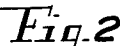
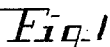


3,079,897

Filed Nov. 29, 1960



BY

Barthel & Bugbee
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CONSTANT-SPEED RECIPROCABLE HYDRO-PNEUMATIC MOTOR

Jerry Kirsch, 3946 Bishop Road, Detroit 24, Mich.

Filed Nov. 29, 1960, Ser. No. 72,476

5 Claims. (Cl. 121-38)

This invention relates to reciprocable fluid pressure motors and, in particular, to reciprocable hydro-pneumatic motors containing a relatively incompressible working fluid, such as a liquid, and also a compressible working fluid, such as a gas.

One object of this invention is to provide a reciprocable hydro-pneumatic motor having a reciprocable hollow piston, the head of which contains a flow control valve which automatically produces a constant rate of flow of hydraulic pressure fluid from one side of the piston head to the other side thereof, the hollow piston containing a free or floating internal piston with a compressed gas, such as nitrogen, on the opposite side of the floating piston from the hydraulic fluid, thereby causing the hollow piston rod to move at a constant speed out of its cylinder.

Another object is to provide a reciprocable hydro-pneumatic motor of the foregoing character wherein the flow control valve includes a sleeve valve member which is movable against opposing spring pressure to open or close or reduce the size of cooperating ports as the hydraulic pressure varies within the hollow piston rod, thereby causing the hydraulic fluid to emerge from the piston head into the main cylinder chamber at a constant rate of flow which produces a constant speed of travel of the piston and cylinder relatively to each other.

Another object is to provide a reciprocable hydro-pneumatic motor of the foregoing character wherein the reciprocable sleeve valve member is mounted in a ported sleeve which in turn is stationarily mounted in the head of the hollow piston.

Other objects and advantages of the invention will become apparent during the course of the following description of the accompanying drawings, wherein:

FIGURE 1 is a central vertical section through a reciprocable hydro-pneumatic motor adapted to produce a constant piston speed, according to one form of the invention, with the piston shown in its fully closed position ready to commence its opening stroke;

FIGURE 2 is a view similar to the upper end of FIGURE 1, but with the sleeve valve member of the flow control valve in the hollow piston head in its actuating position closing off a portion of the flow of hydraulic fluid from the intermediate chamber within the hollow piston rod to the main chamber within the cylinder of the motor, with the parts shown in the positions occupied shortly after the commencement of the opening stroke of the motor; and

FIGURE 3 is a view similar to FIGURE 2 but showing a modified motor with the flow control valve in the hollow piston head in a reverse direction providing regulated flow of the fluid during the closing stroke therein shown and free flow during the opening stroke, which is the opposite of the arrangement shown in FIGURES 1 and 2.

Referring to the drawing in detail, FIGURES 1 and 2 show a constant speed reciprocable hydro-pneumatic motor, generally designated 10, according to one form of the invention as consisting generally of a main cylinder 12, a hollow piston 14 reciprocable within the main cylinder 12, a free or floating piston 16 reciprocable within the hollow piston 14, and a constant speed flow control valve 18 mounted in the head of the hollow piston 14. The hollow piston 14 externally of the main cylinder 12 is closed by a hollow cap 20. The motor 10, by reason of the above construction, possesses a main or inner hy-

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draulic chamber 22 above the hollow piston 14, an intermediate or middle hydraulic chamber 24 above the free piston 16, and a pneumatic or outer chamber 26 below the free or floating piston 16.

The main cylinder 12 is provided with an end wall 23 containing a threaded hydraulic fluid filling port 25 closed by a threaded plug 27 and with a cylinder bore 28, the upper portion of which forms the main hydraulic chamber 22. The lower end portion of the main cylinder 12 is externally threaded and has threaded thereon a stop collar or closure collar 30 having a bore 32 therethrough of slightly smaller diameter than the main cylinder bore 28 with an annular shoulder 34 therebetween. The closure collar 30 has an internally-grooved open end 36 to receive a scraper ring 38.

