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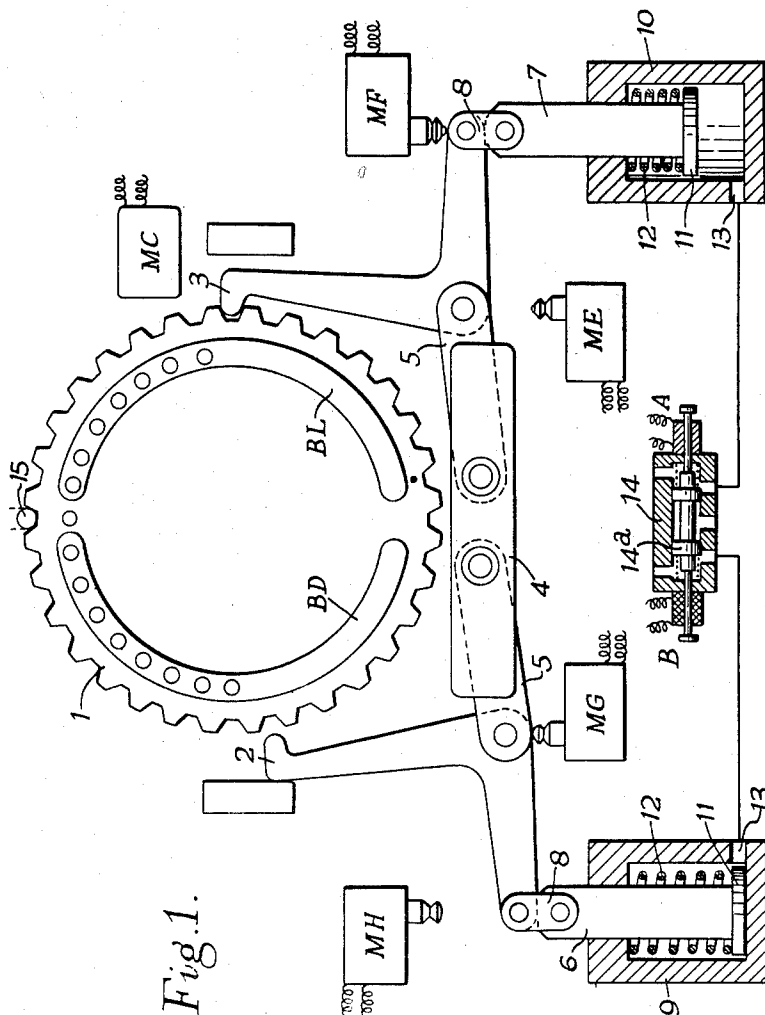
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2,947,317

UNLOADING VALVES FOR HYDRAULIC PUMPS

Filed Oct. 31, 1956

3 Sheets-Sheet 1



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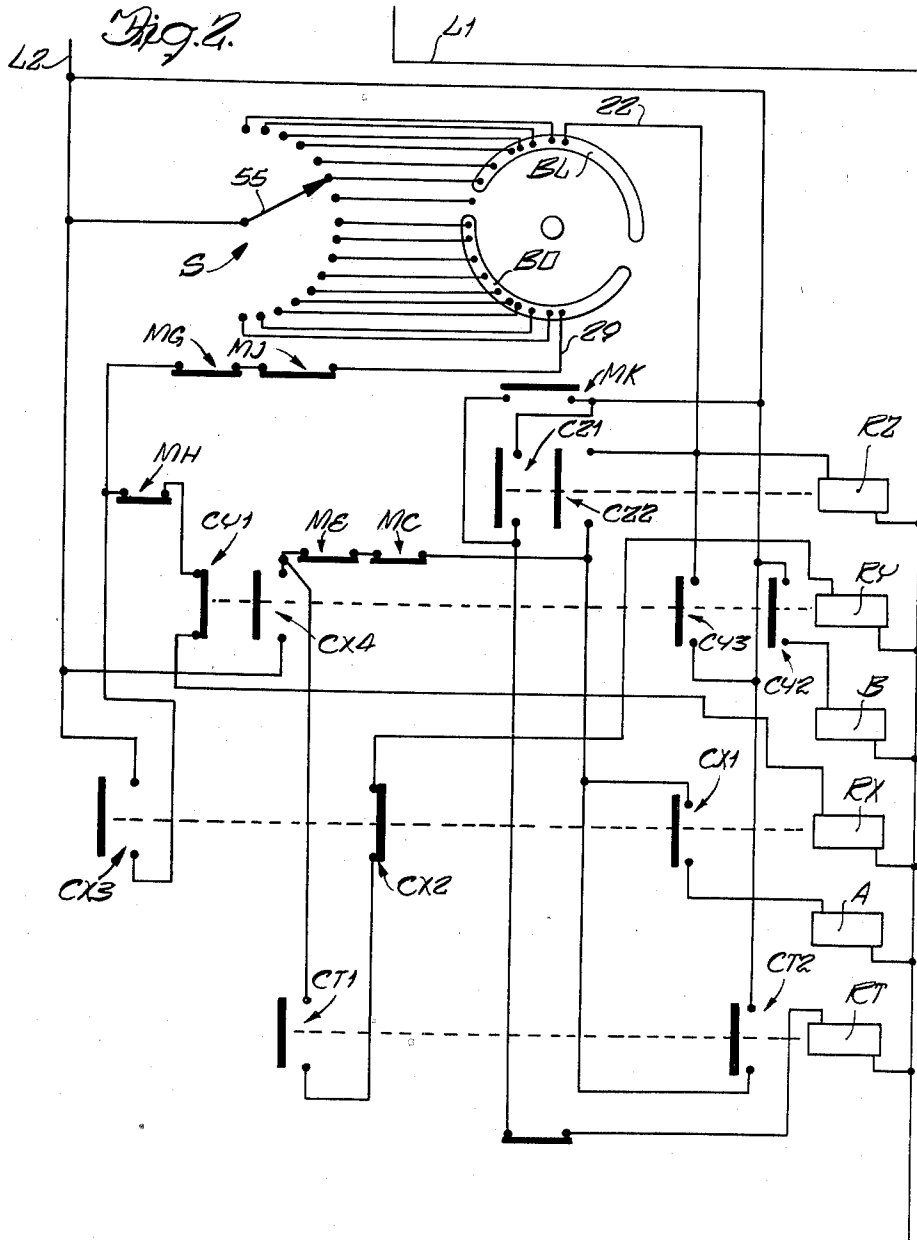
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3 Sheets-Sheet 2

