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D. FIRTH ETAL

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OPERATION OF HYDRAULIC PRESSES

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2 Sheets-Sheet 1

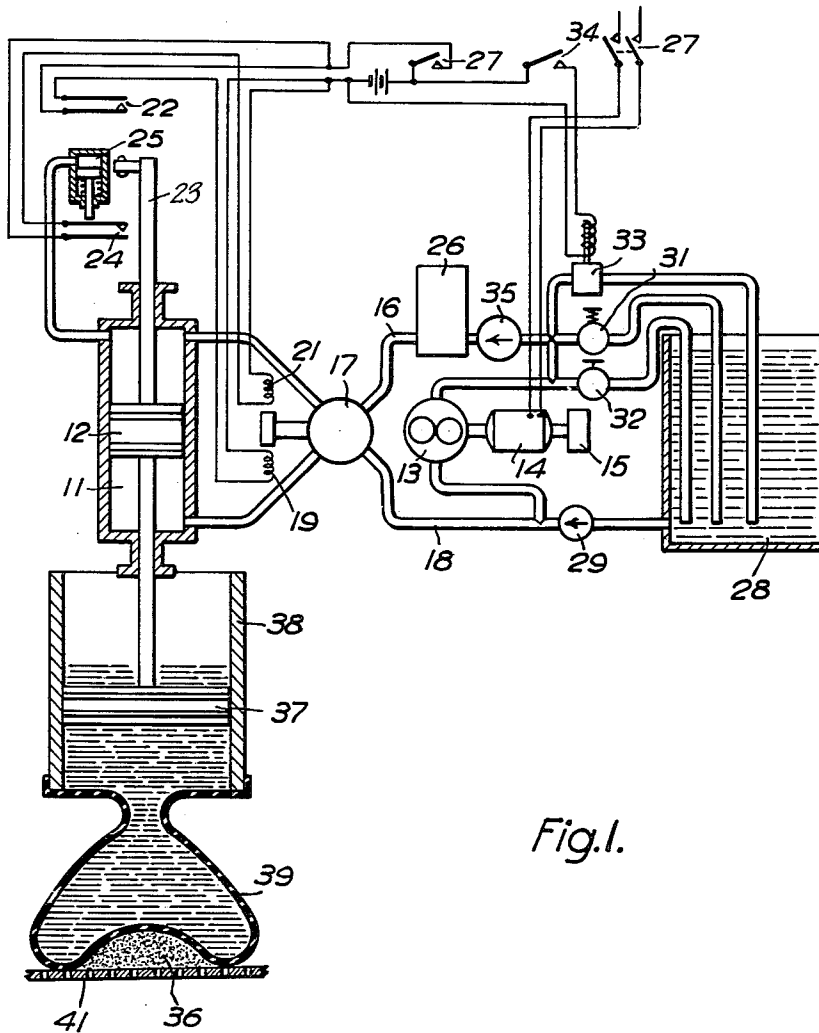


Fig. 1.