The hollow piston 14 includes a piston head 40 reciprocable in the main cylinder bore 28 and a hollow piston rod 42 of smaller diameter which extends downwardly therefrom through the bore 32 in the stop collar 30, thereby providing an annular shoulder 43 between the hollow piston head 40 and hollow piston rod 42 and also an annular space 44 between the piston rod 42 and the cylinder bore 28 which is vented to the atmosphere by a radial vent port 46. The lower end of the hollow piston rod 42 (FIGURE 1) is externally threaded to receive the internally-threaded upper end of the closure cap 20. The latter is provided with a central internally-threaded hole 48 into which is threaded a charging fitting 50 which in turn is internally bored and threaded to receive a spring-pressed filling valve 51 resembling a pneumatic tire filling valve and threaded externally to receive a closure cap 52. The closure cap 20 is provided with a cup-shaped recess 54, the mouth of which is internally-threaded to receive a correspondingly-threaded closure disc 56 sealing off the recess 54. The charging fitting 50 is provided for the purpose of charging the pneumatic or lower chamber 26 with a compressed gas, such as air or nitrogen, after which the plug 52 is tightened and the closure disc 56 inserted to close the mouth of the recess 54.

The hollow piston rod 42 is provided, as its name suggests, with a longitudinal piston rod bore 58 which in itself serves as a cylinder bore in which the free or floating piston 16 freely reciprocates. The latter is externally grooved to receive an O-ring or other sealing ring 60. The upper end of the piston rod bore 58 is counterbored as at 62 to receive the constant speed flow control valve 18, which is mounted in the hollow piston head 40 in the correspondingly-threaded upper flange 64 on the upper end of a valve casing 66 which also completes the piston head 40. The valve casing 66 is spool-shaped with its threaded upper flange 64, a reduced-diameter neck portion 68 and a lower flange 70 which is externally-grooved to receive a sealing ring 72, such as an O-ring. The hollow piston rod 40 is also externally grooved at axially-spaced locations to receive sealing rings 74, such as O-rings. The gasket 38 and the sealing rings 60, 72 and 74 are preferably of elastic deformable material, such as natural or synthetic rubber or compositions thereof.

The upper flange 64 of the valve casing 66 is provided with axial ports 76 extending therethrough from the main or upper hydraulic chamber 22 to the annular space or chamber 78 between the upper and lower valve casing flanges 64 and 70. The neck portion 68 of the valve casing 66 is provided with radial ports 80 extending there-through from the annular valve casing chamber 78 to a valve bore 82 extending axially into the valve casing 66 from the lower end thereof, which is internally-grooved to receive a snap ring or retaining ring 84. The upper end of the valve bore 82 terminates within the upper flange 64 and is there provided with a vent port 86 opening into the main cylinder chamber 22 from a spring

chamber 88 formed by the upper end of the valve bore 82 and containing a helical compression spring 90.

The compression spring 90 at its upper end is seated against the upper flange 64 surrounding the vent 86 and at its lower end engages the annular upper end 92 of a cup-shaped sliding sleeve valve member 94 forming the moving part of the flow control valve 18. The cup-shaped sleeve valve member 94 is provided with a skirt 96 containing a plurality of radial circumferentially-spaced ports 98 disposed on the same level as the valve casing ports 80 in the lowermost position of the sleeve valve member 94 when urged by the compression spring 90 against the snap ring 84 (FIGURE 1). The radial ports 98 in the skirt 96 of the sleeve valve member 94 are interconnected by an annular external groove 100 in the skirt 96, so that the ports 98 are not required to remain in radial alignment with the ports 80 in order to effect communication therewith. The sleeve valve member 94 adjacent the snap ring 84 has an end wall 102 provided with a central port or orifice 104 encircled by inner and outer end wall surfaces 106 and 108 respectively.

In the operation of the constant speed reciprocable hydropneumatic motor 10, let it be assumed that one or more of the motors 10 are placed in a suitable installation such as, for example, with the main cylinder 12 seated in a part engageable with a movable member such as a press platen, while the cap 20 on the end of the hollow piston rod 14 is seated in a relatively stationary part, such as in a die to return a cam slide after closing thereof. Let it also be assumed that the upper or main hydraulic chamber 22 has been filled with hydraulic fluid, such as oil, through the port 25 while the main cylinder end wall 23 is located at its maximum distance away from the hollow piston head 40, so that the annular shoulders 43 and 34 are in close proximity to one another or in direct engagement with one another. This constitutes the open or extended position of the motor 10 in contrast with the compressed or closed position shown in FIGURES 1 and 2. Let it finally be assumed that the lower chamber 26 has been charged with an expansible fluid such as a compressed gas, compressed nitrogen being preferred because of its inert characteristics, this being accomplished by means of a hose (not shown) having a coupling engaging the externally-threaded filling valve 51 in the absence of the closure cap 52 and closure disc 56 (FIGURE 1). When the parts are in the open position of the motor 10, the floating piston 16 is forced by the compressed gas within the lower or pneumatic chamber 26 into close proximity with the lower flange 70 of the valve casing 66.