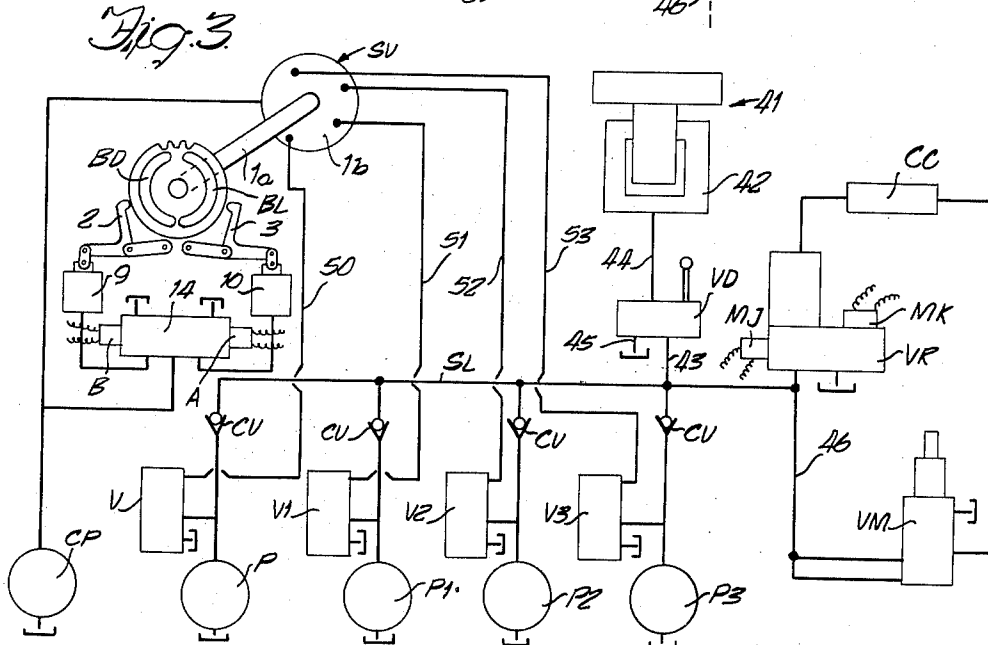
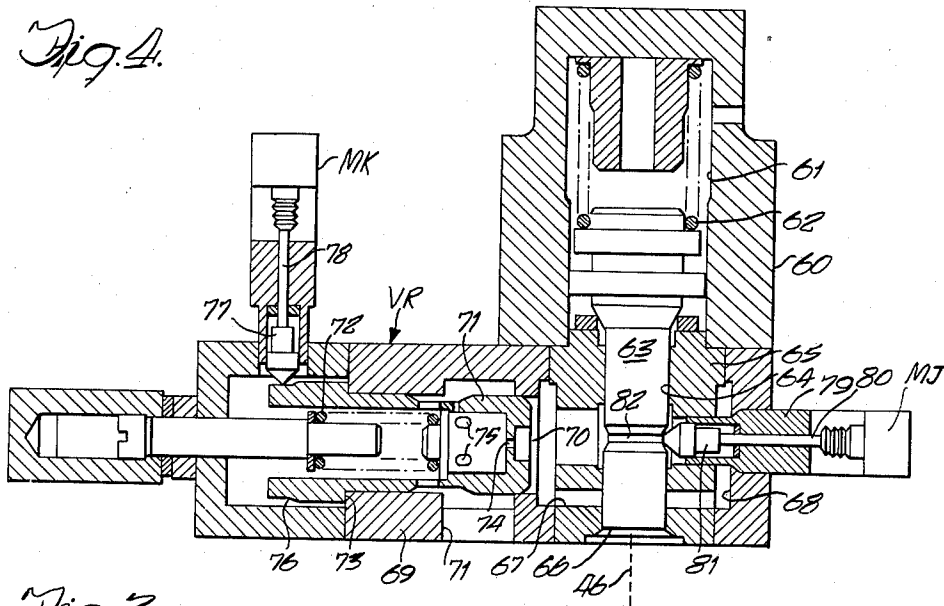


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3 Sheets-Sheet 3



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2,947,317

UNLOADING VALVES FOR HYDRAULIC PUMPS

Frank Hathorn Towler, Dob Park, Otley, England, and John Maurice Towler, deceased, late of Mayfair, London, England, by Frank Hathorn Towler, executor, Dob Park, Otley, England, assignors to Electric Presses Limited, Rodley, near Leeds, Yorkshire, England, a limited-liability company of Great Britain

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14 Claims. (Cl. 137—108)

This invention relates to hydraulic systems for hydraulic presses of the type in which pressure fluid for operation of the press ram is supplied by more than one continuously running pump, and it has for its general object the utilization of changes of pressure in the ram cylinder to govern the operation of unloading valves to effect the loading and unloading of the pumps in a predetermined sequence thereby to control the speed of the press ram. This application is a continuation-in-part of our copending application, Serial No. 435,572, filed June 9, 1954, now abandoned.

