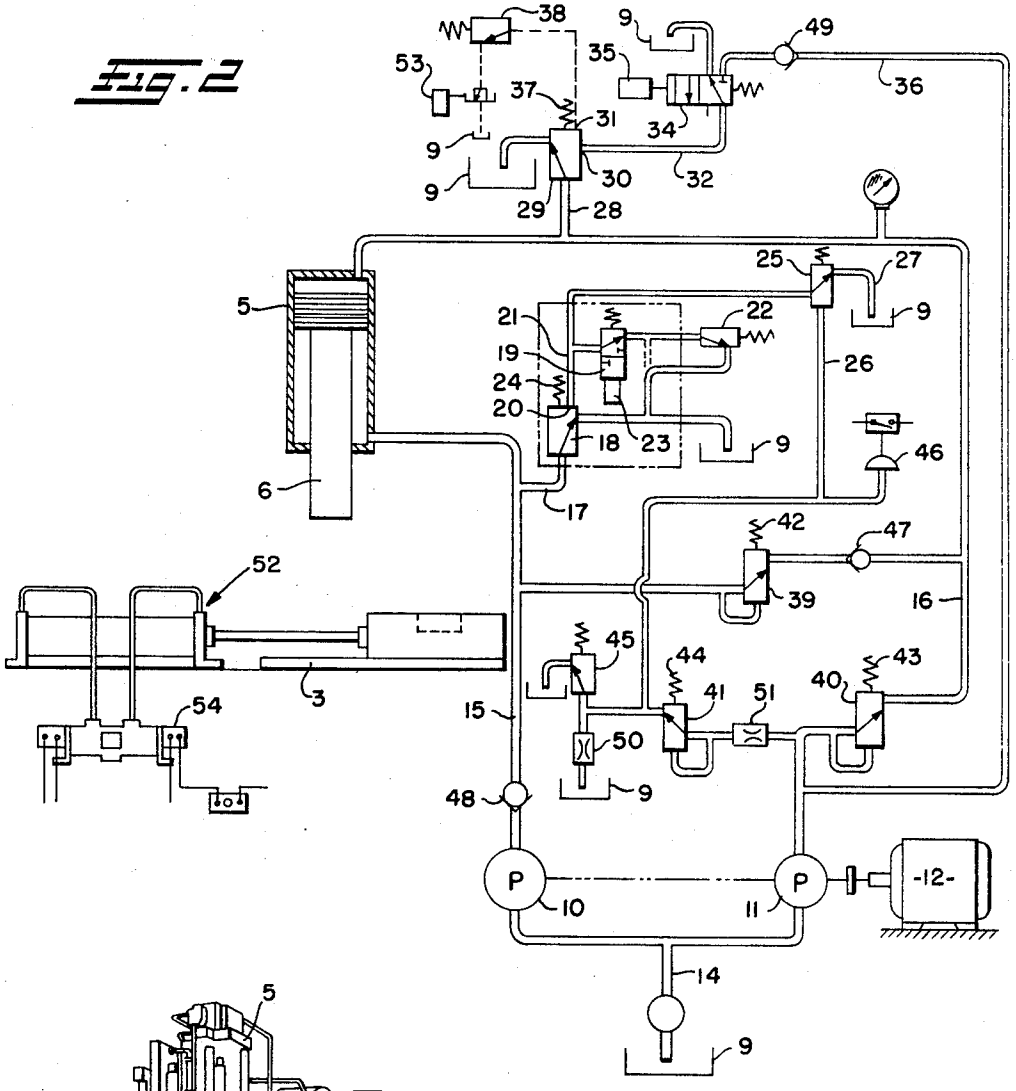
Oct. 14, 1969 R. S. CONABEE 3,472,026

RAPID CYCLE PRESS AND HYDRAULIC SYSTEM THEREFOR

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Fig. 2



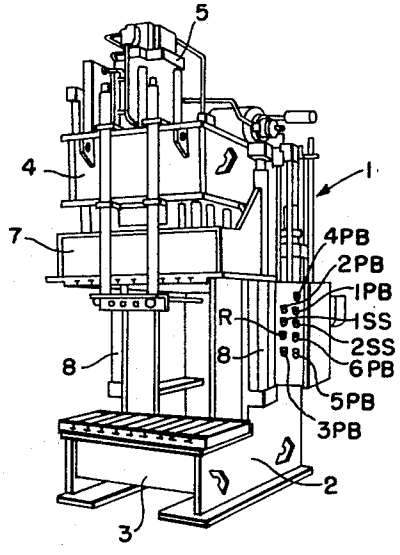


Fig. 1

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Filed May 18, 1967 2 Sheets-Sheet 2