As the press platen or other moving member connected to or engaging the main cylinder 12 carries out its downward or working stroke, such as by the descent of a press platen, the platen or other moving part carries downward with it the main cylinder 12. This action forces hydraulic fluid from the substantially full upper or main hydraulic chamber 22 and causes the fluid to flow freely through the ports 76, the annular external valve casing chamber 78, the now-aligned or fully open ports 80 and 98 so maintained by the urge of the compression spring 90, and the end port 104 of the sleeve valve member 94 into the intermediate or middle hydraulic chamber 24. The accumulation of hydraulic pressure fluid in the intermediate or middle chamber 24 acts against the free or floating piston 16 and forces it downward toward the position shown in FIGURE 1, further compressing the gas or other expansible fluid within the lower or pneumatic chamber 26. In this manner, the lower chamber 26 and the floating piston 16 act in a manner similar to a pneumatic accumulator of hydraulic pressure fluid, storing up potential energy in the lower chamber 26.

When the downward motion of the main cylinder 12 relatively to the hollow piston 14 is terminated (FIGURE 2), and the main cylinder 12 is released to move upward, the compressed gas in the lower chamber 26 acting

against the floating piston 16 moves the latter upward. This action expels hydraulic fluid from the intermediate hydraulic chamber 24 through the lower end port 104 and radial skirt ports 98 through the casing ports 80 and 76 into the upper or main hydraulic chamber 22, causing a pressure drop or differential pressure to be created on opposite sides of the end port 104 as a result of the Venturi effect of fluid flow therethrough.

The instant the cylinder 12 of the motor 10 of FIGURES 1 and 2 starts moving upward (FIGURE 2) after reaching the bottom of its stroke (FIGURE 1), the sleeve valve member 94 moves upward as shown in FIGURE 2, causing its port 98 to move past the ports 80 to throttle or reduce the flow of hydraulic fluid therethrough, in response to the drop in pressure across the end orifice or port 104. As the upward or opening stroke of the cylinder 12 proceeds further and the pressure drops in the middle chamber 24, the sleeve valve member 94 moves downward, causing its port 98 to move into wider opening relationship with the ports 80 and thereby increasing the flow of fluid through the increased resultant port area.

In one form of the valve 10 as actually constructed and successfully tested, it has been found that at high pressures the fluid flow does not exceed the rate of ten gallons per minute and maintains a constant volumetric flow of hydraulic fluid over a wide range of variation of pneumatic pressures in the end chamber 26 and a consequent wide range of variation of hydraulic pressures in the middle chamber 24. In the above-mentioned motor 10 as constructed, the lower or pneumatic chamber or end chamber 26 is precharged, in the open position of the motor 10, with compressed air at a pressure of 300 pounds per square inch which builds up to a pressure of 1800 to 2000 pounds per square inch in the closed position of the motor 10 shown in FIGURE 1. The free or floating piston 16 during operation never moves into actual contact with the valve casing flange 70 because an excessive amount of oil is provided in the middle chamber 24 and other communicating spaces in the motor 10 to compensate for any loss of oil by leakage.

The modified hydro-pneumatic motor, generally designated 110 shown in FIGURE 3 is generally similar in construction to the hydro-pneumatic motor 10 shown in FIGURES 1 and 2, but differs in details of construction and arrangement, hence corresponding parts are designated with corresponding reference numerals increased by one hundred. Most importantly, the flow regulating valve member 194 of the valve 118 of the motor 110 is mounted in a reversed position from that of the valve member 94 shown in the motor 10 of FIGURES 1 and 2. In this reversed position, the hydro-pneumatic motor 110 provides regulated flow of fluid at a constant rate during its closing stroke, as shown in FIGURE 3, and free flow during its opening stroke, in contrast to the motor 10 of FIGURES 1 and 2, which provides regulated flow of fluid at a constant rate during its opening stroke and free flow during its closing stroke. In either form of the invention, it is not primarily the pressure of the working fluid, namely the hydraulic fluid, which shifts the valve spool or movable valve member, but rather the flow of fluid through the end orifice thereof creating a venturi effect of reduction in pressure as a result of flow through the end orifice of the valve member, which in turn results in an increase in the pressure differential on opposite sides of that orifice.