A more specific object is to provide control mechanism operative in response to pressure changes from a predetermined value in a press hydraulic system for operating a rotary control valve step-by-step in either of two directions to load or unload one or more pumps for re-establishing the predetermined pressure in the system.

Another object is to provide control mechanism of the above general character operative to maintain pressure in the system substantially constant which mechanism is free of any tendency to hunt.

Still another object is to provide an automatically operating control system of the above general character which may be present manually to load or unload one or more pumps for increasing or decreasing press ram speed and which automatically reverts to normal automatic operation.

A further object is to provide improved drive gear for automatically positioning a rotary selector valve together with controls therefor.

Other objects and advantages of the invention will become apparent from the following detailed description of the preferred embodiment illustrated in the accompanying drawings in which

Figure 1 is a somewhat diagrammatic view illustrating a preferred form of fluid pressure operated drive mechanism for imparting a step-by-step motion in either direction to a rotary selector valve incorporated in a press hydraulic system embodying the features of the invention.

Fig. 2 is a diagram illustrating the electrical control circuit associated with the rotary selector valve and other control elements of the system and showing the use of a manually operated selector switch for presetting the cut-out position of the selector valve in either direction of rotation.

Fig. 3 is a diagrammatic view of a hydraulic press circuit particularly adapted for the use of the invention.

Fig. 4 is a longitudinal sectional view through the pressure relief valve employed in the system shown in Fig. 3.

While we have shown and will describe herein a preferred embodiment of the invention, it is to be understood that this is not intended to limit the invention to the particular press control organization shown but the intention is to cover all modifications and adaptations

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falling within the spirit and scope of the invention as expressed in the appended claims.

For purposes of illustration the invention has been shown as incorporated in the hydraulic system of a hydraulic press 41 having a main press cylinder or ram 42 as shown diagrammatically in Fig. 3 of the drawings.

In the exemplary system pressure fluid is supplied to the press cylinder by a series of pumps P, P1, P2, and P3, respectively equipped with individual loading and unloading valves V, V1, V2, and V3. In the exemplary system, the pumps run continuously and are normally loaded, that is, they deliver their output of pressure fluid to the hydraulic system of the press. Each pump may be "unloaded" individually by operation of its associated unloading valve which diverts the pump output to exhaust in well known manner. It will be understood that the four pumps shown are merely exemplary and that more or less than four can be used if required. The valves V, V1, V2, and V3 are all alike and may be of any suitable type, as for example, valves of the type shown in out Patent No. 2,655,169, issued October 13, 1953.

In the exemplary system the four pumps are arranged to discharge through individual check valves CV into a common pressure supply line SL which has a branch 43 extending to a direction control valve VD. A conduit 44 connects the valve with the ram cylinder. The valve VD may be of any suitable type adapted to connect the conduit 44 alternatively with the supply line branch 43 or with an exhaust line 45. In the first mentioned valve position, pressure fluid is directed to the cylinder to advance the press ram and in the alternate position, fluid is exhausted from the cylinder to permit retraction of the ram.

A second branch conduit 46 from the pressure supply line SL extends to control means responsive to the pressure obtaining in the hydraulic system. This control means may conveniently take the form of a pressure relief valve VR (Fig. 4). The branch conduit 46 also extends to a master valve VM, the operation of which will be explained in more detail hereinafter. Suffice it to say at this point that the master valve VM may be similar to that shown in our copending application, Serial No. 430,339, filed May 17, 1954.

The master valve VM operates in well-known manner to determine the pressure at which the relief valve VR opens and closes by controlling fluid flow to and from a capacity chamber CC which has an operative connection with the valve VR. In accordance with one aspect of the invention, the relief valve VR, in addition to relieving pressure in the system when required, exerts a controlling action on a selector valve SV (Fig. 3) to load or unload the pumps P, P1, P2 and P3 in predetermined sequence for automatically maintaining selected press operating speeds. Control of the selector valve is effected through the medium of a pair of microswitches MJ and MK and the control circuit shown diagrammatically in Fig. 2. The selector valve controls the loading and unloading of the pumps by regulating the operation of the valves V1—V3.

In the particular hydraulic system illustrated the switch MJ is closed when the pressure in the hydraulic circuit, including the ram cylinder, is at or below a predetermined value. The switch opens when the pressure rises above that value. The switch MK, on the other hand, is normally open and closes only when the pressure in the hydraulic circuit reaches a maximum value as determined by the rate of flow of fluid through the relief valve.

The selector valve SV may be of any preferred type, that shown being generally similar to the valve disclosed

in our copending application, Serial No. 342,006, now Patent No. 2,827,924, but equipped with power operated actuating means or drive gear as shown in Fig. 1. Briefly, the valve is connected by conduits 50, 51, 52 and 53 with the valves V, V1, V2 and V3 and controls a supply of pressure fluid from a control pump CP to those valves to load or unload the pumps individually or in predetermined combinations depending upon the position of the movable valve member.

In the exemplary valve, the movable valve member comprises a rotary member adapted to be turned in either direction by power operated drive gear. This drive gear, as will appear presently, is operable either manually under control of a selector switch S or automatically in accordance with the opening and closing of the relief valve VR. The invention provides an arrangement such that turning of the valve member in one direction from a set position, either under manual control or upon a predetermined increase of pressure in the press cylinder 42, unloads one or more of the pumps to maintain a substantially constant operating speed. Turning of the valve in the opposite direction from a set position or upon a decrease in pressure in the press cylinder loads one or more of the pumps as required to increase the pressure in the press cylinder and maintain a substantially constant operating speed.