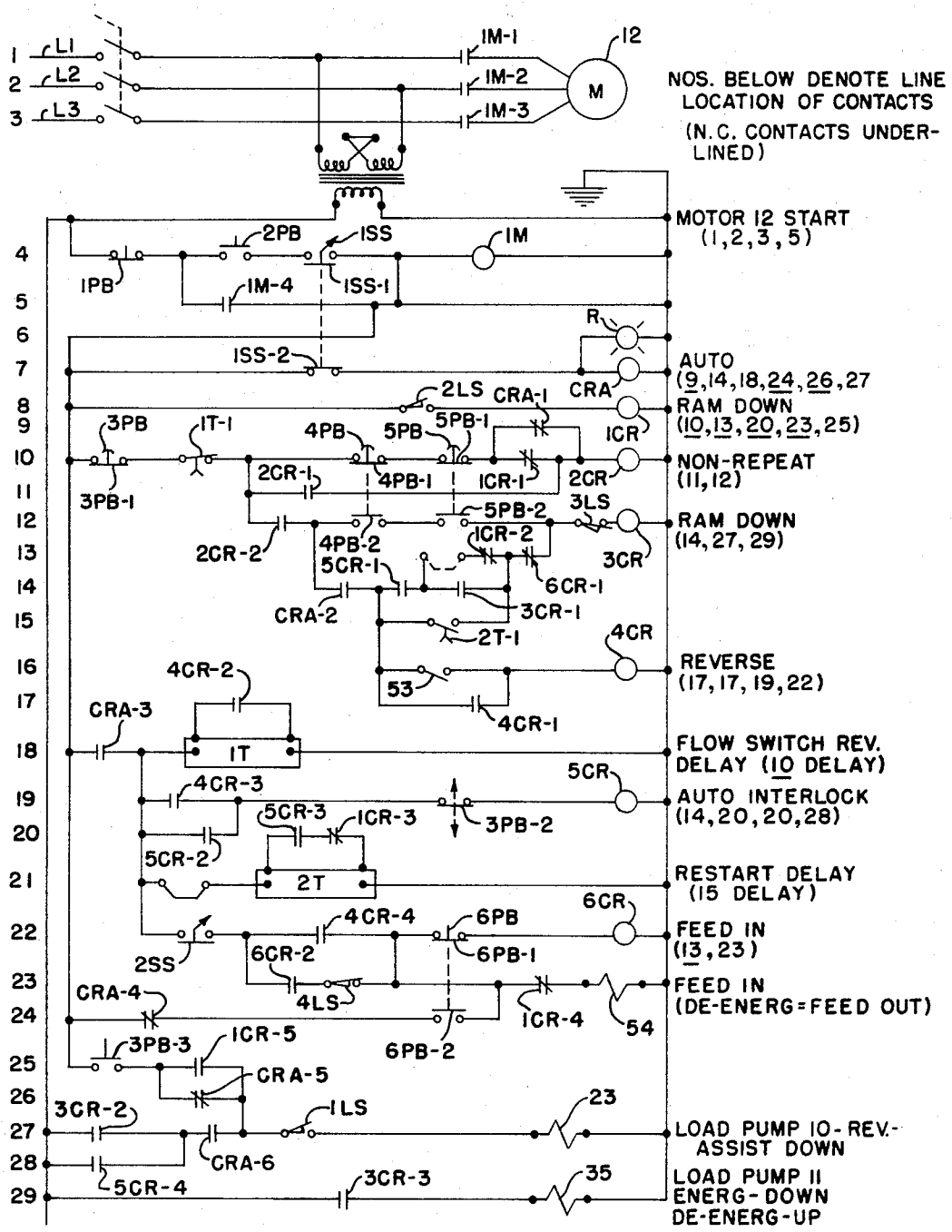


Fig. 3

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United States Patent Office

3,472,026
Patented Oct. 14, 1969

3,472,026

RAPID CYCLE PRESS AND HYDRAULIC SYSTEM THEREFOR

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Filed May 18, 1967, Ser. No. 639,383
Int. Cl. F15b *15/18, 13/044*
U.S. Cl. 60—52 19 Claims

ABSTRACT OF THE DISCLOSURE

Rapid cycle press and hydraulic system therefor characterized in that fluid motor actuation is achieved by flow control of output of a dual pump.

