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[54] **HYDRAULIC SYSTEM WITH SERIES WOUND PUMP DRIVE MOTOR**

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[52] **U.S. Cl.** **60/452,** 60/380, 60/431, 60/DIG. 2

[51] **Int. Cl.** **F15b 11/04**

[58] **Field of Search** 60/452, 380, 445, 448, 451, 60/DIG. 2, 431, 434; 91/275, 355, 420, 459

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[57] **ABSTRACT**

A hydraulic system for apparatus of the type wherein the load resistance during the working stroke of a fluid motor progressively increases from minimum to maximum, characterized in that a fixed displacement pump, driven by a series wound motor, which may be AC OR DC, actuates the fluid motor at high speed under low load resistance conditions (as during the return stroke or during the initial portion of the working stroke), and at progressively decreasing speed and increasing load pressure as the load resistance progressively increases during the remaining portion of the working stroke. The series wound pump drive motor operates at substantially full rated horsepower at all times such that the product of its speed S and torque T, and hence the product of the pump output flow Q and outlet pressure P is approximately equal to a constant K, that is, QP = ST = K.

6 Claims, 3 Drawing Figures

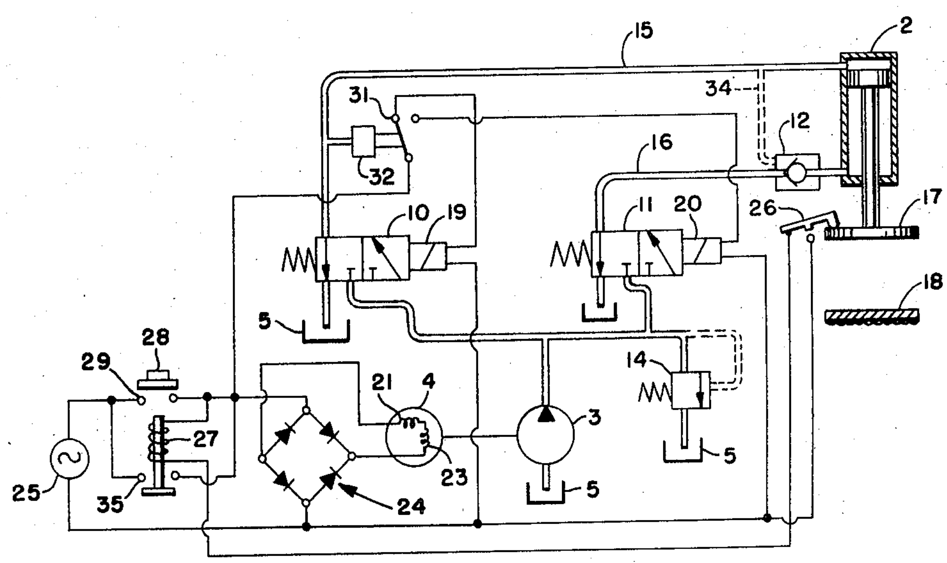

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FIG. 1

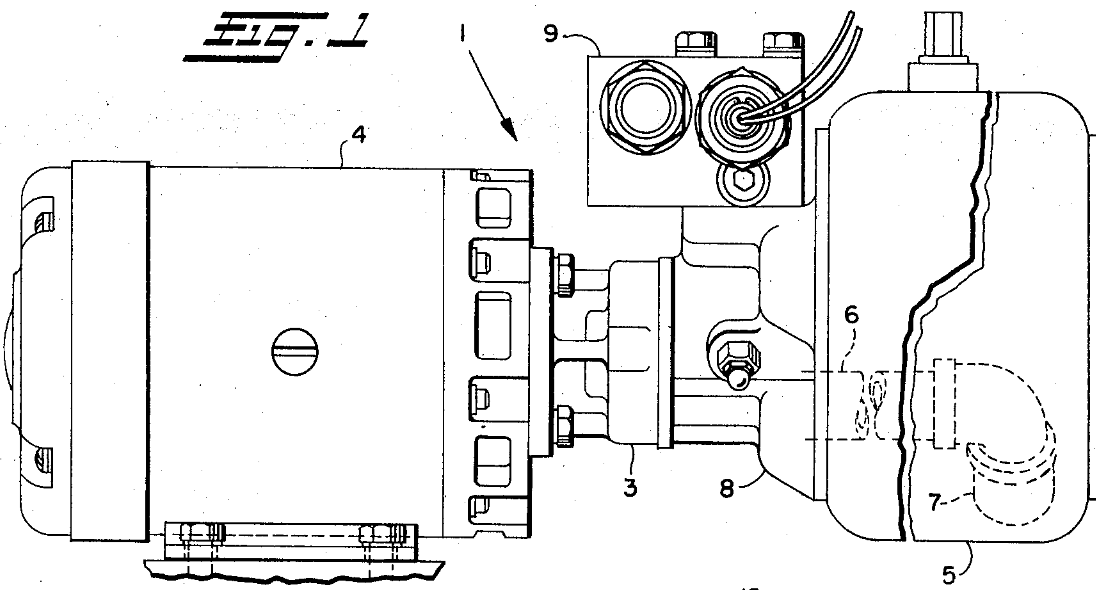
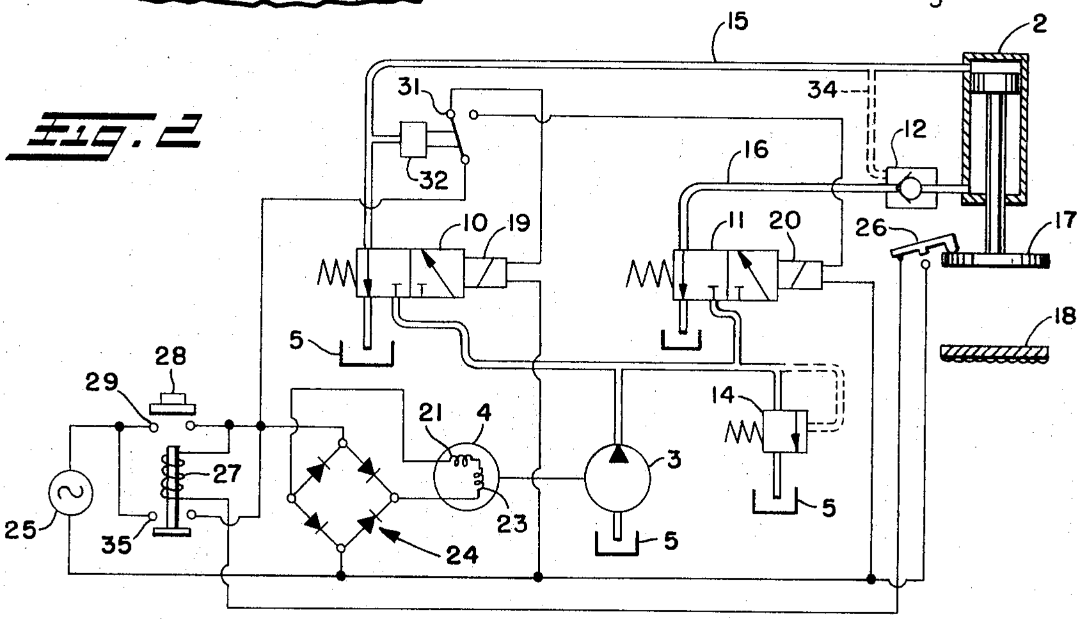


FIG. 2



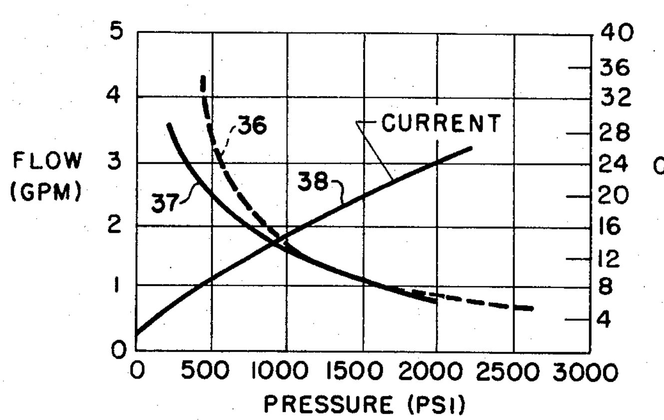


FIG. 3

HYDRAULIC SYSTEM WITH SERIES WOUND PUMP DRIVE MOTOR

BACKGROUND OF THE INVENTION

In hydraulic systems employed as in presses, machine tools, injection molding machines, etc. it is known to provide an electric motor driven dual pump which comprises a high pressure-low volume pump and a low pressure-high volume pump. In such high-low system, both pumps supply fluid to the fluid motor to provide for rapid advance and return under low load resistance conditions. When the ram encounters high load resistance, the low pressure-high volume pump is unloaded so that only the high pressure-low volume pump supplies fluid under high pressure to the fluid motor for performing its high pressure working stroke.

AC drive motors for such dual pumps are generally squirrel cage induction motors which may be classified as constant speed motors having, as do other AC motors such as split phase motors and capacitor start motors, speed-torque characteristics in which the speed decreases slightly up to maximum torque and thereafter both the speed and torque rapidly decrease.