Referring more particularly to Figs. 1 and 3 of the drawings, the drive gear for the selector valve SV comprises a ratchet wheel 1 mounted on the stem 1a by which the rotatable member or disc 1b of the valve is turned. Supported at opposite sides of the ratchet wheel are a pair of pawls 2 and 3 in the form of bell crank levers pivotally supported intermediate their ends on links 5. These links in turn are pivoted to a rigid support 4.

Each of the pawls 2 and 3 has one arm positioned for operative engagement with the ratchet wheel. The other arms of the pawls are pivotally connected respectively by links 8 with plungers 6 and 7 operating respectively in cylinders 9 and 10. Each of the plungers is formed with an enlarged head 11, its inner end within the associated cylinder presenting areas against which pressure fluid is permitted to act to force the plunger outwardly against the force exerted by return springs 12.

Pressure fluid is distributed to the cylinders 9 and 10 in turn through inlets 13 under control of a solenoid operated valve 14. In the neutral position of the valve the cylinders 9 and 10 are opened to exhaust and the plungers are both in their inward positions in their cylinders, having been urged there by the return springs. By reason of such positioning the pawls are withdrawn from operative engagement with the ratchet wheel 1, that is, they occupy positions corresponding to that in which the pawl 2 has been shown in Fig. 1.

Upon delivery of pressure fluid to a cylinder, the associated plunger is forced outwardly by the pressure acting on the enlarged area of the head and, in its advance, it causes the pawl to move upwardly and inwardly into engagement with the ratchet wheel 1. The ratchet wheel is thus advanced a step equal to one tooth. A spring detent 15 retains the ratchet wheel in seated position upon return movement of the pawl which takes place upon the return of the valve 14 to neutral position. Since the pawls are operable selectively and act on opposite sides of the ratchet wheel, it will be apparent that the ratchet wheel, and with it the rotary valve member, may be advanced step-by-step in either direction as required.

The valve 14 controlling the operation of the pawls 2 and 3 as shown herein is a conventional spool-type valve having a spindle 14a which is moved in opposite directions alternately by solenoids A and B which are energized in a manner to be described hereinafter. Opposed centering springs acting on the plunger 14a normally return it to and hold it in a central or neutral position when the operating solenoids are deenergized. In the

neutral position, both cylinders 9 and 10 are connected to exhaust. In the operated positions one or the other of the cylinders remains connected to exhaust while the companion cylinder is connected to a source of pressure fluid, as for example, the continuously running control pump CP (Fig. 3). In the exemplary hydraulic system, the pump CP also supplies fluid to the valve SV for distribution to the pump controlling valves V, V1, V2 and V3.

In accordance with the invention, both manual and automatic control of the selector valve operating gear is effected through the medium of the electrical control circuit shown in diagrammatic form in Fig. 2 of the drawings.

Referring now to the diagram, it will be observed that the control circuit includes relays RT, RX, RY and RZ with their respective contacts CT, CX, CY and CZ. MC, MF and MH are microswitches with normally closed contacts and ME and MG are also microswitches but with normally open contacts. The microswitches MC, ME and MF are mounted for coaction with the pawl 3 and microswitches MG and MH are mounted for coaction with the pawl 2, as will appear presently. The microswitches MJ and MK are associated with the relief valve VR (Fig. 3) and, as previously explained the contacts of switch MK are normally open and are only closed when the pressure in the hydraulic circuit reaches a maximum and the flow through the relief valve exceeds a predetermined limit.

Mounted on the face of the ratchet wheel 1 are a pair of contact strips BD and BL adapted to wipe over a series of contacts spaced apart in correspondence with the rotational steps of the ratchet wheel and each corresponding to one set position of the selector valve SV. These contacts are electrically connected with a similar set of contacts of the selector switch S which accordingly may be set manually to mark any selected position of the valve. In carrying out the present invention, the contact and valve positions are correlated so that each step of the selector switch in a clockwise direction from the off position loads the pumps so as to add a predetermined increment of pressure fluid to the total output. Rotation of the switch in the opposite direction decreases the pressure fluid by a similar increment for each step.

It will be observed that the adjacent ends of the contact strips B, D and BL are spaced apart so that one intervening contact is left free or "dead." As will appear presently the operation of the control circuit is such that the drive gear is operated to automatically turn the valve to a position in which the contact marked by the selector switch is left "dead."

For convenience of identification the switch contacts of the control circuit relays have been identified with the reference characters of the associated relays followed by a numerical suffix. The manner in which the relays and their switch contacts, the selector switch and solenoids A and B are interconnected will be most readily understood from a description of the operation of the system under the various conditions encountered in actual use.

Idle position

In the idle or "off" position of the apparatus, the selector switch S is set to mark the position in which all of the pumps are unloaded. The valve actuating ratchet wheel 1 occupies a corresponding position with the marked contact "dead," that is, between the contact strips BD and BL. All of the relays in the control system will be deenergized as their circuits are open at the selector switch. Solenoids A and B are likewise deenergized and valve 14 is in neutral position.

Start

To place the press in operation the selector switch finger 55 is rotated from the idle position in a clockwise direction one or more steps to a position which marks

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the particular combination of pumps to be loaded, that is, to be placed in operation. Suppose, for example, that the press is to be operated at a speed requiring the loading of three of the four pumps. Switch S is turned clockwise to the position corresponding to that pump combination, say, for example, three steps to mark the proper contact at the ratchet wheel 1. In this position the selector switch closes a circuit from line conductor 2, switch finger 55, selector switch and ratchet wheel contacts, contact strip BD, conductor 29, microswitches MJ, MG, and MH, normally closed contacts CY1 of relay RY, winding relay RX to line conductor L1. Relay RX becomes energized and by closing contacts CX1 it completes an energizing circuit for solenoid A. Relay RX also opens switch contacts CX2 to prevent any possibility of relay RY becoming energized. Closure of contacts CX3 insures energization of the relay RX and solenoid A until the ratchet wheel has made a full step.