BACKGROUND OF THE INVENTION

In general, it is well known in the art of hydraulic control of a fluid motor for a hydraulic press and the like to employ a directional control valve having an inlet port connected with a pump, a return port connected with a tank or reservoir, and at least one motor port connected with said fluid motor, said valve being operative to selectively communicate said motor port with said inlet port or said return port. In the case of a press having a double acting fluid motor, the directional control valve is usually of the four-way open center type having a pair of motor ports alternately communicated with said inlet and return ports to effect reciprocation of the motor piston.

Another known way of controlling actuation of a fluid motor is to provide a reversible pump whereby fluid under pressure is conducted to one end or the other of a double acting fluid motor when the pump is operated in one direction and conducted to the other end of the fluid motor when the operation of the pump is reversed.

It is also known to provide high and low pressure pumps in a hydraulic press circuit in conjunction with valves arranged so that the press ram is lowered by the conjoint discharge of said pumps, with the high pressure pump alone being operative to apply full tonnage at the end of the down stroke of the ram.

SUMMARY OF THE INVENTION

The present invention is characterized in that a large volume medium pressure pump is connected directly to the rod end of the press cylinder, and a small volume high pressure pump is connected directly to the head end of the press cylinder via a sequence valve, the direction of movement of the press ram in the cylinder being controlled by discharge valves in the branch lines tapped into the respective pump discharge lines, said discharge valves being alternately closed and opened for fluid flow directly into one end of the press cylinder through the associated pump discharge line while the fluid displaced from the other end of the press cylinder and the fluid delivered by the other pump is conducted to a tank or reservoir via the associated discharge line and the open discharge valve.

The present invention is further characterized in that there is a cross-over line between the respective pump

discharge lines which enables fast down movement of the press ram by combining the outputs of both pumps to act in the head end of the press cylinder, followed by full tonnage by the fluid pressure delivered by the small volume high pressure pump alone when the ram encounters resistance as when engaging a workpiece being operated upon.

Other objects and advantages of the present invention will become apparent as the following description proceeds.

To the accomplishment of the foregoing and related ends, the invention, then, comprises the features hereinafter fully described and particularly pointed out in the claims, the following description and the annexed drawing setting forth in detail a certain illustrative embodiment of the invention, this being indicative, however, of but one of the various ways in which the principle of the invention may be employed.

BRIEF DESCRIPTION OF THE DRAWING

In said annexed drawing:

FIG. 1 is a perspective view of a typical hydraulic press embodying the present invention;

FIG. 2 is a schematic piping diagram illustrating a preferred embodiment of the present invention; and

FIG. 3 is a schematic wiring diagram for automatic cycling of the press.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now more particularly to the drawing, the press **1** shown in FIG. 1 comprises a frame **2** of the open gap or C type having a bed **3** and a head **4** spaced above the bed **3**. Mounted on said head **4** is the press cylinder **5** having a piston or ram **6** mounted for vertical movement therein toward and away from the bed **3**. If desired, the lower end of the ram **6** may be connected to a die mounting plate **7** which is vertically movably guided on the guide rods **8** on the press frame **2**.

As best shown in FIG. 2, the hydraulic system for controlling actuation of the ram **6** comprises a tank or reservoir **9**, and a large volume medium pressure pump **10** and a small volume high pressure pump **11** both driven as by the electric motor **12**, said pumps **10** and **11** drawing fluid from the tank **9** through the conduit **14** and delivering fluid to the rod and head ends of the cylinder **5** through the respective conduits **15** and **16**.