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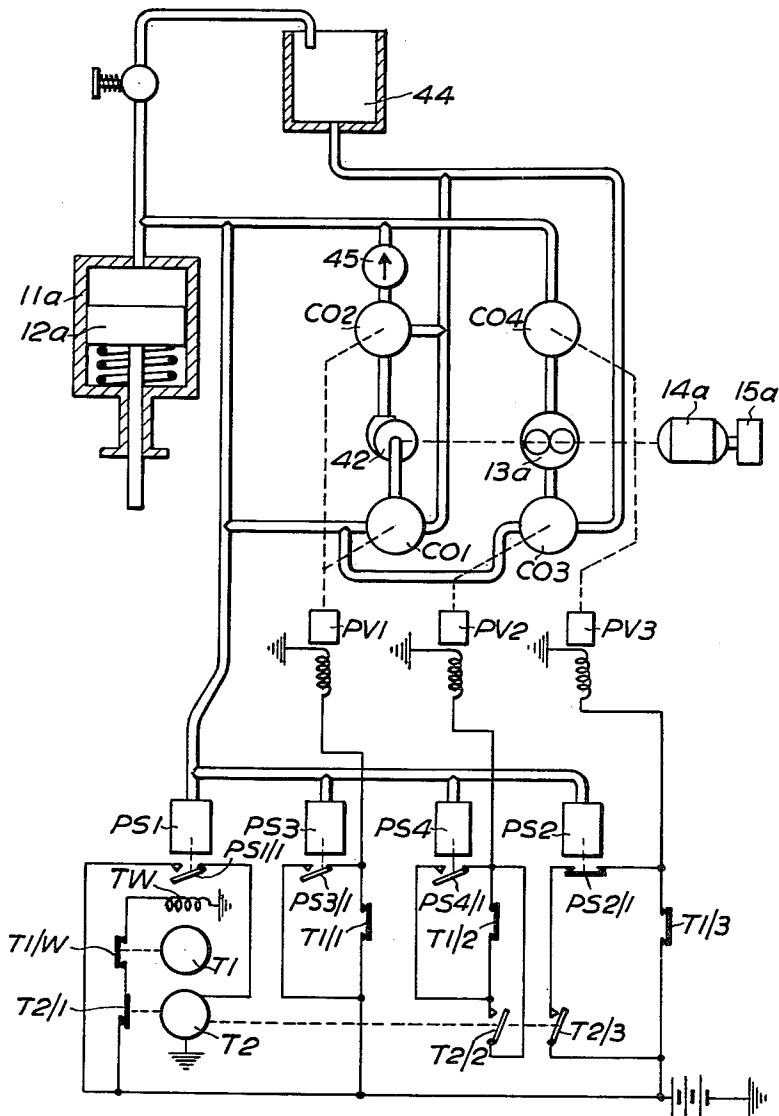


Fig. 2.

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OPERATION OF HYDRAULIC PRESSES

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1 Claim. (Cl. 60—52)

In the operation of hydraulic presses there is often a considerable amount of strain energy stored in the work piece and to a lesser extent in the elements of the press itself at the end of the power stroke. This is especially so when the work piece is highly resilient for example a mass of wool out of which moisture is being squeezed, or a rubber die.

An object of the invention is to recover a substantial proportion of this strain energy. By so doing the running cost is reduced and at the same time the size of the driving motor is reduced and the complete hydraulic circuit is simplified thus reducing the capital cost.

According to the invention a double acting press is used, a pump of a character which can act as a motor, a main driving motor having provision for the storage of kinetic energy and a change over valve which changes over the connections from opposite ends of the cylinder to the supply and return lines when the movement of the press piston is to be reversed.

In the case of a resilient work piece the reaction of the workpiece rises in value from the beginning of the stroke and in many cases rises at a low rate for a great part of the stroke. Thus the supply of pressure fluid only needs to be under comparatively low pressure for a great part of the stroke. It therefore becomes possible to use two pumps one which develops the low pressure in the main part of the stroke and the other which develops the high pressure for the final squeeze.

A further object of the invention is to provide for the possibility of using two pumps in this way while keeping the control arrangements simple and in particular avoiding multiplication of hydraulic power controlling valves. To this end a centrifugal pump is used as the first pump, this having the advantage that it simply stalls when the pressure against which it is working reaches a certain value dependent on the parameters of the pump and associated equipment and thereafter does not constitute a load except for the very small windage losses in the pump. Accordingly this pump can continue running during the whole operation and no hydraulic power controlling valves are needed to switch this pump out of circuit. The two pumps may be hydraulically in parallel, a non-return valve on the outlet side of the centrifugal pump preventing by-passing through it when it has stalled.

The invention will be further described with reference to the accompanying drawings in which FIGURE 1 is a diagram of a layout of an installation according to the invention using only a single pump and FIGURE 2 is a diagram of a layout of an installation according to the invention using two pumps.