The energization of solenoid A shifts valve 14 to a position to direct pressure fluid to the cylinder 9. The stepping pawl 2 is accordingly advanced to turn the ratchet wheel 1 and valve member 1b one step in the direction of the marked contact, i.e., in a clockwise direction. As the plunger 6 advances microswitch MG is opened first, followed by the opening of microswitch MH as the ratchet wheel completes its step. The latter microswitch interrupts the circuit for relay RX which becomes deenergized and opens the circuit for solenoid A. Deenergization of solenoid A permits the valve 14 to return to neutral position and pawl 2 is retracted by the plunger return spring.

Since the selector switch finger 55 was moved more than one step from the idle position, reclosure of the switches MG and MH upon retraction of the pawl 2 will result in the reenergization of relay RX. The stepping operation above described will be repeated, advancing the selector valve member 1b another step in the same direction. In the assumed situation, a third step is executed in the same manner. This third step carries the contact strip BD out of engagement with the contact marked by the selector switch. Accordingly, no further stepping takes place at this time but operation of the press will proceed with the pumps loaded as called for by the set position of the selector switch.

Decrease speed—manual control

If for any reason it is desired to decrease the operating speed of the press, the selector switch S is turned anticlockwise one or more steps as required to establish a combination of loaded pumps with a lower volume output of pressure fluid. Movement of the switch finger 55 from the "dead" contact to the next adjacent contact completes a circuit from line conductor L2, switch finger 55, switch and ratchet wheels contacts, contact strip BL, conductor 22, winding of relay RZ to line conductor L1. Relay RZ becomes energized and closes its contacts CZ1 to energize relay RT over a circuit including normally closed microswitch MF.

Energization of relay RT completes an energizing circuit for relay RY. This circuit includes closed relay contacts CZ2, microswitches MC and ME, relay contacts CT1 and CX2. Relay RY closes contacts CY2 to complete the energizing circuit for solenoid B. The solenoid shifts valve 14 to a position to direct pressure fluid to cylinder 10 and the pawl 3 is accordingly advanced to turn the ratchet wheel 1 back one step.

It may be noted that relay RY opens contacts CY1 to prevent inadvertent energization of relay RX. By closing contact CY3, relay RY completes a holding circuit for solenoid B and for relay RZ independently of the selector switch. Closure of contacts CY4 completes a circuit in parallel with that through the contacts CZ2 to insure a full step of the ratchet wheel. Relay RT by closing contacts CT2 extends the holding circuit to relay RY.

Upon full advance of the ratchet wheel the microswitch MF is opened by the pawl 3, deenergizing relay

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RT which in turn opens the circuit of relay RY at contacts CT1. Relay RY becomes deenergized and opens a circuit over solenoid B at contacts CY2 and the solenoid permits valve 14 to return to the neutral position. The pawl 3 is then retracted by its return spring and the associated microswitches are closed.

If the selector switch S has been turned only one step, the single step of the ratchet wheel will move the contact strip BL out of engagement with the marked contact and consequently will interrupt the circuit for relay RZ. The relay then becomes deenergized and operation of the valve stepping mechanism is terminated.

When the selector switch S is turned back more than one step, additional stepping of the ratchet wheel and selector valve takes place upon reclosure of the microswitch MF. The stepping operation is the same as that explained above. It will be evident therefore that under normal operating conditions, the ratchet wheel and selector valve are stepped around until they occupy the position dictated by the setting of the selector switch S.

Increase speed—manual control

The press speed may be increased manually at any time by simply turning the selector switch S one or more steps in a clockwise direction. The operations of the control system in that case are precisely like those described above in connection with the starting of the press and operation.

Speed reduction by automatic pressure control

When the pressure in the hydraulic system reaches a predetermined value microswitch MJ is opened. Switch MK closes when the fluid flow through the relief valve reaches or exceeds a predetermined value. When microswitch MK closes, assuming switch MF is closed, an energizing circuit is completed for relay RT which closes the energizing circuit for relay RY as previously described. Relay RY closes the circuit for solenoid B which initiates a backward stepping of the selector valve SV to unload a pump or pumps. Pressure in the system decreases due to the lower volume of fluid delivered by the pumps. However, if the pressure drop is not sufficient to permit switch MK to open, the stepping operation is repeated. This stepping may continue if necessary until all of the pumps are unloaded, at which time switch MC opens to prevent further energization of relay RY and thus ends the backward stepping of the valve.

Automatic resetting of selected speed

When press speed is automatically reduced as above explained the selector switch and valve, of course, get out of step. More specifically, the valve will be turned to a position in which contact strip BD engages the contact marked by the selector switch. This would ordinarily call for resetting of the selector valve to load additional pumps but as long as the excessive pressure prevails in the system, the stepping circuit ordinarily rendered effective by the selector switch will be interrupted by the open microswitch MJ. If flow through the relief valve drops below the predetermined volume and switch MJ remains open, switch MK opens and no further change in valve setting takes place.

When the pressure in the system drops sufficiently to allow the relief valve to close microswitch MJ, this switch transfers control to the selector switch and initiates a clockwise stepping of the selector valve as previously described until the valve and switch S are correspondingly positioned.