A branch conduit **17** leads from conduit **15** to tank **9** via a balanced piston relief valve **18** with a solenoid operated pilot valve **19** for controlling the vent connection **20** of said valve **18**. If the vent connection **20** is open to the tank **9** via conduit **21** and pilot valve **19**, the relief valve **18** is also open to the tank **9** at virtually no pressure. When, however, the vent conduit **21** is connected to the tank **9** through the remote low pressure pilot relief valve **22**, as shown, then the major discharge through relief valve **18** takes place at the relief pressure of said valve **22**. When solenoid **23** of pilot valve **19** is energized to block the vent connection **20** and conduit **21**, the major discharge through relief valve **18** is also blocked until system pressure rises to the setting of the relief spring **24** which is set in excess of the pump **10** operating pressure.

Valve **25** is a remote piloted unloading valve (a pilot operated normally closed two-way valve, for example)

set to open at 100 p.s.i., for example, and when valve 25 is piloted open by pressure in pilot line 26 it opens the vent connection 20 of valve 18 to the tank 9 via conduit 27 thus to unload the return system for pump 10.

A branch conduit 28 leads from conduit 16 to tank 9 via a valve 29 which is similar to valve 18 except that a special connection 30 is made leading into the valve 29 to bypass the normal vent port 31. When this connection 30 is open to the tank 9 through the conduit 32 and the solenoid operated pilot valve 34, valve 29 unloads to the tank at very low pressure. When solenoid 35 of pilot valve 34 is energized, pilot pressure is admitted from pilot pressure conduit 36 through valve 34 and conduit 32 to valve 29 to block it quickly. With valve 29 blocked or pressured, as aforesaid, it operates as a relief valve at the setting of spring 37 or of the setting of remote control relief valve 38 whichever is set at the lower pressure.

The valves 39, 40, and 41 are sequence valves which are designed to block flow at their primary ports until system pressure rises to the settings of their respective springs 42, 43, and 44. As long as downstream pressure is lower than this level, the action of each valve 39, 40, and 41 is similar to a relief valve. However, if downstream pressure rises above its spring setting, each sequence valve 39, 40, and 41 is virtually wide open offering only the resistance of its flow passages.

Valve 45 is a direct relief valve set to open at about 200 p.s.i., for example, to limit the pressure in the aforesaid pilot system including conduit 26 which leads to valve 25.

The reference numeral 46 denotes a pressure switch which is set to operate at approximately 100 p.s.i., for example, and valves 47, 48, and 49 are check valves to permit flow only in one direction. The variable orifices 50 and 51 are provided to limit the flow in the lines which they control.

OPERATION

In the idling condition when the motor 12 is started both pumps 10 and 11 circulate oil at low pressure. The delivery of pump 11 develops a pilot pressure as it flows through sequence valve 40 and assuming that this is set for 200 p.s.i., this pressure stands through the pilot line 36 and check valve 49 to a blocked port in solenoid valve 34. Since the special vent connection 30 of valve 29 is connected to the tank 9 through valve 34, the pump 11 discharge from sequence valve 40 unloads through valve 29 to the tank 9.

The pump 10 discharges through check valve 48 and unloads through relief valve 18 to the tank 9. The low pressure pilot relief valve 22 is set so that the pump 10 discharge will maintain sufficient pressure to counterbalance the moving weight of the press ram 6 and its components. For small press cylinders and light loads, the valve 22 may be eliminated. If the ram 6 is in the down position it may creep to the upper limit of its travel if valve 22 is set at too high a relief pressure.

Initial return of the ram 6 to its up position is effected by energizing the solenoid 23 which blocks the vent line 21 as described above, and causes the pump 10 delivery to flow into the rod end of the press cylinder 5 thus to rapidly raise the ram 6. As the ram 6 moves up, the head end discharge is unloaded through the valve 29 to the tank along with the delivery from pump 11.

Downstroke and low pressure differential approach of the ram 6 is achieved by energizing both solenoids 23 and 35, whereby valve 34 shifts to admit pilot pressure from line 36 to the vent connnection 30, whereby valve 29 is blocked and the pump 11 delivery is directed in its entirety into the head end of the press cylinder 5.

The energization of solenoid 23 blocks the delivery of pump 10 at the valve 18 and pressure in the return system rises rapidly and the sequence valve 39 opens so that the pump 10 discharge flows through sequence valve 39 and check valve 47 to join the pump 11 discharge. The discharge from the rod end of the press cylinder 5 joins the pump 10 delivery and also flows through sequence valve 39 and check valve 47 to augment the pump 11 delivery. These three flows, that is, pump 11, pump 10 and the rod end discharge, combine to flow into the head end of the cylinder 5.

