part which escapes from between the cylinder barrel and the pintle at the front end thereof enters the cylinder 48 and creates therein a pressure which acts upon the inner end of the cylinder 48 and upon the rear face of th piston 45—46. Since the piston 45—46 is restrained from axial movement by being fixed to the pintle, this pressure urges the cylinder barrel toward the large end of the pintle to reduce the clearance between the cylinder barrel and the pintle and thereby reduce the slip of the pump.

Liquid may escape from the cylinder 48 through a radial passageway 54 which is formed in the rear face of the plate 45, an axial passageway 55 which is formed in the pintle 2 and communicates at its front end with the passageway 54, and a radial passage 56, which is formed in the pintle 2 and in the pintle block 36 and communicates at its inner end with the passage 55.

The escape of liquid from the cylinder 48 is retarded by directing the liquid through a restricted passage or other choke or resistance in order to control the pressure in the cylinder 48. As shown, a choke 57 and a pressure responsive valve 58 are arranged in the pintle block 36 and connected to the passage 56 in parallel with each other.

The choke 57 consists of one or more disks 59 (9 being shown) which are closely fitted in a bore 60 extending inward from the rear end of the pintle block 36 and communicating with the passage 56.

Each disk 59 is provided with a small orifice 61, and the several disks are retained in position within the bore 60 by spacer rings 62 which are held in position within the bore 60 by a ring or hollow plug 63 threaded in the rear end thereof.

If a single disk 59 were employed, the orifice 61 therein would necessarily be so small that it might readily become clogged by foreign matter carried by the motive liqiud. Hence, in practice, each orifice is made larger and a number of disks are employed.

The several disks and spacer rings form a series of low pressure chambers and, since the rate of flow of liquid through an orifice depends upon the drop in pressure across the orifice, this series of pressure chambers and orifices provide such resistance that the rate of flow of liquid therethrough is very low even when a relatively high pressure prevails in the passage 56.

The pressure responsive valve 58 is provided with a hollow piston 64 which is closely fitted for reciprocation within a bore 65 formed in the pintle block 36 and having a ring or hollow plug 66 threaded into the rear end thereof.

The piston 64 is provided at its inner end with a valve stem 67 having a valve or head 68 fixed upon the inner end thereof and normally arranged in a chamber 69 formed in the pintle block 36.

The chamber 69 is connected at its front end to the passage 56 by a passage 70 and communicates at its rear end with the bore 65 through a smaller bore 71 the diameter of which is substantially the same as the diameter of the valve 68 and into which a predetermined high pressure in the passage 56 will urge the valve 68 to close communication between the passage 56 and the bore 65.

The piston 64 is normally retained in engagement with the front end of the bore 65 by a helical compression spring 72 which is arranged therein between the front or head end thereof and the plug 66.

The front or head end of the piston 64 is provided with a chamber 73 which communicates at

its front end with the bores 65 and 71 through small ducts 74 arranged around the stem 67, and which is partially closed at its rear end by a replaceable plug 75 having a small orifice 76 formed therein.

When the piston 64 is in the position shown in Fig. 2, liquid from the cylinder 48 may flow through the valve 58 via the chamber 69, the bores 71 and 65, the ducts 74, the chamber 73 and the orifice 76 and, if the rate of flow therethrough is incorrect, it may be varied by replacing the plug 75 with a similar plug having an orifice 76 of different cross-sectional area.

The orifice 76 limits the rate at which liquid may flow through the valve 58 and, when the rate of flow exceeds the capacity of the orifice 76, there will be created in the liquid a pressure which varies in accordance with the variations in the rate of liquid flow.

This pressure acts upon the front ends of the piston 64 and the valve 68 and, when the rate of flow increases to the point where the force exerted thereon by the liquid exceeds the resistance of the spring 72, the piston 64 and the valve 68 will be urged rearward until the valve 68 reduces the flow to the rate at which liquid can pass through the orifice 76, thereby reducing the pressure in the bores 65 and 71 and leaving only the front end of the valve 68 exposed to the pressure in the passage 70. If this pressure is high enough, the force exerted by the liquid upon the valve 68 will urge it into the bore 65 so that any liquid which escapes from the cylinder 48 must pass through the choke 57.