In Fig. 4 of the drawings there is shown a preferred form of the relief valve VR illustrating the manner in which the microswitches MJ and MK may be associated with the valve. Insofar as its pressure relieving action is concerned this valve is structurally similar to and adapted to operate in the same manner as the valve disclosed in our copending application, Serial No. 430,-

339, filed May 17, 1954. More particularly, flow through the valve is controlled by a plunger biased to a closed position by a light spring and loaded to resist opening by pressure fluid supplied through the master valve VM.

In addition to its pressure relieving action the valve VR is equipped with auxiliary means for metering fluid blowing off through the relief valve. This auxiliary metering means provides for actuating the microswitch MK when the fluid flow through the valve reaches or exceeds a predetermined volume. Microswitch MJ is associated with the valve so that it is operated when the fluid pressure in the system rises sufficiently to open the valve.

Referring more in detail to Fig. 4 of the drawings, the valve VR as shown comprises a casing 60 having a cylindrical bore 61, the upper portion of which constitutes a pressure chamber and a housing for a spring 62 acting on the shiftable plunger 63. The plunger is slidable in a valve bore 64 formed in a valve bushing 65 seated in the lower end of the bore 61. Valve bore 64 opens to a port 66 to which the branch 46 of the main pressure line is connected. It will be evident that the lower end of the plunger is subjected to the full pressure of the fluid in the hydraulic system in which it is incorporated.

An outlet or exhaust port 67 opens laterally from the bore 64 into an annular chamber 68 in the valve casing. Thus, when the pressure exerted on the plunger 63 is sufficient to overcome the bias of the spring 62 and the hydraulic load imposed on the upper end of the plunger, the plunger is shifted to establish communication between the port 66 and the chamber 68 and the system is vented to exhaust, as will appear presently.

Rigidly secured to the casing 60 adjacent its lower end is an auxiliary casing 69 having a central bore 70 in communication with the chamber 68. The bore 70 has a lateral outlet port or exhaust 71 connected by an exhaust line to the storage reservoir or sump of the hydraulic system. Communication between the chamber 68 and the exhaust port 70 is normally closed off by a plunger 71 slidable in the bore 70 and urged to a closed position by a spring 72.

As shown, the plunger 71 is formed with a rearwardly extending skirt portion having an axially facing shoulder 73 adapted to abut a stepped shoulder formed in the bore 70 to define the limit position of the plunger. Bypass ports 74 and 75 are provided in the head of the plunger to permit flow of fluid from the chamber 68 to exhaust when the volume is small. Upon increase in flow above a predetermined value the pressure built up in the chamber 68 forces the plunger 71 rearwardly against its relatively light biasing spring 72 to allow substantially unrestricted flow to exhaust.

Rearward movement of the plunger 71 is operative to actuate the microswitch MK. For this purpose the skirt portion of the plunger is formed with a cam surface 76 engageable by a follower 77 connected by a rigid stem 78 with the switch MK. As previously explained, switch MK is normally open and rearward movement of the plunger 71 to accommodate a predetermined volume of fluid flow to exhaust acts to close the switch.

Microswitch MJ is operatively associated with the relief valve plunger 63 in a manner such that the switch is opened when fluid blows off through the relief valve. For this purpose the switch is carried by a housing 79 mounted within an aperture in the valve casing 60 and extending through the bushing 65 to the bore 64. An operating stem 80 extending from the switch is equipped with a tapered head 81 normally seating in a cam groove 82 formed in the plunger 63. Upon movement of the plunger toward open position the head 81 is cammed outwardly and acts to open the associated microswitch MJ.

In the operation of a hydraulic press equipped with the improved control system, the operating speed of the press is preset by appropriate positioning of the manual-

ly operable selector switch S. Upon positioning of the switch the selector valve SV is rotated to a corresponding position by the hydraulically operated drive gear and its associated electrical control circuit. The positioning of the selector valve results in the loading of one or a selected combination of a plurality of pumps, the pumps P, P1, P2 and P3 supplying pressure fluid to the hydraulic system to provide a press operating speed corresponding to that selected by the switch system.

While the press is in operation the preset operating speed is automatically maintained by the resetting of the selector valve in accordance with pressure changes in the hydraulic system. Such resetting is effected under control of the relief valve VR acting through the drive gear and its electrical control circuit. Thus, if the pressure in the hydraulic system rises above a predetermined value, fluid blows off through the relief valve and the control switch MJ is opened. When the blowoff of fluid reaches or exceeds a predetermined volume the control switch MK is closed and the drive gear operates to turn the selector valve SV back one step. This unloads a pump and reduces the output of pressure fluid to the system. If the system pressure still remains too high, that is, if the switches MJ and MK remain actuated, the valve is turned back another step and another pump is unloaded to further reduce the pressure. This resetting may be repeated as long as required, until control of pressure is obtained or until all pumps have been unloaded.

If after such resetting of the selector valve the pressure in the system falls sufficiently to allow the relief valve to close, switch MJ is again actuated to cause the drive gear to turn the selector valve ahead one step. This resetting of the valve reloads a pump and correspondingly increases the supply of pressure fluid to the system. Should the relief valve remain closed the selector valve is again stepped ahead and the stepping action may be repeated until the selector valve is positioned as called for by the setting of the selector switch S.

While reference has been made to the loading and unloading of the pumps one at a time, it will be appreciated that the change in pressure fluid output may be effected by loading the pumps in different combinations. This latter mode of operation is preferred when the hydraulic system is equipped with a plurality of pumps of different capacities. It will be understood, of course, that the correct sequence of pump loading and unloading is insured by appropriate connection of the pump unloading valves with the selector valve.