DC series wound motors have nearly the same characteristics as single phase series wound AC motors and when used for dual pump systems are generally of the shunt type because of their inherent stable speed under varying load.

The high-low systems, aside from being quite complex, may induce severe shock loads therein at the time that the low pressure-high volume pump is unloaded.

SUMMARY OF THE INVENTION

In apparatus where the load increases during the working stroke of the fluid motor, such as in a trash compactor, the piston or other hydraulically actuated member is generally moved toward a stationary support member and the load resistance initially is relatively small or even negative, and progressively increases after the actuated member engages the trash to be compacted. Likewise, after the working operation has been completed, it is desired to return the piston or actuated member to its starting position preparatory to the next working stroke. To achieve these results it is desired to provide a pump drive motor which operates at substantially full rated horsepower irrespective of the magnitude of load resistance encountered during the movement of the actuated member. Hydraulically, the constant horsepower curve is in the form of a hyperbola in which the product of the pump output flow Q and the pump output pressure P is equal to a constant K or in which the product of the drive motor speed S and the motor torque T is equal to the constant K.

Contrary to known high-low pressure systems employing dual pumps as aforesaid, the present hydraulic system employs a series wound drive motor, which may be either AC or DC, for a single fixed displacement pump which operates at substantially constant full horsepower so that its speed-torque curve (and the flow-pressure curve of the pump) substantially conforms to $ST = QP = K$ whereby when the fluid motor is operating at low load resistance conditions as during the initial portion of the working stroke and during the entire return stroke, the pump output will be maximum to achieve rapid actuation of the fluid motor, and as the load resistance progressively increases during the remainder of the working stroke of the fluid motor, the pump output flow progressively decreases and the pump output pressure progressively increases.

In order to achieve closer matching of the pump output flow Q (drive motor speed S) and pump output pressure P (drive motor torque T) with the ideal constant horsepower curve $QP = ST = K$, the series wound pump drive motor arrangement disclosed herein has associated therewith rectifier means to supply DC to the motor, the self-inductance of the motor windings serving to smooth out ripples in the DC output from the rectifying means.

Other objects and advantages of the present invention will appear hereinafter.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a side elevation view of an integrated hydraulic system embodying a tank, a fixed displacement pump and electric drive motor therefor, solenoid operated directional control valving, a pilot operated check valve, and a relief vlave;

FIG. 2 is a schematic piping and electrical wiring diagram showing the FIG. 1 unit operatively connected to a double acting fluid motor; and

FIG. 3 is a chart plotting actual pump output flow versus pump output pressure (solid line curve) and comparing it with the ideal curve (dotted line curve), said chart also showing the current draw of the pump drive motor.

DESCRIPTION OF THE PREFERRED EMBODIMENT

As shown in FIG. 1, the hydraulic system comprises an integrated unit **1** including all of the components except the fluid motor **2** shown in FIG. 2. Said unit **1** comprises a fixed displacement pump **3**, preferably a gear pump, which is driven by a series wound motor **4**, a tank **5** for liquid having therein a pump intake line **6** provided with a strainer **7**, and a pump housing **8** which has mounted thereon a valve block **9**, said housing **8** being provided with pressure outlet and return passages through which pressure delivered by the pump **3** is conducted through the valve block **9** for actuation of the double acting fluid motor **2** and through which fluid displaced by the fluid motor **2** is returned into the tank **5**. The valve block **9** preferably includes therein a solenoid operated directional control valve assembly, such as for example, a spool valve assembly **10, 11**, a pilot operated check valve **12**, and a relief valve **14**.

Referring especially to FIG. 2, the unit **1** comprising the tank **5**, the pump **3** driven by the series wound motor **4**, the directional control valve assembly which herein comprises two solenoid operated three-way valves **10** and **11**, the relief valve **14**, and the pilot operated check valve **12** are connected to the double acting fluid motor **2** by conduits **15** and **16.** In the case of a trash compactor or the like, the movable component of the fluid motor **2** has a compacting member **17** which moves toward a stationary support member **18** to compact trash therebetween. When the solenoids **19** and **20** are de-energized, the spools or like valve elements in said three-way valves **10** and **11** are spring-biased to the position shown in FIG. 2 to communicate both motor ports with the tank **5** and, of course, the check valve **12** is closed thus to retain the compactor member **17** against downward drifting. It is to be understood that instead of employing two three-way valves **10** and **11** to control the actuation of the double acting fluid motor 2, a three-position four-way valve may be substituted.

The series wound pump drive motor 4 includes a field winding 21 and armature winding 23 and has therein a rectifying means 24, preferably in the form of a silicon avalanche bridge rectifier. The reference numeral 25 denotes an AC electric power source.