When the pump is operated at pressures within a given pressure range, the resistance of the spring 72 in the valve 58 is substantially balanced by the pressure on the piston 64 and the valve 68 so that the valve 68 ordinarily floats between a fully open and a fully closed position.

The rate of flow through the valve 58 thus decreases as the pressure increases while the rate of flow through the choke 57 increases as the pressure increases.

The choke 57 and the valve 58 provide a combination of resistances which may be so proportioned and adjusted as to maintain substantially constant the total slip consisting of both the real and the apparent slip.

When the pump is idle, there is always sufficient clearance between the cylinder barrel and the pintle to permit the lubricating film therebetween to be replenished or established during the first few revolutions of the cylinder barrel.

This clearance is assured by providing a helical compression spring 77 between the plate 45 which is fixed to the pintle and the plate 49 which is fixed to the cylinder barrel, a ball bearing 78 being arranged between the outer end of the spring and the plate 49 to prevent the spring from being rotated by the cylinder barrel.

The spring 77 also prevents the cylinder barrel from shrinking upon the pintle in case the cylinder barrel should have a higher coefficient of expansion than the pintle and the pump be stopped immediately after operating under high temperatures and pressures.

If the spring 77 should move the cylinder barrel too far forward, the pump when started would simply bypass liquid from one pintle port to the other. It is therefore essential that the forward movement of the cylinder barrel be limited, and this is ordinarily accomplished by limiting the distance between the floating ring 46 and the front end of the cylinder barrel which constitutes the inner end of the cylinder 48.

After the pump has been started and the liquid delivered thereby meets a resistance which causes the pump to develop pressure, liquid seeps between the cylinder barrel and the pintle, enters the cylinder 48 and develops a low pressure therein due to the resistance of the choke 57 and the valve 58 to the escape of liquid therefrom.

This low pressure urges the cylinder barrel toward the large end of the cylinder to reduce the clearance therebetween and thereby reduce the rate at which liquid escapes from between the cylinder barrel and the pintle but, at the same time, the liquid between the cylinder barrel and the pintle is acting upon the tapered surfaces thereof and urging the cylinder barrel toward the small end of the pintle with a force which varies in accordance with variations in pump pressure, thereby tending to increase the slip of the pump.

The rate at which liquid will flow through a restricted passage varies in accordance with variations in either or both the pressure and the viscosity of the liquid.

Therefore, as the pump pressure or the temperature of the motive liquid increases, liquid will flow between the cylinder and the pintle and into the cylinder 48 at a faster rate and thereby tend to escape from the cylinder 48 through the passages 54, 55 and 56 at a faster rate.

However, the escape of liquid from the cylinder 48 is restricted by the choke 57 and the valve 58 so that the pressure in the cylinder 48 increases and urges the cylinder barrel rearward against the resistance of the spring 77 and against the forces exerted upon the tapered bore of the cylinder barrel by the lubricating film and, as the area of the cylinder 48 is such that a relatively low pressure therein exerts a greater rearward force upon the cylinder barrel than the forward force exerted thereon by the lubricating film, the cylinder barrel is moved rearward and the clearance between the cylinder barrel and the pintle is reduced.

The choke 57 and the valve 58 are so proportioned and adjusted that the pump will have at a given low pressure a total slip which is at least as great as its total slip would be at a pressure higher than any pressure which the pump will create under normal operating conditions.

Then, as the pump pressure increases with a resultant increase in pressure in the cylinder 48 and in the passage 56, the flow of liquid through the choke 57 will increase and the flow of liquid through the valve 58 will decrease.

If the valve 58 were adjusted to decrease the flow of liquid therethrough at the same rate that the flow through the choke 57 increases, the flow of liquid from between the cylinder barrel and the pintle into the cylinder 48 would be maintained constant but, since the total slip consists also of other factors such as the liquid which escapes past the pistons and from the rear end of the cylinder barrel, compressibility of the liquid and deflection of pump parts, the valve 58 is adjusted to decrease the flow therethrough faster than the flow through the choke 57 increases to thereby increase the pressure in the cylinder 48 with the result that the cylinder barrel is urged rearward and the rate at which liquid can flow into the cylinder 48 is decreased in proportion to the increase in the other slip factors, thereby maintaining the net output of the pump substantially constant through-

out the entire range of operating temperatures and pressures.

