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VARIABLE VOLUME HYDRAULIC MOTOR WITH
PRESSURE RESPONSIVE VOLUME CONTROL

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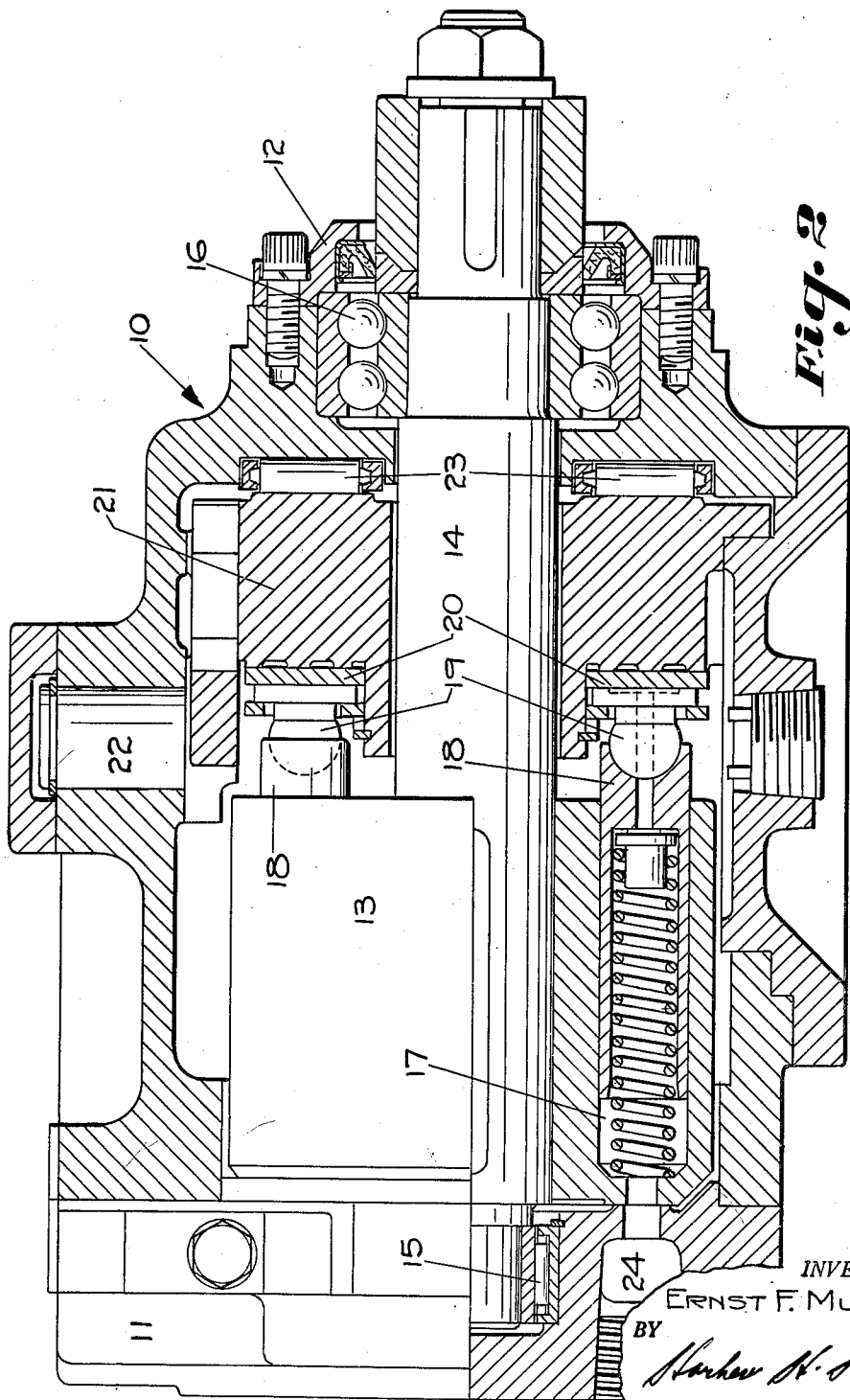


Fig. 2

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VARIABLE VOLUME HYDRAULIC MOTOR
WITH PRESSURE RESPONSIVE VOLUME
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This invention relates to a variable volume type of hydraulic motor, and an object of the invention is to provide improved means for controlling automatically the volume of the motor for each revolution in response to the pressure of the hydraulic fluid delivered to said motor and in which means is provided to adjust the motor to maximum volume whenever the motor is first started in operation, after which the volume of said motor will be adjusted automatically as aforesaid.