When the compacting member 17 is in its raised position as shown in FIG. 2, the limit switch 26 is open, said limit switch 26 being in series with the holding relay coil 27 of the main switch 28. When the main switch button 28 is depressed the pump drive motor 4 is energized by the DC output of the rectifying means 24. At the same time that the motor 4 is energized by the closing of the main switch contacts 29, the solenoid 19 of the left three-way valve 10 is energized via the contact 31 of the pressure switch 32 which is connected in the conduit 15 between the three-way valve 10 and the head end of the fluid motor 2 thus to actuate the three-way valve 10 to communicate the pump output with the head end of the fluid motor 2. Pilot pressure in the pilot line 34 opens the check valve 12 to permit return flow of fluid from the rod end of the fluid motor 2 to the tank 5 via the right-hand three-way valve 11. As the compacting member 17 moved downwardly the limit switch 26 closes to energize the holding coil 27 to close its contacts 35 to maintain the circuit even though the contacts 29 open upon release of the push button 28.

If the fluid motor 2 and compacting member 17 do not encounter any substantial load resistance, the pump 3 will be operated at high speed by the motor 4 to effect rapid downward movement and as the compacting member 17 engages the trash on support member 18, the load resistance will progressively increase with accompanying progressive decrease in pump output flow while load pressure progressively increases.

In FIG. 3 the dotted curve 36 is an ideal constant horsepower curve in which the product of the flow Q and the pressure P is a constant K. The solid line curve 37 is the actual horsepower curve employing a fixed displacement gear pump 3 and a series wound AC pump drive motor 4 which is operated at substantially its full rated horsepower in a manner wherein its speed is related to pump output flow and its torque is related to pump output pressure, this curve 37 being substantially matched to the ideal constant horsepower curve 36. The curve 38 shows the current draw of the pump drive motor 4 as it drives the pump 3 at the flows and pressures of curve 37.

When the trash has been compacted to the desired extent as determined by rise of load pressure to a prescribed value, the pressure switch 32 will be actuated to de-energize the solenoid 19 of the left three-way valve 10 and to energize the solenoid 20 of the right three-way valve 11 thus to initiate reversal of the fluid motor 2 whereby pump output pressure is delivered through the right three-way valve 11 and check valve 12 into the rod end of the fluid motor 2 and fluid displaced from the head end of the fluid motor 2 is conducted to the tank 5 via the left three-way valve 10. The piston in the fluid motor 2 in thus being raised, is

encountering but little load resistance as represented by its weight and that of the compacting member 17 plus friction in the fluid motor seals, and therefore the pump 3 will be operated at high speed to effect rapid upward withdrawal of the compacting member 17 from the compacted trash. When the compacting member 17 reaches the upper retracted position, the limit switch 26 will be opened to de-energize the holding coil 27 with resulting opening of the holding contacts 35, whereby the pump drive motor 4 will be de-energized and the solenoid 20 of the right-hand three-way valve 11 will be deenergized, thus to stop the operation with the parts in the position shown, until the main switch button 28 is again depressed to initiate another complete cycle of operation of the hydraulic system.

The hydraulic system as herein described is illustrative only as other arrangements may be utilized, as, for example, the use of a sequence valve instead of a pressure switch for effecting reversal of the compacting member 17.

We, therefore, particularly point out and distinctly claim as our invention:

1. An electric motor driven fixed displacement pump for apparatus of the type wherein load resistance during the working stroke of a fluid motor progressively increases, characterized in the provision of an A.C. power source; a series wound pump drive motor; and rectifying means operatively connected between said A.C. source and said drive motor to energize said motor to drive said pump at a speed and torque such that at any load resistance between minimum and maximum the product of the pump output flow Q and the pump output pressure P is approximately equal to a constant K.

2. In a hydraulic system for apparatus of the type wherein load resistance during the working stroke of a fluid motor progressively increases, said system including a fluid motor, an electric motor driven fixed displacement pump, a tank, and a control valve operatively interconnected for flow of fluid under pressure delivered by said pump to said fluid motor via said control valve and for flow of fluid displaced by said fluid motor to said tank via said control valve, the improvement which comprises an A.C. power source; a series wound pump drive motor and rectifying means operatively connected between said A.C. source and said drive motor to energize said motor to drive said pump at a speed such that at any load resistance between minimum and maximum, the product of the pump output flow Q and the pressure P is approximately equal to a constant K.

3. The pump of claim 1 wherein said rectifying means is a bridge rectifier.

4. The pump of claim 1 wherein said rectifying means is a silicon avalanche bridge rectifier.

5. The system of claim 2 wherein said rectifying means is a bridge rectifier.

6. The system of claim 2 wherein said rectifying means is a silicon avalanche bridge rectifier.

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