It will be apparent from the foregoing that the invention provides a novel and advantageous control system for hydraulic presses and comparable hydraulic systems in which the pressure fluid is supplied by a plurality of continuously running pumps. Loading of one or more of the pumps to provide a desired press speed is effected quickly and easily by the setting of a manually operable selector switch. Moreover, substantial uniformity of press speed is maintained automatically by pressure responsive valve means which serves to load or unload pumps as required to maintain substantially uniform pressure in the system. The invention provides novel means in the form of a selector valve and power operated driving means therefor by which the setting of the selector valve is effected. In general, therefore, optimum operating conditions are established and maintained in a simple, expeditious manner insuring efficient operation of the press at all times.

We claim as our invention:

1. In a hydraulic system supplied with pressure fluid from a plurality of sources, in combination, an unloading valve individual to each fluid source effective when operated to divert the fluid from the source to exhaust, a multi-position selector valve operatively connected with each of the unloading valves, said selector valve

being settable in selected positions each of which represents a particular number of effective fluid sources, power operated means for moving said selector valve from one position to another, a relief valve in the hydraulic system operative to divert fluid to exhaust when the pressure in the system rises to a predetermined value, and control means operable in response to the flow through the relief valve exceeding a predetermined volume for initiating operation of said power operated means to move said selector valve in a direction to operate an additional unloading valve or valves and reduce the number of effective fluid sources.

2. In a hydraulic system supplied with pressure fluid from a plurality of sources, in combination, an unloading valve individual to each fluid source adapted when operated to divert the fluid from the source to exhaust, a multi-position selector valve operatively connected with the unloading valves, said selector valve being settable in selected positions each of which represents a particular number of effective fluid sources, power operated means for moving said selector valve from one position to another, a relief valve in the hydraulic system operative to divert fluid to exhaust when the pressure in the system rises to a predetermined value, auxiliary valve means connected to receive the fluid diverted by said relief valve and adapted to open varying degrees according to the volume of fluid diverted, and means actuated by said auxiliary valve when the volume of fluid reaches a predetermined value for initiating the operation of said power operated means to move said selector valve in a direction effective to reduce the number of effective fluid sources.

3. In a hydraulic system supplied with pressure fluid from a plurality of sources, in combination, an unloading valve individual to each fluid source adapted when operated to divert the fluid from the source to exhaust, a multi-position selector valve operatively connected with each of the unloading valves, said selector valve being settable in selected positions in each of which it acts to operate a particular combination of unloading valves to determine the number of effective fluid sources, power operated means for moving said selector valve from one position to another, a relief valve in the hydraulic system operative to divert fluid to exhaust when the pressure in the system rises to a predetermined value, control means operable in response to the fluid diverted through the relief valve exceeding a predetermined volume to initiate the operation of said power operated means for moving the selector valve in a direction effective to reduce the number of effective fluid sources, said control means cooperating with other control means actuated by said relief valve when the pressure in the system falls below said predetermined value for initiating operation of said power operated means to move said selector valve in a direction effective to increase the number of effective fluid sources.

4. In a hydraulic system supplied with pressure fluid from a plurality of sources, in combination, an unloading valve individual to each source adapted when operated to divert the fluid from the source to exhaust, a multi-position selector valve operatively connected with each of the unloading valves, said selector valve having a member rotatable to selected positions in each of which it is effective to operate one or a combination of the unloading valves to determine the number of effective fluid sources, drive means for said valve including a ratchet wheel fixed to the rotatable valve member, a bell crank lever having a pawl on one of its arms engageable with the teeth of the ratchet wheel, a link pivoted at one end on a stationary part of the valve gear and pivoted at its other end to the intermediate portion of said bell crank, an actuator connected with the other arm of said bell crank operable to shift the same between a retracted and an advanced position, the pivotal connection between said link and said bell crank being located so that in the

initial movement of said actuator from retracted position the bell crank is rocked about that pivotal connection to engage said pawl with the teeth of the ratchet wheel, further movement of said actuator being operative to rock said link about its pivot and to shift said bell crank body in a direction to impart a rotative step to said ratchet wheel.

5. A hydraulic system as defined in claim 4 in which the selector drive means also includes a second pawl carrying bell crank lever and an actuator positioned to coast with the ratchet wheel and operative to impart step-by-step rotative movement thereto in a direction opposite to that imparted by the first-mentioned pawl carrying bell crank lever.

6. A hydraulic system as defined in claim 4 in which the actuator for the pawl carrying bell crank lever comprises a cylinder with a working piston spring biased to one position and shiftable to an alternate position upon introduction of pressure fluid into the cylinder.

7. A hydraulic system as defined in claim 5 in which the actuators for the pawl carrying bell cranks are pressure fluid operated and in which the operation of the actuators is controlled by a second selector valve.

8. A hydraulic system as defined in claim 7 in which the second selector valve is normally biased to a neutral position to shut off fluid flow to the actuators and is shiftable to either of two operative positions by separate solenoids to direct fluid flow to one or the other of the actuators individually.

9. In a hydraulic system supplied with pressure fluid from a plurality of sources, in combination, an unloading valve individual to each fluid source adapted when operated to divert the fluid from the source to exhaust, a multi-position selector valve operatively connected with each of the unloading valves, said selector valve having a member rotatable to selected positions to determine the number of unloading valves operated, drive means for said selector valve including a ratchet wheel fixed to and rotatable with the valve member, first and second pawl and ratchet mechanisms operative respectively to impart step-by-step rotative movement to said ratchet wheel in opposite directions, a pressure fluid operator for each mechanism, a valve connected to control the operation of said actuators, a first solenoid operative when energized to shift said control valve to a position to initiate the operation of one of said actuators, a second solenoid operative when energized to shift said control valve to a position to initiate the operation of the other of the said actuators, means for establishing an operating circuit for each solenoid including a contact strip mounted on and rotatable with said ratchet wheel, a series of stationary contacts each representative of a particular position of said ratchet wheel, said contacts being arranged for engagement successively by said strips in the rotation of the ratchet wheel, and a manually operative switch adapted to close the circuit through any one of the selected contacts, the solenoid associated with the strip engaging the selected contact being energized to initiate the operation of the associated actuator to rotate said ratchet wheel to the position represented by the selected contact.