Other objects of the invention will appear hereinafter, the novel features and combinations being set forth in the appended claims.

In the accompanying drawings:

Fig. 1 is an elevational view, with parts broken away, showing an improved hydraulic motor incorporating features of my invention; and

Fig. 2 is a sectional view, with a part of the rotor and head shown in plan, of the motor of Fig. 1.

The hydraulic motor includes a main casting forming a housing or casing 10 having a removable combination feed end cap and port plate 11 at one end and a bearing retaining cap 12 at the other end. Within the casing 10 there is a rotor 13 mounted on a drive shaft 14 which is carried in spaced anti-friction bearings 15 and 16 carried adjacent opposite ends thereof.

The rotor 13 is provided with a plurality of axially extending cylinders, one of which is seen at 17 in Fig. 2 of the drawings, within each of which cylinders there is a piston 18 having a bearing shoe 19 which rides on a thrust plate 20 carried by a trunnion 21 mounted for adjustment on an axis which is at right angles to the axis of the shaft 14 and includes a bearing shaft 22. Thrust received by the trunnion 21 is transmitted to the casing 10 through a pair of arcuate roller bearings 23, the outer surface of the trunnion 21 being formed in an arc of a circle which rolls over said arcuate roller bearings 23.

The motor is preferably of a reversible character and is provided with feed and exhaust ports, one of which is seen at 24, there being a similar port diametrically opposed thereto in a manner well understood in this art. By making port 24 either a pressure port or an exhaust port; in other words, by connecting it selectively to the pressure line or the exhaust line, the direction of rotation of the motor may be selectively controlled.

As best illustrated in Fig. 1 of the drawings the trunnion 21 is provided with a socket receiving the head of a push rod 25 which is urged

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by a heavy spring 26 to the minimum volumetric position of the trunnion 21, in which position the thrust plate 20 is in a plane substantially vertical with the axis of the shaft 14. It is obvious that when the thrust plate 20 is so positioned the pistons 18 will have little or no reciprocatory motion for each revolution of the rotor 13 and shaft 14. One end of the spring 26 abuts one end of a collar 27 carried by the push rod 25, the other end abutting an appropriate washer carried by the cap 11.

Diametrically opposite the push rod 25 there is a composite piston designated in its entirety by the reference character 28 which from a functional or operative standpoint includes two separate pistons 29 and 30 formed integrally. The piston 29 has a larger diameter than the piston 30, and the former reciprocates in a relatively large diameter cylinder 31, the latter in a smaller diameter cylinder 32 which is formed by extending a sleeve 33 in one end of the cylinder 31 and adjacent the cap 11, said sleeve 33 being held in position by cooperating shoulders between it and the cylinder 31 and by said cap 11, as is obvious from Fig. 1 of the drawings.

The principal portion of the piston 29 is provided with a relatively large bore 34 which receives an elongated pin 35 having a shoulder 36 formed thereon, which shoulder 36 cooperates with the bottom of the bore 34 to limit movement of the pin 35 toward the left as viewed in Fig. 1 of the drawings. Said pin 35 is urged to the left by a helical spring 37 which is held in adjusted position by a movable cap 38 threaded in the bore 34, said cap 38 being provided with drain bores 39 to drain oil which may reach the bore 34. The cap 38 is preferably hardened and cooperates with a hardened thrust button 40 carried by the trunnion 21.

It may be pointed out at this time that hydraulic pressure on the piston 30 or on the piston 29, or both of them, will exert a force through said composite piston 28 tending to rock the trunnion 21 in a direction against the action of the spring 26 and tending to increase the volume of the motor which, of course, means the volumetric consumptions for each revolution thereof.

The left-hand portion of the pin 35 normally extends into a bore 41 which extends through the piston portion 30 of the composite piston 28 and into a portion of the piston 29 thereof. The composite piston 28 is provided with four radial bores 42 spaced ninety degrees (90°) apart, which under certain conditions provide a passageway

for oil from the bore 41 to the large cylinder 31, to the end that said oil under pressure may operate on the piston 29 and urge said piston to the right to increase the capacity of the motor.

