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Douglas

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[54] **INTENSIFIER PUMP WITH HALF WAVE MODULATOR**

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[51] **Int. Cl.** **F04b 35/00**

[58] **Field of Search** 417/401–404, 417/398, 390, 399; 60/413, 416; 91/464, 466, 403, 304, 461

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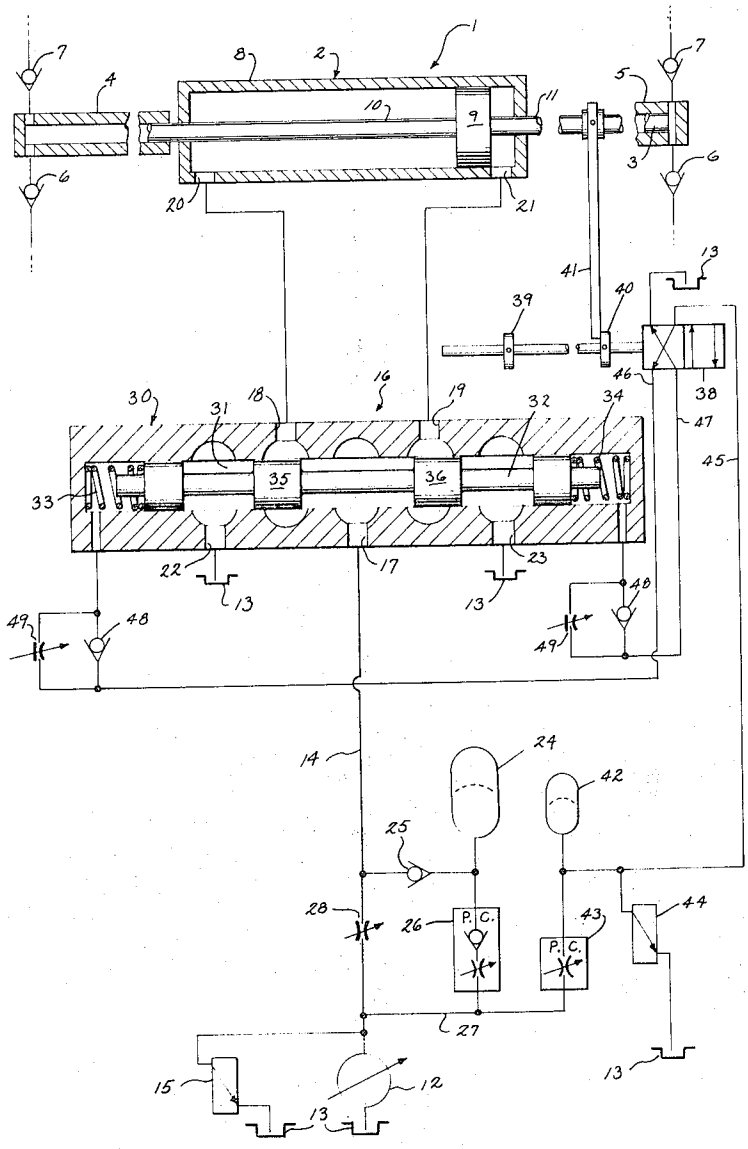
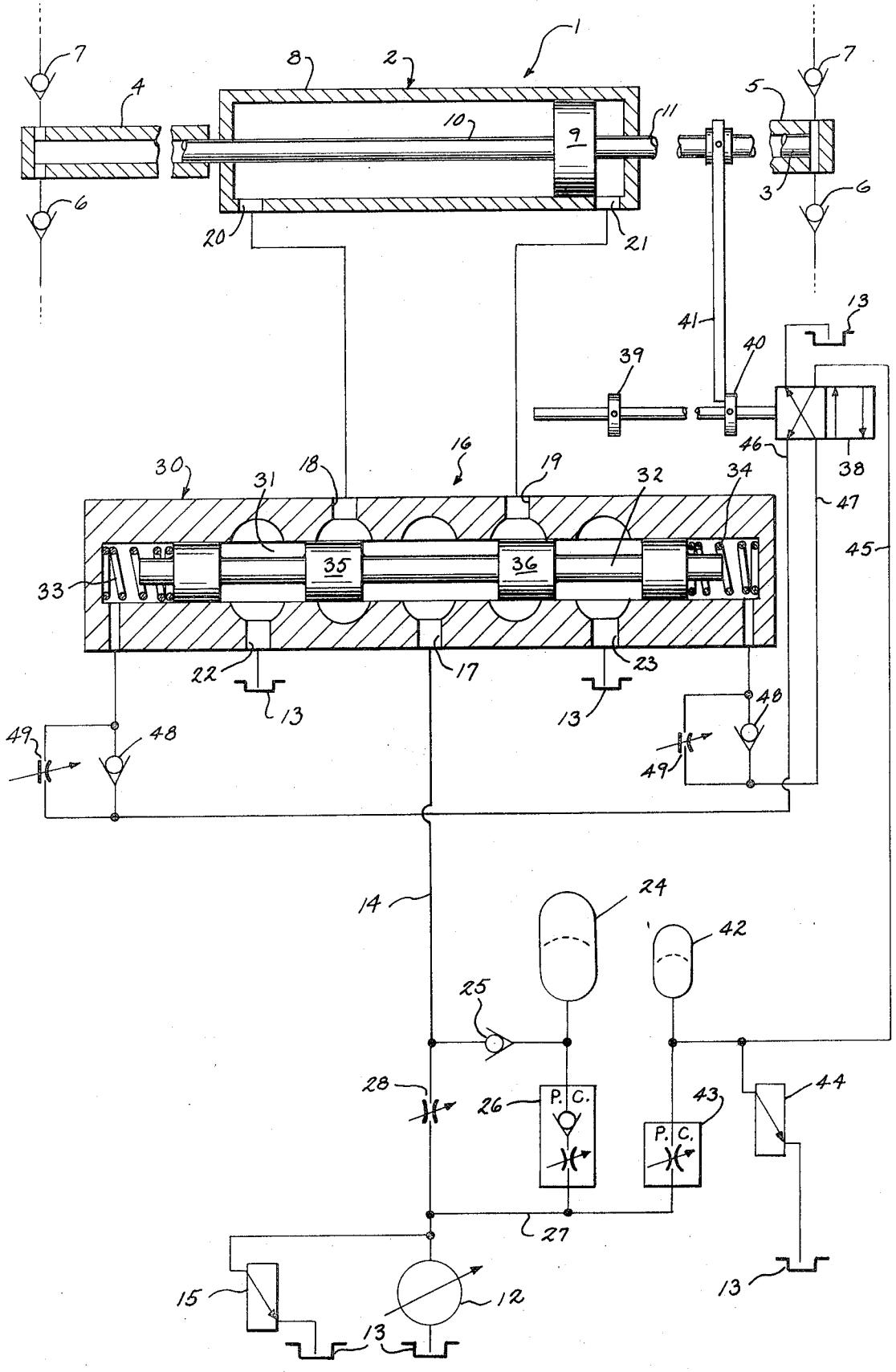
[57] **ABSTRACT**