Also, the pump may be adjusted to compensate for variations in leakage in a hydraulic circuit fed by it, providing that the leakage is not excessive and the variations therein are due to variations in pump pressure, thereby obtaining a substantially constant speed in any motor connected into that circuit.

If the pump is to compensate for leakage in a circuit, it is adjusted to have at a low pressure an initial slip which is at least as great as the combined pump slip and circuit leakage at a pressure at least as high as the greatest pressure created in the circuit by the pump under normal operating conditions, and then the choke 57 and the valve 58 are adjusted to compensate for variations in slip, as previously explained.

If the pump is to be employed as a motor, it is necessary to adjust choke 57 and valve 58 to obtain a constant motor speed throughout the range of operating pressures since the factors which constitute the slip of a motor differ somewhat from the factors which constitute the slip of a pump.

The invention herein set forth is susceptible of various modifications without departing from the scope thereof as hereinafter claimed.

The invention is hereby claimed as follows:

1. In a pump or motor, the combination of a tapered pintle, a cylinder barrel journaled upon said pintle, a fluid motor for urging said cylinder barrel toward the large end of said pintle and means for energizing said motor by directing thereto liquid which escapes from between said cylinder barrel and said pintle.

2. In a pump or motor, the combination of a tapered pintle adapted to be moved to vary the displacement of said pump or motor, a cylinder barrel journaled upon said pintle, a fluid motor for urging said cylinder barrel toward the large end of said pintle and movable with said pintle, and means for energizing said motor by directing thereto liquid which escapes from between said cylinder barrel and said pintle.

3. In a pump or motor, the combination of a tapered pintle, a cylinder barrel journaled upon and carried by said pintle, a fluid motor for urging said cylinder barrel toward the large end of said pintle carried by said pintle, and means for energizing said motor by directing thereto liquid which escapes from between said cylinder barrel and said pintle.

4. In a pump or motor, the combination of a tapered pintle, a cylinder barrel journaled upon said pintle, a fluid motor for urging said cylinder barrel toward the large end of said pintle, means for energizing said motor by directing thereto liquid which escapes from between said cylinder barrel and said pintle, and means for controlling the escape of liquid from said motor.

5. In a pump or motor, the combination of a tapered pintle, a cylinder barrel journaled upon said pintle, a fluid motor for urging said cylinder barrel toward the large end of said pintle, means for directing liquid leaking from between said cylinder barrel and said pintle to said motor to energize the same, and means responsive to variations in the pressure in said motor for varying the rate of escape of liquid therefrom.

6. A pump or motor, comprising a casing, a tapered pintle provided with intake and discharge ports and passages arranged within said casing and restrained from axial movement relative thereto, a cylinder barrel fitted upon and carried by said pintle to rotate thereon and provided with cylinders which communicate with said pintle ports alternately as said cylinder barrel rotates, pistons arranged in said cylinders, means for rotating said cylinder barrel and reciprocating said pistons, and a piston and a cylinder carried by said pintle and operated by liquid from said cylinders to urge said cylinder barrel toward the large end of said pintle and thereby control the escape of liquid from between said cylinder barrel and said pintle.

7. A pump or motor, comprising a casing, a tapered pintle provided with intake and discharge ports and passages arranged within said casing and restrained from axial movement relative thereto, a cylinder barrel fitted upon and carried by said pintle to rotate thereon and provided with cylinders which communicate with said pintle ports alternately as said cylinder barrel rotates, pistons arranged in said cylinders, means for rotating said cylinder barrel and reciprocating said pistons, a piston and a cylinder carried by said pintle and operated by liquid from said cylinders to urge said cylinder barrel toward the large end of said pintle and thereby control the escape of liquid from between said cylinder barrel and said pintle, means for permitting escape of liquid from said last named cylinder and means for controlling the rate of said escape.