As clearly illustrated in Fig. 1 of the drawings the piston 29 has a portion adjacent its left-hand end which is reduced in diameter, thus providing in effect an operating chamber 43 to which hydraulic fluid may be delivered under certain conditions as hereinafter set forth to act on the piston 29. A very small drain passageway 44 extends longitudinally along the cylinder 29 to allow drainage of hydraulic fluid from the chamber 43. This passageway 44 is small enough that when fluid under pressure is delivered to the chamber 43 it will not drain away fast enough to prevent operation of the piston 29.

Hydraulic fluid delivered to the motor under pressure, either to the aforescribed port 24 or its companion port, not shown, is delivered to the cylinder 32 by either of two branch passageways 45. To insure that passageways 45 will always connect to the pressure port rather than the exhaust port I provide a well known form of automatic valve which includes a piston 46 in a cylinder 47 which is connected at opposite ends to passageways 48 and 49, one of which is connected to one of the ports, such as port 24, the other being connected to the other port which is the companion of said port 24. The piston 46 will respond automatically to connect passageways 45 with whichever passageway 48 or 49 is under pressure.

The operation of the hydraulic motor can probably best be understood in connection with a typical operation wherein such a motor is employed. Such a motor is useful, for example, as the driving motor for the traction wheels of a vehicle, for example, a shuttle car, loading machine, or mining machine as used in coal mines. Assuming the vehicle to be standing still and the source of supply, such as a pump, being in operation but not connected to the motor by the control valve. Assuming further that the operator wishes to start the vehicle and operates the control valve to deliver hydraulic fluid under pressure to one of the ports, such as port 24, of said motor. Since the vehicle is at rest it is desirable that it deliver maximum torque at minimum speed to start it in motion. This is effected automatically in the following manner by the hydraulic motor of my invention. The hydraulic fluid delivered to the cylinder 32 will flow through the passageway 41 and against the end of the pin 35 which is within the bore 41 and will shut off the radial bores 42. This will be substantially the operating pressure of the system. The pin 35 and spring 37 cooperate with the bores 41 and 42 to provide a pressure relief valve which is contained within the composite piston 28. This pressure relief valve may, for example, be set to open at 1700 p. s. i., where the operating pressure of the system is approximately 1500 p. s. i. and the overload relief valve of the entire system is set at 2000 p. s. i. These pressures, of course, are merely illustrative.

When this hydraulic fluid under pressure is first delivered to the cylinder 32 as aforesaid, the pressure will build up almost instantaneously to an amount adequate to crack the relief valve provided by the pin 35, spring 37, bores 41 and 42, thus permitting the hydraulic fluid to flow through said bore 41 and through the radial bores 42 to the chamber 43, whereupon the large piston 29 will be subject to the hydraulic pressure

of the system as is the piston 30, which, of course, is subject to said fluid pressure immediately upon its being delivered to the cylinder 32. This force developed by the pistons 29 and 30 is, of course, transmitted through the head 28 to the button 40 and is adequate to rock the trunnion 21 against the spring 26 to the maximum volumetric position of the motor. In other words, the thrust plate 20 will thus be moved to its greatest angle so that the volume of the motor will be a maximum for each revolution, thus providing a maximum torque and a minimum speed of said motor. This, of course, is the desirable starting characteristic of a hydraulic motor.

As the vehicle being moved gains in velocity the tendency will normally be for the required torque to decrease and this would produce a decrease in the pressure in the cylinder 32. This decrease in pressure will allow the check valve 35-37 to close, thus in effect shutting off the flow of hydraulic fluid to the large cylinder 31, or, in other words, to the chamber 43. Under these conditions the trunnion positioning force is developed entirely by the piston 30, none of its being produced by the larger piston 29. Piston 30 will respond automatically to the pressure delivered to the cylinder 32 which is the pressure of the hydraulic system to adjust the trunnion 21 against the spring 26 so that the speed of the motor and thus the speed of the driven vehicle will be such as to maintain the pressure of the hydraulic system substantially constant.

Stated another way, once the vehicle is in operation the smaller piston 30 takes control to adjust the volume of oil consumed by the motor per revolution, such that the speed of the vehicle will consume the energy delivered hydraulically by the pump. The motor therefore is in effect an automatic speed regulator because should the vehicle encounter significant resistance to speed it will automatically slow down in response to a rise in pressure in the hydraulic system. Conversely, when the vehicle is traveling against light resistance its speed will automatically increase by responding to the hydraulic pressure in a manner to decrease the consumption of oil for each revolution of the motor.