The rate of flow of motive fluid to the power cylinder of a reciprocating intensifier pump is modulated to initiate it's quick reversal by the transfer of only a half wave of pressure fluid from one end of the power cylinder to it's opposite end.

2 Claims, 1 Drawing Figure

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INTENSIFIER PUMP WITH HALF WAVE MODULATOR

BACKGROUND OF THE INVENTION

The invention relates to a reciprocating intensifier pump and means instantly effecting substantial initial displacement of each pumping stroke so as to maintain pump output constant.

The intensifier pump comprises a power cylinder with a double ended and double acting working piston of relatively large area driving a pair of pumping pistons aligned therewith, each of relatively small area. Motive fluid is supplied at a uniform rate and alternately directed by a reversing valve to opposite ends of the power cylinder. To effect quick reversal, an accumulator is employed to discharge into the supply line after the reversing valve has shifted.

One such prior art pumping system is described in U.S. Pat. No. 3,669,572, which describes such initial displacement necessary for a 30,000 PSI intensifier pump as being 10 to 12 percent of the total stroke before pressure is restored to normal working pressures and it employs an accumulator that discharges into the supply line when the pressure in the accumulator exceeds the pressure in the supply line by a predetermined amount.

SUMMARY OF THE INVENTION

The present invention of a reciprocating intensifier pumping system, like that of the prior art, also employs a double acting and double ended working piston in a power cylinder with motive fluid alternately directed to opposite ends thereof by a reversing valve, and an accumulator that discharges into the supply line to assist reversal of the working piston. However, the reversing valve, in the present invention, is constructed and arranged to provide for the utilization of the energy of compressed motive fluid built up in the power cylinder behind the working piston and the energy of intensified pressure fluid remaining in a pumping cylinder and reacting on a pumping piston by transferring such energy as a slug of motive fluid from behind the working piston to the other side of the working piston, i.e., to the other end of the power cylinder, while the reversing valve is shifting between it's two operating positions. This arrangement more quickly initiates the reverse displacement of the working piston and substantially reduces the time required for the intensifier pump to start flow again of intensified pressure liquid.

It is therefore an object of the present invention to utilize the energy stored in a reciprocating intensifier pump upon completion of a pumping stroke to initiate a reverse pumping stroke.

Another object is to provide for the transfer of such energy as a pressure surge in the motive fluid from behind the power piston to the other side of the power piston.

Another object is to limit the transfer of fluid between the ends of the power cylinder to a half wave surge of pressure fluid.

Another object is to provide for the transfer of energy of compressed motive fluid stored behind a power piston at the end of it's stroke to the other side of the power piston and to limit such transfer to a half wave of the pressure surge.

Another object is to include in the transfer an additional amount of motive fluid displaced by expansion of intensified pressure fluid remaining in a pumping cylinder and reacting on a pumping piston during said half wave surge of motive fluid.

Another object is to provide a reversing valve that conducts fluid, equivalent to the energy stored in the intensifier pump at the end of a power stroke, from one end of the power cylinder to the opposite end thereof while the reversing valve is shifting between it's fluid directing operating positions.

An embodiment of the invention is herein described with reference to accompanying drawing that schematically illustrates the control of a reciprocating intensifier pump.

A PREFERRED EMBODIMENT

The intensifier pumping system comprises a conventional intensifier pump **1** including a linear acting hydraulic motor **2** to drive a pair of reciprocating pumping pistons **3** in pump cylinders **4, 5.**

The pump cylinders **4, 5** during a suction stroke of their pistons each receive a liquid such as a process fluid through a check valve **6,** and during a pumping stroke compress such liquid to overcome back pressure on a check valve **7** and deliver such liquid to a container, not shown.

The hydraulic motor **2** comprises a power cylinder **8** with a double acting and double ended working piston **9** whose rod ends **10, 11** are suitably connected to the pumping pistons **3.** A hydraulic pump **12** delivers hydraulic fluid at a uniform rate which is alternately directed to opposite ends of the power cylinder **8** to reciprocate the working piston **9** and the pumping pistons **3** which it drives. Any selected intensifier pressure is equal to the product of the hydraulic pressure multiplied by the ratio of the effective area of the working piston to the area of the pumping piston.

The pump **12** is a variable displacement pump whose stroke is selected to fix the rate of delivery of motive fluid to the power cylinder **8.** The pump **12** receives hydraulic fluid from a reservoir **13** and delivers it to a supply line **14** that is connected to the inlet port **17** of a reversing valve **16** whose outlet ports **18, 19** are connected respectively to ports **20, 21** at opposite ends of the power cylinder **8.** The reversing valve **16,** more particularly decribed hereinafter, also has drain ports **22, 23** connected to reservoir **13,** and the reversing valve is operable in one position to connect port **20** of the power cylinder to valve pressure port **17** and to connect port **21** of the power cylinder to drain port **23,** and in another position to connect port **21** of the power cylinder to valve pressure port **17** and to connect port **20** of the power cylinder to drain port **22.**

A relief valve **15** is connected across pump **12** to limit it's output pressure. The relief **15** may also have an electrically operated by-pass, not shown, to drain accumulator pressure on shut down of the system.

A precharged accumulator **24** is supercharged with hydraulic fluid and is operably connected through a low resistance check valve **25** to supply line **14** so as to discharge thereto when the pressure in supply line **14** is lower than that of the accumulator. The accumulator discharge momentarily assists pump **12** in raising pressure in a low pressure end of the power cylinder.