10. In a hydraulic system supplied with pressure fluid from a plurality of sources, in combination, an unloading valve individual to each fluid source, adapted when operated to divert the fluid from the source to exhaust, the combination of a multi-position selector valve operatively connected with each of the unloading valves, said selector valve having a member rotatable to selected positions to determine the number of unloading valves operated, drive means for said selector valve including a ratchet wheel fixed to and rotatable with the valve member, first and second pawl and ratchet mechanisms operative respectively to impart step-by-step rotative movement to said ratchet wheel in opposite directions, a pressure fluid operator for each mechanism, a valve connected to

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control the operation of said actuators, a first solenoid operative when energized to shift said control valve to a position to initiate the operation of one of said actuators, a second solenoid operative when energized to shift said control valve to a position to initiate the operation of the other of the said actuators, means for establishing an operating circuit for each solenoid including a contact strip mounted on and rotatable with said ratchet wheel, a series of stationary contacts each representative of a particular position of said ratchet wheel, said contacts being arranged for engagement successively by said strips in the rotation of the ratchet wheel, a manually operative switch adapted to close a circuit through any selected one of the said contacts, the solenoid associated with the strip engaging the selected contact being energized to initiate the operation of the associated actuator to rotate said ratchet wheel to the position represented by the selected contact and a supplementary switch operable to initiate the operation of one of said actuators to step the ratchet wheel away from the position represented by the selected contact.

11. In a hydraulic system supplied with pressure fluid from a plurality of sources, in combination, an unloading valve individual to each fluid source adapted when operated to divert the fluid from the source to exhaust, the combination of a multi-position selector valve operatively connected with each of the unloading valves, said selector valve having a member rotatable to selected positions to determine the number of unloading valves operated, drive means for said valve including a ratchet wheel fixed to and rotatable with the valve member, first and second pawl and ratchet mechanisms operative respectively to impart step-by-step rotative movement to said ratchet wheel in opposite directions, a pressure fluid operator for each mechanism, a valve connected to control the operation of said actuators, a first solenoid operative when energized to shift said control valve to a position to initiate the operation of one of said actuators, a second solenoid operative when energized to shift said control valve to a position to initiate the operation of the other of the said actuators, means for establishing an operating circuit for each solenoid including a contact strip mounted on and rotatable with said ratchet wheel, a series of stationary contacts each representative of a particular position of said ratchet wheel, said contacts being arranged for engagement successively by said strips in the rotation of the ratchet wheel, a switch settable manually to close a circuit through any selected one of said contacts, the solenoid associated with said strip engaging the selected contact being energized to initiate the operation of the associated actuator to rotate said ratchet wheel to the position represented by the selected contact, and a switch operable when the pressure in the system exceeds a predetermined value for initiating operation of one of said actuators to impart a step to the ratchet wheel effective to position said valve for reducing the number of unloading valves operated.

12. In a hydraulic system having a plurality of fluid sources supplying fluid under pressure to a common supply line and an individual unloading valve associated with each fluid source adapted when operated to direct the fluid from the source to exhaust, a control system including a selector valve operatively connected with each of the unloading valves and rotatable to different positions to operate said unloading valves in different combinations, power operated means for rotating said selector valve step-by-step, a control circuit including a manually operable selector switch having a plurality of positions corre-

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sponding to the positions of said selector valve, said control circuit being operative upon the setting of the switch in a selected position for initiating operation of said drive mechanism to rotate said valve to a corresponding position, valve means responsive to the pressure in said supply line, and switch means actuated by said valve means for initiating the operation of said drive mechanism to shift said valve from its set position to a new position when the pressure in the line varies from a predetermined value.

13. In a hydraulic system having a plurality of fluid sources supplying fluid under pressure to a common supply line and an individual unloading valve associated with each fluid source adapted when operated to direct the fluid from the source to exhaust, a control system including a selector valve operatively connected with each of the unloading valves and rotatable to different positions to operate said unloading valves in different combinations, power operated means for rotating said selector valve step-by-step, a control circuit including a manually operable selector switch having a plurality of positions corresponding to the positions of said selector valve, said control circuit being operative upon the setting of the switch in a selected position for initiating operation of said drive mechanism to rotate said valve to a corresponding position, a relief valve connected to said supply line operative to divert fluid from the line to exhaust when the pressure exceeds a predetermined value, and means including a switch actuated when the volume of fluid diverted by said relief valve exceeds a predetermined value for initiating the operation of said drive mechanism to shift said valve in a direction to increase the number of unloading valves operated.

14. In a hydraulic system having a plurality of fluid sources supplying fluid under pressure to a common supply line and an individual unloading valve associated with each fluid source adapted when operated to direct the fluid from the source to exhaust, a control system including a selector valve operatively connected with each of the unloading valves and rotatable to different positions to operate said valves in different combinations, power operated means for rotating said valve step-by-step, a control circuit including a manually operable selector switch having a plurality of positions corresponding to the positions of said valve, said control circuit being operative upon the setting of the switch in a selected position for initiating operation of said drive mechanism to rotate said valve to a corresponding position, a pressure responsive valve connected to said supply line operative upon a predetermined pressure rise in the line for initiating the operation of said drive mechanism to shift said valve in a direction to increase the number of unloading valves operated.

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