It is particularly important that during starting there are two pistons cooperating to oppose the spring 26 and thus insure maximum torque with a minimum speed for any gallonage consumption of the motor. After this starting with maximum torque and minimum speed it is important that the trunnion be adjusted by a single piston or a piston which develops less total thrust than that involved during the starting period.

Obviously those skilled in the art may make various changes in the details and arrangement of parts without departing from the spirit and scope of the invention as defined by the claims hereto appended, and applicant therefore wishes not to be restricted to the precise construction herein disclosed.

Having thus described and shown an embodiment of the invention, what is desired to secure by Letters Patent of the United States is:

1. A hydraulic motor including means for adjusting its hydraulic capacity for each revolution, a hydraulically operated mechanism for adjusting said adjusting means by hydraulic fluid under pressure operating said motor, said hydraulically operated mechanism including means forming a pair of cylinders, a piston in each of said cylinders for adjusting said adjusting means, con-

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duit means for conducting said hydraulic fluid to said cylinders, and valve means normally isolating one of said cylinders adapted to open and close at a predetermined hydraulic pressure whereby when the pressure of said fluid exceeds said predetermined pressure the fluid may flow to said one cylinder.

2. A hydraulic motor including means for adjusting its hydraulic capacity for each revolution, hydraulically operated mechanism for adjusting said adjusting means by hydraulic fluid under pressure operating said motor, said hydraulically operated mechanism including means forming a pair of cylinders of different internal diameters, a piston in each of said cylinders for adjusting said adjusting means, conduit means for conducting said hydraulic fluid to the smaller of said cylinders, and valve means between said cylinders adapted to open and close at a predetermined hydraulic pressure whereby when the pressure of fluid in said smaller cylinder exceeds said predetermined pressure the fluid may flow from one cylinder to the other.

3. A hydraulic motor including means for adjusting its hydraulic capacity for each revolution, hydraulically operated mechanism for adjusting said adjusting means by hydraulic fluid under pressure operating said motor, said hydraulically operated mechanism including means forming a pair of cylinders, a piston in each of said cylinders for adjusting said adjusting means, conduit means for conducting said hydraulic fluid to one of said cylinders, means forming a fluid passageway adapted to interconnect said cylinders, and means forming a valve responsive to pressure in said one cylinder normally blocking said passageway and adapted to open and close at a predetermined hydraulic pressure whereby when the pressure of fluid in said one cylinder exceeds said predetermined pressure it may flow to and from the other cylinder.

4. A hydraulic motor including means for adjusting its hydraulic capacity for each revolution, hydraulically operated mechanism for adjusting said adjusting means by hydraulic fluid under pressure operating said motor, said hydraulically operated mechanism including means forming a pair of cylinders, a piston in each of said cylinders for adjusting said adjusting means, one of said pistons including means forming a fluid passageway adapted to connect said cylinders, conduit means for conducting said hydraulic fluid to the cylinder having said passageway forming piston, and valve means associated with said passageway normally blocking it and adapted to open at a predetermined hydraulic pressure whereby when the pressure of said hydraulic fluid in said one cylinder is above said predetermined pressure said fluid may flow to said other cylinder.

5. A hydraulic motor including means for adjusting its hydraulic capacity for each revolution, hydraulically operated mechanism for adjusting said adjusting means by hydraulic fluid under pressure operating said motor, said hydraulically operated mechanism including means forming a pair of axially aligned cylinders of different internal diameters, means forming interconnected pistons one in each of said cylinders including a passageway connecting said cylinders, conduit means for conducting said hydraulic fluid to one of said cylinders, and valve means normally blocking said passageway adapted to open at a predetermined hydraulic pressure whereby when the pressure of said hydraulic fluid in said one

cylinder exceeds said predetermined pressure fluid may flow to both of said cylinders.

6. A hydraulic motor including means for adjusting its hydraulic capacity for each revolution, hydraulically operated mechanism for adjusting said adjusting means by hydraulic fluid under pressure operating said motor, said hydraulically operated mechanism including means forming a pair of axially aligned cylinders of different internal diameters, means forming interconnected pistons one in each of said cylinders, the smaller piston of which includes means forming a passageway interconnecting said cylinders, conduit means for conducting said hydraulic fluid to the smaller of said cylinders, and a spring loaded valve means normally blocking said passageway adapted to open at a predetermined hydraulic pressure whereby when the pressure of said hydraulic fluid in the smaller of said cylinders exceeds said predetermined pressure hydraulic fluid may flow to said larger cylinder through said passageway.