Referring to FIGURE 1 a double acting press is represented by a cylinder 11 and water sealed piston 12. The supply of liquid under pressure is obtained from a hydraulic pump 13 which is capable of acting as a motor if supplied with liquid under pressure. Various types of pumps are able to do this and one well known and convenient type is the Deri-sine pump and another is a gear wheel pump. The pump may comprise more than one stage in parallel or series and the liquid used may be oil.

The pump 13 is driven from a motor 14 which is of a type capable of storing kinetic energy. A suitable form

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of driving motor is an electric motor and if the inertia of its rotor is insufficient for the purpose in view, it can be supplemented by a fly-wheel indicated at 15.

The power stroke of the press is assumed to be downwards. During this stroke liquid under pressure from the pump 13 passes through a line 16 and a change over valve 17 to the upper end of the cylinder 11 while the cylinder space beneath the piston 12 is connected through the change over valve 17 to a return line 18. In this way the liquid from lower end of the cylinder 11 is discharged without any substantial resistance being imposed.

For the return stroke the change over valve 17 is changed over so as to connect the upper end of the cylinder 11 to the return line 18 and the lower end of the cylinder 11 to the supply line 16 but during the return stroke as well as the supply from the pump being connected to the under side of the piston 12 the stored up strain energy of the work piece and to a lesser extent in the parts of the press also reacts on the piston 11 speeding up the return movement. As soon as this speed is sufficient to overtake the rate of supply from the pump the liquid thus displaced in the upper end of the cylinder 11 and through the return line 18 causes the pump to act as a motor and the energy thus converted into kinetic energy is stored up in the driving motor 14 so that it is available in the next power stroke.

It will be understood that the main driving motor supplies the net energy consumption but it only needs to have a power rating corresponding to the average power required. During the power stroke the energy supply is supplemented from the kinetic energy previously stored up so that the driving motor slows down while during the return stroke the driving motor speeds up thus increasing its store of energy. The change over of the valve 17 may be effected electrically as indicated by windings 19, 21, which can, as shown, change the valve over directly or they could control a pilot valve which does this as in FIGURE 2. The winding 19 which effects the change over at the end of the return stroke can readily be controlled by contacts 22 directly operated from the piston rod 23. The contacts 24 controlling the other winding 21 which operates at the end of the power stroke are preferably actuated by a pressure responsive device indicated at 25 so that the contacts will be closed when a certain pressure is used irrespective of the position of the piston 12. A mechanical actuation of the contacts 24 from the piston rod 23 is also provided however, so that the change over will be effected if the piston reaches the end of the permissible stroke before the pressure for which the device 25 is set is reached. In some cases the pressure operated device can be omitted, for instance where it is certain that the pump can supply sufficient pressure to ensure that the piston 12 always makes its full stroke. Manual switches 27 in the supplies to the contacts and to the motor 14 enable operation of the press to be stopped at any time.

A pressure accumulator indicated at 26 which may be air loaded or mechanically loaded, may be provided to smooth out fluctuations in pressure. The closed hydraulic circuit above described does not allow for leakage or various other well known contingencies in hydraulic apparatus. To provide for these the system is shown supplemented by a reservoir 28 with which the return line 18 communicates enabling the pump to draw from it. A non-return valve 29 is then necessary to ensure that the return flow from the upper end of the cylinder 11 passes through the pump 13 as above described. A pressure release valve 31 controls a line from the pressure side of the pump 13 back to the reservoir to limit the maximum pressure which can be developed in the system. A manually controlled unloading valve 32 enables the pressure side of the pump to be relieved for instance when

starting up or at other times. There may also be an electrically controlled unloading valve 33 which enables the operation of the press to be interrupted by appropriate control at any time whilst the pump is kept in operation. By way of example a switch is shown at 34 for operating the valve 33. Still further there may be a non-return valve 35 in the pressure line which enables the press piston to be held under pressure with the pump relieved of load.