8. A pump or motor, comprising a casing, a tapered pintle provided with intake and discharge ports and passages arranged within said casing and movable transversely to vary pump displacement but restrained from axial movement relative to said casing, a cylinder barrel fitted upon said pintle to rotate thereon and provided with cylinders which communicate with said pintle ports alternately as said cylinder barrel rotates, pistons arranged in said cylinders, means for rotating said cylinder barrel and reciprocating said pistons, and a piston and a cylinder movable with said pintle and operated by liquid from said cylinders to urge said cylinder barrel toward the large end of said pintle and thereby control the escape of liquid from between said cylinder barrel and said pintle.

9. A pump or motor, comprising a casing, a tapered pintle provided with intake and discharge ports and passages arranged within said casing and movable transversely to vary pump displacement but restrained from axial movement relative to said casing, a cylinder barrel fitted upon said pintle to rotate thereon and provided with cylinders which communicate with said pintle ports alternately as said cylinder barrel rotates, pistons arranged in said cylinders, means for rotating said cylinder barrel and reciprocating said pistons, a piston and a cylinder movable with said pintle and operated by liquid from said cylinders to urge said cylinder barrel toward the large end of said pintle and thereby control the escape of liquid from between said cylinder barrel and said pintle, and means for controlling the rate at which liquid may escape from said last named cylinder.

10. A pump or motor, comprising a casing, a tapered pintle provided with intake and discharge ports and passages arranged within said casing and restrained from axial movement relative thereto, a cylinder barrel fitted upon and carried by said pintle to rotate thereon and provided with cylinders which communicate with said pintle ports alternately as said cylinder barrel rotates, pistons arranged in said cylinders,

means including a driveshaft for rotating said cylinder barrel and reciprocating said pistons, and a piston and a cylinder arranged between said driveshaft and said pintle and operated by liquid from said cylinders to urge said cylinder barrel toward the large end of said pintle and thereby control the escape of liquid from between said cylinder barrel and said pintle.

11. The combination, with a pump or motor having a tapered pintle and a cylinder barrel journaled upon said pintle to rotate thereon, of a piston arranged upon one end of said pintle, and a cylinder fitted upon said piston and arranged upon said cylinder barrel to receive leakage liquid from between said cylinder barrel and said pintle to enable said liquid to create pressure in said cylinder and urge said cylinder barrel toward the large end of said pintle and thereby tend to reduce the clearance between said cylinder barrel and said pintle.

12. The combination, with a pump or motor having a tapered pintle and a cylinder barrel journaled upon said pintle to rotate thereon, of a piston arranged upon one end of said pintle, a cylinder fitted upon said piston and arranged upon said cylinder barrel to receive leakage liquid from between said cylinder barrel and said pintle to enable said liquid to create pressure in said cylinder and urge said cylinder barrel toward the large end of said pintle and thereby tend to reduce the clearance between said cylinder barrel and said pintle, and means for controlling the escape of liquid from said cylinder to thereby control the pressure therein.

13. The combination, with a pump or motor having a tapered pintle and a cylinder barrel journaled upon said pintle to rotate thereon, of a piston arranged upon one end of said pintle, a cylinder fitted upon said piston and arranged upon said cylinder barrel to receive leakage liquid from between said cylinder barrel and said pintle to enable said liquid to create pressure in said cylinder and urge said cylinder barrel toward the large end of said pintle and thereby tend to reduce the clearance between said cylinder barrel and said pintle, and means urging said cylinder barrel toward the small end of said pintle and thereby tending to increase the clearance between said cylinder barrel and said pintle.

14. The combination, with a pump or motor having a tapered pintle and a cylinder barrel journaled upon said pintle to rotate thereon, of a piston arranged upon one end of said pintle, a cylinder fitted upon said piston and arranged upon said cylinder barrel to receive leakage liquid from between said cylinder barrel and said pintle to enable said liquid to create pressure in said cylinder and urge said cylinder barrel toward the large end of said pintle and thereby tend to reduce the clearance between said cylinder barrel and said pintle, means for controlling the escape of liquid from said cylinder to thereby control the pressure therein, and means urging said cylinder barrel toward the small end of said pintle and thereby tending to increase the clearance between said cylinder barrel and said pintle.