The modified hydro-pneumatic motor 110 is provided with a main cylinder 112, a hollow piston 114 reciprocable within the main cylinder 112, a free or floating piston 116 (not shown) similar to the floating piston 16 of FIGURES 1 and 2 and similarly mounted for reciprocation within the hollow piston 114, and a constant speed flow control valve 118 mounted in the head of the hollow piston 114 but with its sleeve valve member 194 mounted in a reversed position as compared with the sleeve valve member 94 of FIGURES 1 and 2. Other distinctions of construction

of the modified hydro-pneumatic motor 110 are that the threaded upper flange 164 on the valve casing 166 is solid and not provided with ports, whereas the lower flange 170 is provided with axial ports 176 corresponding to the ports 76 in the upper flange 64 of the valve casing 66 of the motor 10 of FIGURES 1 and 2.

The operation of the modified hydro-pneumatic motor, generally designated 110 of FIGURE 3 is consequently the reverse of that of the hydro-pneumatic motor 10 described above and shown in FIGURES 1 and 2.

What I claim is:

1. A unidirectionally constant-speed reciprocable hydropneumatic motor comprising a cylinder having a cylinder bore therein and having a closed end and an open end, a restrained piston reciprocably mounted in said cylinder bore, said restrained piston having a piston head defining with said cylinder bore and closed end an inner chamber adapted to contain hydraulic fluid, said restrained piston having a hollow restraining piston rod extending from said piston head outwardly through the open end of said cylinder and having a closed outer end, said piston rod having a longitudinal bore therein, a free piston floatingly mounted in said restrained piston rod bore and defining with said piston head a middle chamber adapted to contain hydraulic fluid and defining with said closed piston rod end an outer chamber adapted to contain a compressed pneumatic fluid, and yieldingly-urged valve means in said piston head having a valve passageway of variable cross-sectional area interconnecting said inner and middle chambers, said valve means being responsive to the flow of hydraulic fluid in one direction between said middle chamber and said inner chamber resulting from relative motion between said cylinder and said restrained piston in one direction for varying the effective cross-sectional area of said valve passageway to maintain a substantially constant rate of flow of hydraulic fluid through said passageway in said one direction of hydraulic fluid flow, said valve means including a movable valve member and resilient means urging said valve member in a passageway-opening direction, said valve member having an orifice therein responsive to flow of hydraulic fluid there-

through to create a differential pressure on opposite sides thereof to move said valve member in the direction of said flow in a passageway-closing direction which in cooperation with the opposing urge of said resilient means upon said valve member varies the cross-sectional area of said valve passageway to maintain a constant rate of hydraulic fluid flow in one direction therethrough and consequently to impart a constant speed of reciprocation of said motor in one direction irrespective of the variation of hydraulic pressure within said motor.

2. A unidirectionally constant-speed reciprocable hydropneumatic motor, according to claim 1, wherein said valve means provides substantially free flow of hydraulic fluid in the opposite direction from said one direction of hydraulic fluid flow.

3. A unidirectionally constant-speed reciprocable hydropneumatic motor, according to claim 2, wherein said valve member is a sleeve with said port on the side wall thereof.

4. A unidirectionally constant-speed reciprocable hydropneumatic motor, according to claim 3, wherein said restrained piston head has a bore in which said sleeve valve member is reciprocable, said bore having a side wall with a port therein registrable with the side wall port of said sleeve valve member.

5. A unidirectionally constant-speed reciprocable hydropneumatic motor, according to claim 1, wherein said restrained piston head has a passageway therethrough and a port in said passageway and wherein said valve means includes a movable valve member having a passageway therethrough and a port in said passageway registering with said restrained piston head passageway port.

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