If the above mentioned non-return valve 35 in the pressure line and electrically controlled unloading valve 33 are provided it becomes possible by using a pressure cut out or timing devices as in FIGURE 2, either electrically or hydraulically operated, to provide a dwell during the power stroke. Further by the use of dwells or sequence controls the operation of the press can be conveniently fitted into an automatic sequence with other operations. Such provision has an influence on the necessary power rating of the motor and the inertia of the parts in which the kinetic energy is stored.

The piston rod 23 of the press may act on the workpiece in any suitable way according to its nature. For example in the case of the squeezing of moisture out of a mass of wool 36, it may displace a single acting piston 37 in a further hydraulic cylinder 38 charged with water and the outer end of which is closed by the known device of a flexible bag 39 of rubber or other suitable material, the mass of wool 36 being placed between the bottom of the bag and a perforated platen 41. Such a bag moulds itself to the shape of the mass of wool and efficiently squeezes the moisture out of it.

Referring now to FIGURE 2 this shows the use of a centrifugal pump 42 to supply liquid during the first part of the stroke of the hydraulic piston and it also shows control means for providing complete automatic sequence with a dwell at the end of the power stroke and also an interval at the end of the return stroke for the purpose of changing the work piece. Those parts which correspond with the parts used in FIGURE 1 have been given the same reference numbers with the suffix *a* and insofar as their function is the same they need not be described again. However in this example there is a fluid connection only to the upper end of the cylinder 11a and negative pressure is employed to complete the return stroke. To make this possible, in the vertical arrangement shown, the weight of the piston 12a and parts attached thereto is balanced by a spring beneath the piston.

The input side of the centrifugal pump 42 through a first changeover valve CO1 can draw either from a header tank 44 or from the upper end of the cylinder 11a. The centrifugal pump 42 discharges through a second changeover valve CO2 which connects it either to the header tank 44 or through a non-return valve 45 to the upper end of the cylinder 11a. Similarly the positive displacement pump 13a can draw through a third changeover valve CO3 either from the header tank 44 or from the upper end of the cylinder 11a while its output can be supplied through a fourth changeover valve CO4 either to the header tank 44 or to the upper end of the cylinder 11a. The changeover valves could be directly operated as in FIGURE 1 but are more conveniently operated by pilot valves which are solenoid operated under the control of timers and pressure actuated switches operated by the pressure in the cylinder 11a as will be described. The first and second changeover valves CO1, CO2 may be as shown operated by a common pilot valve PV1 because they both always need to change over at the same time, though if more convenient separate pilot valves may be used. The third and fourth changeover valves CO3, CO4 have respective pilot valves PV2, PV3 because these changeover valves do not always change over at the same time.

Two timers T1 and T2 are provided. The first T1 when triggered closes a contact T1/w in the circuit of a winding TW which when excited closes three contacts

T1/1, T1/2 and T1/3 which are in the circuits respectively of the solenoids of the three pilot valves PV1, PV2 and PV3. This timer T1 when triggered holds the contact T1/w closed for a predetermined period. The second timer T2 when triggered opens a contact T2/1 in the supply controlled by the contact T1/w and it closes two contacts, one in parallel with the contact T1/2 and the other T2/3 connected as will be described.

Four pressure operated switches PS1, PS2, PS3 PS4 are provided. The first of these PS1 holds its contact PS1/1 open until the maximum pressure required, say 450 lbs. per sq. inch is reached whereupon it closes and serves to trigger the second timer T2. The second, PS2 is a differential switch which has its contact PS2/1 open at maximum pressure but closes it at a somewhat lower pressure, for example 400 lbs. per sq. inch. Its contact PS2/1 is in series with the contact T2/3 in a connection in parallel with the contact T1/3. The third PS3 closes its contact PS3/1 which is in parallel with the contact T1/1, at the stalling pressure of the centrifugal pump 42, for example 28 lbs. per sq. inch. The fourth, PS4 has its contact PS4/1 which is in parallel with the contacts T1/2 and T2/2, open at pressures above zero (atmospheric) but closes it at and below this pressure.