15. The combination, with a pump or motor having a tapered pintle and a cylinder barrel journaled upon said pintle to rotate thereon, of a piston arranged upon one end of said pintle, a cylinder fitted upon said piston and arranged upon said cylinder barrel to receive leakage liquid from between said cylinder barrel and said pintle to enable said liquid to create pressure in said cylinder and urge said cylinder barrel toward the large end of said pintle and thereby tend to reduce the clearance between said cylinder barrel and said pintle, and means responsive to the pressure in said cylinder for controlling the escape of liquid therefrom to thereby control the pressure in said cylinder and thereby control the escape of liquid from between said cylinder barrel and said pintle.

16. The combination, with a pump or motor having a tapered pintle and a cylinder barrel journaled upon said pintle to rotate thereon, of a piston arranged upon one end of said pintle, a cylinder fitted upon said piston and arranged upon said cylinder barrel to receive leakage liquid from between said cylinder barrel and said pintle to enable said liquid to create pressure in said cylinder and urge said cylinder barrel toward the large end of said pintle and thereby tend to reduce the clearance between said cylinder barrel and said pintle, and means for controlling the escape of liquid from said cylinder including an orifice choke and a pressure responsive valve connected in parallel with each other.

17. In a pump or motor having a tapered pintle and a cylinder barrel journaled upon said pintle to rotate thereon, the combination of a piston connected to said pintle and restrained from axial movement thereby, and a cylinder fitted upon said piston and arranged upon said cylinder barrel to receive leakage liquid from between said cylinder barrel and said pintle to enable said liquid to create pressure in said cylinder and urge said cylinder barrel toward the large end of said pintle and thereby tend to reduce the clearance between said cylinder barrel and said pintle, said piston having a part thereof arranged to rotate with said cylinder.

18. In a pump or motor having a tapered pintle and a cylinder barrel journaled upon said pintle to rotate thereon, the combination of a cylinder arranged upon said cylinder barrel to receive liquid leaking from between said cylinder barrel and said pintle, a piston fitted in said cylinder and having a part thereof rotatable with said cylinder and another part thereof connected to said pintle to be restrained from relative axial movement thereby, and means for resisting the escape of liquid from said cylinder to enable the liquid therein to urge said cylinder barrel toward the large end of said pintle and thereby tend to reduce the clearance between said cylinder barrel and said pintle.

19. In a pump or motor having a tapered pintle and a cylinder barrel journaled upon said pintle to rotate thereon, the combination of a cylinder arranged upon said cylinder barrel to receive liquid leaking from between said cylinder barrel and said pintle, a piston fitted in said cylinder and having a part thereof rotatable with said cylinder and another part thereof connected to said pintle to be restrained from relative axial movement thereby, packing means arranged between said rotatable piston part and the wall of said cylinder and rotatable therewith, and means for resisting the escape of liquid from said cylinder to enable the liquid therein to urge said cylinder barrel toward the large end of said pintle and thereby tend to reduce the clearance between said cylinder barrel and said pintle.

20. In a pump having a tapered pintle and a cylinder barrel fitted upon said pintle to rotate thereon, the combination of a flange carried by said pintle upon the end thereof, a floating ring abutting said flange and making a tight running joint therewith and connected to said cylinder barrel to rotate therewith in contact with said

flange, and a cylinder connected at its rear end to said cylinder barrel to receive liquid leaking from between said cylinder barrel and said pintle and fitted upon said floating ring to enable it to resist the escape of liquid through the front end of said cylinder to thereby enable liquid in said cylinder to urge said cylinder barrel toward the large end of said pintle.

21. In a pump having a tapered pintle and a cylinder barrel fitted upon said pintle to rotate thereon, the combination of a flange carried by said pintle upon the end thereof, a floating ring abutting said flange and making a tight running joint therewith and connected to said cylinder barrel to rotate therewith in contact with said flange, a cylinder arranged upon said cylinder barrel to enclose said ring and said flange and to receive liquid leaking from between said cylinder barrel and said pintle, a piston ring carried by said floating ring in contact with the wall of said cylinder and forming with said floating ring and said flange a piston for said cylinder to enable liquid entering said cylinder to urge said cylinder barrel toward the large end of said pintle, means for controlling the escape of liquid from said cylinder, and means urging said cylinder barrel toward the small end of said pintle.

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