The high pressure full tonnage stroke portion is obtained by unloading pump 10. When work resistance is met by the ram 6, pressure continues to rise in the differential condition to the setting of sequence valve 41 which may be, say 1000 p.s.i. The 1000 p.s.i. sequence valve 41 then opens and the discharge flows through valve 45. Orifice 51 is set down to limit its flow to a low value sufficient to perform the unload duty only. Orifice 50 is adjusted to a minute flow forcing the major discharge through valve 45 which is set for approximately 200 p.s.i. for example. This 200 p.s.i. flow constitutes a pilot system in line 26 which stands on the unloader 25 and pressure switch 46. Valve 25 opens venting the pilot port 20 of the valve 18 to the tank 9. Valve 18 fully opens allowing the pump 10 to discharge freely into the tank 9 together with the fluid discharged from the rod end of the press cylinder 5. High system pressure is checked at the check valve 47.

When the pressure switch 46 is closed, a signal is delivered to the control system as hereinafter explained in detail to start the reversing time delay. The final stroke continues on the delivery of pump 11 and system pressure is ultimately limited by the setting of the spring 37 of relief valve 29 or the setting of the remote control valve 38 whichever is the lower.

For reversal, the pressure switch 46 signal developed at the time of unloading of the pump 11 initiates an electronic time delay which can be set for a very short period. The minimum setting is adjusted to permit the system to come to full pressure before developing the return stroke if the most rapid cycling is required. Any additional time set on this delay results in a pressure dwell which may sometimes be required depending on the work which is being done by the press ram 6.

At the end of the dwell period, the ram 6 is reversed by de-energizing solenoid 35 allowing valve 34 to return to the position shown. This opens the vent connection 30 and vent line 32 of valve 29 to the tank 9 unlocking the valve 29 for movement of its piston to open position. The system pressure in conduit 16 is dropped and the pump 11 discharge unloads to the tank 9 through valve 29. When the system pressure in conduit 16 drops, sequence valve 41 closes. The 200 p.s.i. pilot system 26 drops pressure through orifice 50, and the valves 25 and 45 reclose and the pressure switch 46 resets.

Since solenoid 23 remains energized, valve 18 is again blocked as unloader valve 25 closes. The pump 10 delivery through valve 18 is thereby blocked and therefore the delivery of pump 10 is caused to flow into the rod end of the cylinder 5 to move the press ram 6 upwardly. The discharge from the head end of cylinder 5 joins the pump 11 discharge in flowing through the now open valve 29. As the ram 6 moves upwardly it may be arranged to actuate a limit switch as hereinafter described to start a second electronic time delay which may be used to trigger a workpiece feeding or indexing mechanism 52. The time dwell set on the second time delay unit is to allow time for the feeding or indexing mechanism 52 to complete its work. If no feeding or indexing device 52 is used, the time dwell can be set to zero or the second timer eliminated.

At the end of the dwell period (if the second timer is used) or at the position switch signal (if no feed stroke is required), the return stroke of ram 6 is interrupted and caused to move down again by energization of solenoid 35.

The reverse action again develops followed by another index and downstroke, and this is repeated until the automatic cycling is interrupted. Rapid cycling strokes have been made as short as 7/8" on a 50 ton press and a cycling

rate of 134 strokes per minute have been developed with both of the aforesaid time delays set as close to zero as practical.

If no pressure dwell is required, the pressure switch **46** signal can be eliminated and a reversing pressure switch (not shown) can be set to operate at the ultimate pressure condition. This can be a high pressure switch in the cylinder **5** head end system or a flow switch **53** operating in the valve **38** discharge line.

If no feed device **52** is used, the aforesaid position switch signal can be used to energize solenoid **35** directly instead of the second time delay signal to initiate the second and subsequent cycles.