Operation, FIG. 2 Modification

For convenience the cycle may be described from the instant of triggering the timer T1 by an impulse derived as will be described later. At this instant the pressure in cylinder 11a is at slightly negative (subatmospheric value) and the piston 12a is fully or nearly fully retracted. The contact T1/w is open and consequently the contacts T1/1, T1/2 and T1/3 are also open. The timer T2 is in its centrifugal or released condition so that the contact T2/1 is closed and the contacts T2/2 and T2/3 are open. The contact PS1/1 is open, the contact PS2/1 is closed, the contact PS3/1 is open and the contact PS4/1 is closed. From this instant the timer T1 provides a delay period A before closing the contact T1/w. The period is made sufficient for completion of retraction of the piston 12a if necessary and for removing a workpiece and replacing it, a period of say three seconds if the workpieces are on a conveyor. At the end of the delay period the contact T1/w is closed and the contact T2/1 is also in the closed condition, winding TW is energised, the contacts T1/1, T1/2 and T1/3 are closed and the solenoids of all three pilot valves are therefore energised and under these conditions the changeover valves are set so that both pumps 13a, 42 are pumping fluid from header tank 44 towards the cylinder 11a, and the power stroke is commenced (period B). As soon as the negative pressure has disappeared, contact PS4/1 closes and the circuit is in the condition shown in FIGURE 2. PS2/1 is closed and the contacts PS3/1 as well as PS4/1 are open at this time, without affecting the operations just described.

As the reaction of the load rises, so does the pressure in the cylinder 11a. When the stalling pressure of the centrifugal pump 42 is reached the contact PS3/1 closes but as the solenoid of pilot valve PV1 is already energised through contact T1/1 there is no change in the position of the changeover valves. The centrifugal pump simply stalls and though the valves CO1, CO2 on each side of it remain in the same position, this pump simply continues to rotate without delivering any liquid. Up to this point however the bulk of the liquid has been delivered by this pump and the piston 12a has moved comparatively rapidly on the power stroke.

After the centrifugal pump 42 has stalled the positive displacement pump 13a continues the supply at a lower rate but with the pressure increasing and when the pressure for which the first pressure operated switch PS1 is set, is reached, this switch PS1 closes. This switch initiates a dwell period C by triggering the second timer T2 which by opening the contact T2/1 de-energizes winding

TW and causes all three contacts T1/1, T1/2 and T1/3 to open. However, as contact T2/2 is closed at the same time and contact PS3/1 had already closed at the stalling pressure of pump 42, the solenoids of pilot valves PV1 and PV2 remain energised, leaving the changeover valves CO1, CO2 and CO3 unchanged. But since at this pressure contact PS2/1 is also open, although the contact T2/3 has also just been closed by the timer T2, the solenoid of pilot valve PV3 is de-energised and the valve CO4 therefore changes over, so unloading the pump 13a by connecting its outlet side to the header tank 44. Under these conditions the pressure in the cylinder 11a will tend to fall and when it has dropped by the predetermined amount this switch PS2 again closes the contact PS2 through the pilot valve PV3 causing the fourth changeover valve CO4 to change over again so that the pump 13a is brought into action and the pressure again rises until the switch PS2 reopens which will be before top pressure is reached. This alternation continues during the dwell period C, say 15 seconds, determined by the second timer T2 and over this period the pressure in the hydraulic cylinder 11a is maintained within the limits at which the switch PS2 opens and closes e.g. between 400 lbs. and something like 450 lbs. per square inch. To avoid too frequent opening and closing of the switch PS2, a reasonable difference between the pressure at which it closes and that which must be reached before it reopens must be allowed, say 40 lbs. per square inch.