The accumulator **24** is preferably supercharged with hydraulic fluid by supply pump **12.** In order that pump

12 deliver fluid at a uniform rate to the power cylinder, the rate of flow for supercharging the accumulator must also be fixed at a uniform rate and this is effected by a unidirectional pressure compensated flow control valve **26** connected between the accumulator and line **27** to pump **12.** Valve **26** is adjustable to select the rate of flow required to supercharge the accumulator during each stroke of the working piston **9.** An adjustable orifice **28** is positioned in the supply line **14** to match the pressure drop across the flow control valve **26** so that the accumulator will be supercharged to the normal pressure delivered to the power cylinder **2.**

The reversing valve **16** comprises a valve body **30** whose valve chamber **31** has inlet port **17** centrally located, has outlet ports **18, 19** adjacent opposite sides of the inlet port **17,** and has drain ports **22, 23** next adjacent to the outlet ports. A movable valve member or valve spool **32** is normally centered in the valve chamber by a pair of opposing springs **33, 34.** The valve spool has lands **35, 36** spaced apart, with valve ports **17, 18, 19** open to each other when the valve spool is centered in the valve chamber, as illustrated. In this position the lands **35, 36** block communication of these ports with drain ports **22, 23.**

When the valve spool is shifted to one operating position, such as to the right, valve inlet port **17** is open to valve outlet port **19,** and valve outlet port **18** is open to valve drain port **22.** Conversely, when the valve spool is shifted to the other operating position, such as to the left, valve inlet port **17** is open to valve outlet port **18,** and valve outlet port **19** is open to valve drain port **23.** Thus in alternate operation positions, the valve **16** directs motive fluid to a different end of the power cylinder.

Means are provided to shift the valve spool **32** from one operating position to another at a predetermined rate at the end of each power stroke of the working piston **9.** Such means preferably comprises a two position pilot valve **38** which in one position directs control pressure fluid to one end of the valve chamber **31** and in the other position directs the control pressure fluid to the other end of the valve chamber. Pilot valve **38** has an extension of its movable member on which are adjustably mounted a pair of collars **39, 40** alternately engaged by a trip finger **41** mounted to reciprocate with rod end **11** of the working piston **9.**

Control pressure is preferably provided by a relatively small precharged accumulator **42** also supercharged with hydraulic fluid at a very limited rate through a pressure compensated flow control valve **43** from lines **27, 14** and supply pump **12.** Control pressure is limited by a pressure relief valve **44.**

The control circuit includes a choke **49** in series with the source of control pressure and its return, and the choke **49** is preferably provided in each line **46, 47,** closely connected to the respective end chamber of the reversing valve **16,** with each choke operably shunted by a check valve **48** permitting free flow toward its associated end of the reversing valve. Each choke **49** is adjusted or selected to provide a flow to fix the rate of shifting of the valve member **32** of the reversing valve, between its two flow directing operative positions, to correlate the time that the cylinder ports **20, 21** are interconnected during the movement of the valve member with the very short interval of time of a half wave surge of pressure fluid between the ends of the power cylinder.

The reversing valve as illustrated shows the valve spool centered therein, a position to which it is urged by its opposing springs. Under operating conditions, however, the valve spool is displaced to the left or right by control pressure applied to an end of the valve spool, and the valve spool in being displaced from either its left or right operating positions passes through the centered position illustrated.

Assuming an operating condition, the intensifier pump has just completed a pumping stroke and has shifted the pilot valve **38** to the position illustrated. The pilot valve **38** therefore directs control pressure fluid by way of line **46** through a check valve **48** to the left end chamber of the reversing valve **16.** This displaces the valve spool toward the right, through the centered position illustrated, and the valve spool displaces fluid from the right end chamber of the reversing valve, through a choke in line **47** to the pilot valve and to return or reservoir.

When the pilot valve is again shifted by the completion of another stroke of the intensifier pump, it directs control pressure fluid to the opposite end chamber of the reversing valve by way of line **47** and it is the choke **49** in line **46** that limits the rate of displacement of the valve spool **32** of the reversing valve **16.**

The valve spool **32** in crossing the centered position interconnects ports **17, 18** and **19** for an interval of time in milliseconds which permits the transfer of a wave of pressure fluid from the high pressure end of the power cylinder **2** to the low pressure end thereof. At the same time the supply pump **12** continues to supply motive fluid at a uniform rate to inlet port **17** of the reversing valve, and the accumulator **24** triggered by a drop in pressure in line **14** supplies additional high pressure fluid to the inlet port **17** of the reversing valve, which it continues to supply until line pressure is restored and maintained by the supply pump **12.**

I claim:

1. In a reciprocating intensifier pumping system having two pumping pistons to alternately pump intensifier fluid at a predetermined pressure and at a constant flow rate, a power cylinder having a double ended and double acting working piston connected in line with said pumping pistons, said power cylinder having cylinder ports at opposite ends thereof, a supply pump to deliver hydraulic fluid at a constant rate, a reversing valve operable at each predetermined stroke of the working piston to reverse the connections of said cylinder ports across said pump and conduct hydraulic fluid therebetween,

said reversing valve having an inlet port at an open center in said valve between a pair of outlet ports closely connected respectively to said cylinder ports, said inlet port connected to a delivery line from said supply pump, a pair of return ports next adjacent said outlet ports and connected to a return to said supply pump, a valve member having a pair of spaced apart lands defining said open center and biased to a normally inoperative center position in which said lands open said outlet ports to each other through said valve center while blocking said outlet ports to said return,

said valve member having two operating fluid directing control positions, in one of said operating positions of said valve member said valve connects said inlet port to a first of said outlet ports and connects a second of said outlet ports to said return, in the

other of said operating positions of said valve member said valve connects said inlet port to said second outlet port and connects said first outlet port to said return,

said valve member in moving from said one operating position to said other operating position sequentially provides: blocking of said return to flow from said second outlet port, opening of said second outlet port to said valve center and to flow from said first outlet port, blocking of said first outlet port to said valve center and to flow from said second outlet port, and opening of said first outlet port to said return,

said working piston at the end of a stroke in said power cylinder defines large and small volume ends respectively on opposite sides of the working piston,

and means timing the rate of movement of said valve member in shifting from one operating position to the other operating position so that while said valve member is in transit between said operating positions the valve conducts a very high velocity fluid surge generated by expansion of compressed fluid in said large volume end of the power cylinder to the small volume end thereof and at the time of the peak value of said surge said valve member closes said large volume end to any return of said surge and opens said large volume end to pump return, whereby the momentum of said surge to said low volume end of the power cylinder is effective to initiate a reverse stroke of the working piston.

2. In a reciprocating intensifier pumping system having two pumping pistons to alternately pump intensifier fluid at a predetermined pressure and at a constant flow rate, a power cylinder having a double ended and double acting working piston connected in line with said pumping pistons, said power cylinder having cylinder ports at opposite ends thereof, a supply pump to deliver hydraulic fluid at a constant rate, a reversing valve operable at each predetermined stroke of the working piston to reverse the connections of said cylinder ports across said pump and conduct unrestricted flow of hydraulic fluid therebetween,

said reversing valve having an inlet port at an open center in said valve between a pair of outlet ports closely connected respectively to said cylinder port, said inlet port connected to a delivery line from said supply pump, a pair of return ports next adjacent said outlet ports and connected to a return to said supply pump, a valve member having a pair of spaced apart lands defining said open center and biased to a normally inoperative center position in which said lands open said outlet ports to each other through said valve center while blocking said outlet ports to said return,

said valve member having two operating fluid directing control positions, in one of said operating positions of said valve member said valve connects said inlet port to a first of said outlet ports and connects a second of said outlet ports to said return, in the other of said operating positions of said valve member said valve connects said inlet port to said second outlet port and connects said first outlet port to said return,

said valve member in transit between said first and second operating positions sequentially provides that a leading one of said lands blocks communication between said second outlet port and return and opens said second outlet port to the valve center while the first outlet port is still open to the valve center to thereby interconnect said outlet ports and the large and small volume ends of the power cylinder defined by the position of the working piston at the end of a power stroke, and then a trailing one of said lands blocks communication between said first outlet port and said valve center and opens communication between said first outlet port and return;

said reversing valve having end chambers each connected respectively through a choke shunted by a check valve poled for flow toward the end chambers and connected through a pilot valve to a source of control pressure and a return, said pilot valve operable at each predetermined stroke of said working piston to reverse the direction of flow of control pressure fluid to said end chambers and return, and said chokes adjustable to time the rate of shifting of said valve member from one operating position to the other operating position so that said reversing valve conducts a high velocity surge of fluid generated by expansion of compressed fluid in said large volume end of the power cylinder to the small volume end thereof, then blocks the return of said surge to said large volume end so that the momentum of said surge provides a hydraulic impact that initiates a reverse stroke of said working piston,

and an accumulator connected through a check valve to said delivery line of said pump and operable to discharge hydraulic fluid thereto while the pressure therein is below a working pressure normally sustained by said pump so that said accumulator assists said pump in reverse stroking of the working piston until working pressure is restored.

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