Referring now to detailed operation with reference to the schematic wiring diagram FIG. 3, the start switch 2PB and the "Jog-Auto" switch 1SS is set to automatic position whereby the motor relay 1M is energized to close its contacts 1M–1, –2, –3, and –4 thus closing the circuit for the drive motor **12**, the contact 1M–4 being a holding contact to permit momentary closing of 2PB and contacts 1SS–1. With ram **6** at its upper position limit switches 1LS and 2LS are open and with feeder mechanism **52** in its withdrawn position limit switch 3LS is closed. In this initial condition, the automatic relay CRA and its indicator light R are energized by contacts 1SS–2 and relay 2CR is energized and held by its contact 2CR–1.

Step 1.—Operator presses both down buttons 4PB and 5PB to energize the relay 3CR and the solenoid **35** which cause the ram **6** to move down slowly on the delivery of pump **11** while the output of pump **10** and the rod end displacement is conducted to the tank **9** via valve **18**.

Step 2.—As soon as the ram **6** moves down a short distance limit switch 1LS is closed thereby to energize solenoid **23** whereby the ram **6** moves down at rapid traverse as pump **10** is loaded.

Step 3.—At the automatic stroke limit, the limit switch 2LS is closed to energize relay 1CR whereby the closing continues at rapid traverse.

Step 4.—Ram **6** continues down, contacts the work and builds up to intermediate pressure whereby valve **41** opens, valve **25** opens to unload valve **18**, and pressure switch **46** operates, thus causing energization of relay 4CR which holds at its contact 4CR–1, timer 1T is started, relay 5CR is energized and holds at its contact 5CR–2 and if feed switch 2SS is "on," relay 6CR is energized and holds at its contact 6CR–2. At this point the pump **10** is unloaded and the pressure stroke continues on the discharge of pump **11**. The energization of the timer 1T starts the pressure dwell time.

Step 5.—At the end of the pressure dwell time period of timer 1T, its contact 1T–1 opens and then recloses as the pressure drops and the pressure switch **46** reopens as pressure drops. At that time, the relays 2CR, 3CR and 4CR, along with solenoid **35** and timer 1T are de-energized whereby the ram **6** reverses and, of course, the solenoid **23** is held energized by contact 5CR–4 of the relay 5CR.

Step 6.—As the ram **6** returns up, the limit switch 2LS is opened to de-energize the relay 1CR and as its contact 1CR–1 closes, the relay 2CR is energized and holds at its contact 2CR–1. As the contact 1CR–3 of relay 1CR closes, the second timer 2T is energized. With the feed switch 2SS closed, solenoid **54** is energized as contact 1CR–4 closes, thus to provide the feed-in stroke of the mechanism **52** to the limit switch 4LS. With timer 2T energized, the restart time delay period begins and the purpose of the restart time delay period is to allow time for the feed stroke of the feeding and indexing mechanism **52**. The first true automatic cycle begins at this Step 6. The press **1** is now reversing after the first stroke from the limit switch 1LS position as started by the "Down" push button switches 4PB and 5PB. Also, relay 5CR is energized in addition to relay CRA.

Step 7.—At the feed "in" position, the limit switch 4LS is opened whereby relay 6CR and solenoid **54** are de-energized and with feed switch 2SS closed, the feed stroke mechanism **52** moves out.

Step 8.—When the timer 2T has timed out, and when the limit switch 3LS is closed by the feeder return, relay 3CR and solenoid **35** are energized whereby the ram **6** moves down at rapid traverse.

Step 9.—The limit switch 2LS recloses as closing stroke continues, and relay 1CR is energized, the timer 2T being de-energized as the contact 1CR–3 opens. The downward movement of the ram **6** continues at rapid rate.

Step 10.—The ram **6** continues down, contacts the work, builds up to intermediate pressure, whereby valve **41** opens, valve **25** unloads, and pressure switch **46** operates, thus energizing relay 4CR which holds at its contacts 4CR–1, timer 1T is started, and with feed switch 2SS closed, the relay 6CR is energized, holding at 6CR–2. At this time there is a pressure build up and the pump **10** is unloaded at the setting of valve **41**, and the timer 1T causes the pressure dwell period to start.

Step 11.—At the end of the timer 1T period its contact 1T–1 opens and recloses as pressure drops and pressure switch **46** reopens as pressure drops, thus causing de-energization of relays 2CR, 3CR, 4CR, timer 1T, and solenoid **35** whereby the ram **6** reverses, while solenoid **23** is held by the contact 5CR–4.