Provided the switch PS2 reopens before the pressure reaches the top value the switch PS1 will not be actuated again during the dwell period C. The timer T1 should be set so that it remains as originally triggered until some instant within the period C. The period B is itself not determined by timing but by pressure rise, but in practice it will be a good deal shorter than the period C and there is no difficulty in ensuring that the timer T1 remains as triggered until well into period C and its release before period C ends. When it so releases, it opens contact T1/w.

At the end of this period C the second timer T2 returns to its released or untriggered position in which contact T2/1 recloses and contacts T2/2 and T2/3 reopen. The closing of T2/1 has no effect because contact T1/w is already open. As the contacts PS4/1, T1/2 and T1/3 are already open, opening of contacts T2/2 and T2/3 cause the solenoids of both pilot valves PV2, PV3 to be de-energised even if the contact PS2/1 should happen to be closed at this instant. Accordingly the changeover valves CO3, CO4 move to the position in which the intake side of the positive displacement pump 13a is connected to the upper end of the hydraulic cylinder 11a and the outlet side of the header tank 44. The piston 12a under the elastic recovery of the load now commences its return stroke and displaces liquid through the pump 13a which is thus driven as a motor and the energy which is thereby converted into kinetic energy is stored in the rotor or fly-wheel 15a of the motor 14a.

During this part of the return stroke, period D, while the pressure in the cylinder 11a is still above the delivery pressure of the centrifugal pump and the pump remains stalled, the contact PS3/1 remains closed, the solenoid of the pilot valve PV1 remains energised and the change

over valves CO1, CO2 remain as previously set. When the pressure drops to this value however, the third pressure operated switch opens its contact PS3/1 and as the contact T1/1 is also open, this opens the circuit of the solenoid of the first pilot valve PV1 thus changing over the valves CO1, CO2 and reconnecting the centrifugal pump 42 in such a direction that it pumps liquid away from the cylinder 11a and back into the header tank 44, during a further period E. During this further period E the circuits of the solenoids of the two pilot valves PV2 and PV3 remain open just as during the period C so that the pump 13a continues pumping from the cylinder 11a to the tank 44.

When the pressure reaches zero (atmospheric value) contact PS4/1 of the fourth pressure operated switch PS4 closes the circuit of the solenoid of the second pilot valve PV2 thereby causing the third change over valve CO3 to reconnect the inlet side of the pump 13a to the header tank thus unloading the positive displacement pump so as to avoid operation of this pump at negative pressure. The centrifugal pump continues to operate however at sufficient negative pressure to return the piston 12a completely to the starting position, period F, and at a convenient point the first timer T1 is brought into action to recommence the cycle at the beginning of period A. This timer T1 may be triggered mechanically by the return of the piston 12a to its starting point or it may be triggered by the fourth pressure operated switch PS4 when this responds to a negative pressure.

It should be explained that for simplicity FIG. 2 assumes an earth return for all the circuits and a single source of supply for all the switches. As will be understood by those skilled in the art this is not essential. Also direct switching is indicated whereas it may be desirable to employ relays or other similar devices of a known character. No details are given of the mechanical construction because all the elements are in themselves of well known kind.

We claim:

Hydraulic pressure apparatus for exerting pressure on a resilient workpiece comprising a hydraulic cylinder and piston, liquid for operating the apparatus, a pump for supplying pressurized liquid to the cylinder, said pump acting as a motor under return flow of said liquid, a main driving motor driving said pump and having provision for the storage of kinetic energy, and means for controlling liquid flow between the cylinder and the pump whereby after the pressure stroke, under the resilient recovery of a workpiece, the liquid is returned from the cylinder through the pump to cause it to act as a motor rotating in the same direction as the main driving motor on the pressure stroke and thereafter the return stroke is completed.

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