7. A hydraulic motor including means for adjusting its hydraulic capacity for each revolution, hydraulically operated mechanism for adjusting said adjusting means by hydraulic fluid under pressure operating said motor, said hydraulically operated mechanism including means forming a pair of axially aligned cylinders of different internal diameters, means forming interconnected pistons one in each of said cylinders, the smaller piston of which includes means forming a passageway interconnecting said cylinders, conduit means for conducting said hydraulic fluid to the smaller of said cylinders, and a spring loaded valve means normally blocking said passageway adapted to open at a predetermined hydraulic pressure whereby when the pressure of said hydraulic fluid in the smaller of said cylinders exceeds said predetermined pressure hydraulic fluid may flow to said larger cylinder through said passageway, said spring loaded valve means including a valve plunger and a spring carried within the larger of said pistons.

8. A variable volume rotary hydraulic motor including a casing, a rotor mounted in said casing and having reciprocable cylinders, pistons in said cylinders, a thrust plate positioned to take the thrust of said pistons, means mounting said thrust plate for adjustment to adjust the volumetric consumption of said motor for each revolution, spring means urging said thrust plate toward a minimum consumption position, pressure responsive means opposing said spring means and urging said thrust plate to a maximum consumption position, said pressure responsive means including a line pressure chamber, a cylinder having a relatively large area and a second cylinder having a relatively small area, a piston in each of said cylinders operative in response to pressure therein to urge said thrust plate in opposition to said spring means, means connecting said cylinder of relatively small area permanently to said line pressure chamber, and pressure responsive valve means for connecting said cylinder of relatively large area to said line pressure chamber whenever the line pressure reaches a predetermined value.

9. A variable volume rotary hydraulic motor including a casing, a rotor mounted in said casing and having reciprocable cylinders, pistons in said cylinders, a thrust plate positioned to take the thrust of said pistons, means mounting said thrust plate for adjustment to adjust the

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volumetric consumption of said motor for each revolution, spring means urging said thrust plate toward a minimum consumption position, pressure responsive means opposing said spring means and urging said thrust plate to a maximum consumption position, said pressure responsive means including a line pressure chamber, a pair of cylinders, a piston in each of said cylinders operative in response to pressure therein to urge said thrust plate in opposition to said spring means, means connecting one of said pair of cylinders permanently to said line pressure chamber, and pressure responsive valve means for connecting the other of said pair of cylinders to said line pressure chamber whenever the line pressure reaches a predetermined value.

10. A pressure responsive variable volume motor including a member adjustable to vary the effective volume of said motor for each revolution, means urging said member to a minimum volume position, fluid pressure responsive means urging said member to a maximum volume position, said fluid responsive means including a pair of pistons of unequal area, the smaller of which is normally in communication with the fluid pressure, and pressure responsive valve means for putting the larger of said pistons in communication with the fluid pressure whenever the fluid pressure reaches a predetermined value and cutting it off of communication therewith when the fluid pressure drops below said predetermined value.

11. A pressure responsive variable volume motor including a member adjustable to vary the effective volume of said motor for each revolution, means urging said member to a minimum volume position, fluid pressure responsive means urging said member to a maximum volume position, said fluid responsive means including a pair

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of pistons, one of which is normally in communication with the fluid pressure, and pressure responsive valve means for putting the other of said pistons in communication with the fluid pressure whenever the fluid pressure reaches a predetermined value and cutting it off of communication therewith when the fluid pressure drops below said predetermined value.

12. A variable volume hydraulic motor including an adjustable volume control member, pressure responsive means for adjusting said volume control member including a pair of aligned cylinders of different diameters, different size connected pistons, one in each of said cylinders, a passageway formed in the smaller of said pistons connecting the two cylinders together when said passageway is open, and a high pressure responsive valve including a spring housed in the larger of said pistons normally closing said passageway.

13. A variable volume hydraulic motor including an adjustable volume control member, pressure responsive means for adjusting said volume control member including a pair of aligned cylinders of different diameters, different size connected pistons, one in each of said cylinders, a passageway formed in the smaller of said pistons connecting the two cylinders together when said passageway is open, and a high pressure responsive valve normally closing said passageway.

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