The cycle repeats Steps 6 through 11 until the "Jog-Auto" switch 1SS is turned to the "jog" position whereby the restart system is not energized.

For manual operation of the press, it will be apparent from the circuit diagram of FIG. 3 that such control may be achieved as by the push-button switches 1PB (STOP), 3PB (UP), and 6PB (MANUAL FEED IN).

Other modes of applying the principle of the invention may be employed, change being made as regards the details described, provided the features stated in any of the following claims, or the equivalent of such, be employed.

I therefore particularly point out and distinctly claim as my invention:

1. A fluid power system for a double acting cylinder having a piston reciprocable therein comprising a pair of pumps having discharge ports connected with the respective ports of said cylinder; a pair of vent valves, one of said vent valves associated with each of the respective cylinder ports and pumps operative when open to vent fluid from the respective cylinder ports and pumps, and when closed to permit delivery of fluid under pressure from said pumps into the respective cylinder ports; and means selectively operable alternately to open and close said vent valves to cause said piston to be moved in opposite directions in said cylinder; the discharge pressure of one pump being greater than that of the other pump; and a check valve communicating with the discharge ports of said pumps to permit flow of fluid therethrough from said other pump and the associated cylinder port to augment the delivery of fluid from said one pump to the associated cylinder port, thus to achieve rapid movement of said piston in one direction.

2. A fluid power system for a double acting cylinder having a piston reciprocable therein comprising a pair of pumps having discharge ports connected with the respective ports of said cylinder; a pair of vent valves operative when open to vent fluid from the respective cylinder ports and pumps, and when closed to permit delivery of fluid under pressure from said pumps into the respective cylinder ports; and means selectively operable alternately to open and close said valves whereby said piston is moved in opposite directions in said cylinder; and a sequence valve disposed between one pump and the corresponding cylinder port to minimize pressure drop in fluid delivered by said one pump to said cylinder port when said sequence valve is open.

3. A fluid power system for a double acting cylinder having a piston reciprocable therein comprising a pair of pumps having discharge ports connected with the respective ports of said cylinder; a pair of vent valves operative

when open to vent fluid from the respective cylinder ports and pumps, and when closed to permit delivery of fluid under pressure from said pumps into the respective cylinder ports; and means selectively operable alternately to open and close said valves whereby said piston is moved in opposite directions in said cylinder; said means comprising a pilot valve which is operatively connected with a vent valve either to conduct fluid under pressure delivered by the associated pump to a control port of said vent valve to close said vent valve or to vent such control port to open said vent valve.

4. A fluid power system for a double acting cylinder having a piston reciprocable therein comprising a pair of pumps having discharge ports connected with the respective ports of said cylinder; a pair of vent valves operative when open to vent fluid from the respective cylinder ports and pumps, and when closed to permit delivery of fluid under pressure from said pumps into the respective cylinder ports; and means selectively operable alternately to open and close said valves whereby said piston is moved in opposite directions in said cylinder; said means comprising a pilot valve which is operatively connected with a control port of a vent valve either to block or permit flow of fluid from said control port to a vent thus to close or open said vent valve.

5. A fluid power system for a double acting cylinder having a piston reciprocable therein comprising a pair of pumps having discharge ports connected with the respective ports of said cylinder; a pair of vent valves operative when open to vent fluid from the respective cylinder ports and pumps, and when closed to permit delivery of fluid under pressure from said pumps into the respective cylinder ports; and means selectively operable alternately to open and close said valves whereby said piston is moved in opposite directions in said cylinder; said means comprising an unloading valve which is operatively connected with a control port of one vent valve either to block or permit flow of fluid from said control port to a vent thus to close or open said one vent valve; said unloading valve being responsive to predetermined buildup of fluid pressure in the portion of said system including the other pump and other cylinder port to open said one vent valve for venting said one pump and one cylinder port.

6. A fluid power system for a double acting cylinder having a piston reciprocable therein comprising a pair of pumps having discharge ports connected with the respective ports of said cylinder; a pair of vent valves operative when open to vent fluid from the respective cylinder ports and pumps, and when closed to permit delivery of fluid under pressure from said pumps into the respective cylinder ports; and means selectively operable alternately to open and close said valves whereby said piston is moved in opposite directions in said cylinder; said means comprising a first pilot valve which is operatively connected with one vent valve either to conduct fluid under pressure delivered by the associated pump to a control port of said one vent valve to close said one vent valve or to vent such control port to open said one vent valve; and a second pilot valve and a relief valve, said second pilot valve being operatively connected with a control port of the other vent valve either to block or to permit flow of fluid from said control port of said other vent valve to said relief valve thus to close or open said other vent valve.

7. The system of claim 3 wherein said means further comprises a relief valve; said pilot valve being operatively connected with the control port of said vent valve either to block or permit flow of fluid from said control port to said relief valve thus to close or open said vent valve.

8. The system of claim 4 further comprising an unloading valve which is also operatively connected with said control port either to block or permit flow of fluid from said control port to a vent.

9. The system of claim 6 wherein an unloading valve is also operatively connected with the control port of said other vent valve either to block or permit flow of fluid from the control port of said other vent valve to a vent thus to close or open said other vent valve; said unloading valve being responsive to predetermined buildup of fluid pressure in the portion of said system including said one vent valve and associated pump to maintain said other vent valve in open position by bypassing said second pilot valve and relief valve.

10. A fluid power system for a differential displacement double acting cylinder having a piston reciprocable therein, the piston rod thereof constituting the movable ram of a hydraulic press and the like, said system comprising a first pump having a discharge port connected with the port at the head end of said cylinder; a second pump of lower discharge pressure than said first pump having a discharge port connected with the port at the rod end of said cylinder; a first vent valve operative when open to vent fluid from said first pump and from the head end of said cylinder and when closed to permit delivery of fluid under pressure from said first pump into the head end of said cylinder; a second vent valve operative when open to vent fluid from said second pump and from the rod end of said cylinder and when closed to permit delivery of fluid under pressure from said second pump into the rod end of said cylinder; and means selectively operable to close said first vent valve and to open said second vent valve to effect movement of said piston toward the rod end of said cylinder, and to open said first vent valve and to close said second vent valve to effect movement of said piston toward the head end of said cylinder.

11. The system of claim 10 wherein a sequence valve is operatively disposed between said first pump and the head end of said cylinder so that fluid pressure delivered by said first pump provides an internal signal to open said sequence valve.

12. The system of claim 10 wherein said means comprises a pilot valve which is operatively connected to said first vent valve either to conduct fluid pressure delivered by said first pump to a control port of said first vent valve to close the latter or to vent such control port to open said first vent valve.

13. The system of claim 10 wherein a sequence valve is operatively disposed between said first pump and the head end of said cylinder so that fluid pressure delivered by said first pump provides an internal signal to open said sequence valve; and wherein said means comprises a pilot valve which is operatively connected to said first vent valve either to conduct fluid pressure from said first pump at a point upstream of said sequence valve to a control port of said first vent valve to close the latter or to vent such control port to open said first vent valve.

14. The system of claim 10 wherein a check valve communicating with the discharge ports of said first and second pumps permits flow of fluid therethrough from said second pump and from the rod end of said cylinder when said means are operated to close said first and second vent valves to augment the delivery of fluid from said first pump to the head end of said cylinder, thus to achieve rapid movement of said piston toward the rod end of said cylinder.

15. The system of claim 10 wherein an unloading valve piloted by fluid presure delivered thereto by said first pump is operative, when opened as by buildup of fluid pressure. delivered by said first pump, to vent said second vent valve.

16. The system of claim 10 wherein said means comprises first and second pilot valves which are operatively connected with said first and second vent valves either to block or open communication of a control port of the respective first and second vent valves with a vent whereby to close or to open the respective first and second vent valves.

17. The system of claim 16 wherein an unloading valve piloted by fluid pressure delivered thereto by said first pump is operative, when opened as by buildup of fluid

pressure delivered by said first pump, to vent said second vent valve.

18. The system of claim **16** wherein a relief valve is operatively connected with said control port of said second pilot valve to vent the latter at a predetermined fluid pressure.

19. The system of claim **18** wherein an unloading valve piloted by fluid pressure delivered thereto by said first pump is operative, when opened as by buildup of fluid pressure delivered by said first pump, to vent said second vent valve even though said second pilot valve is in position blocking communication of said control port with such vent.

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