Feb. 2, 1960 O. A. WHEELON 2,923,130

HIGH SPEED HYDRAULIC PRESS SYSTEM AND METHOD

Filed Sept. 26, 1955 2 Sheets-Sheet 1

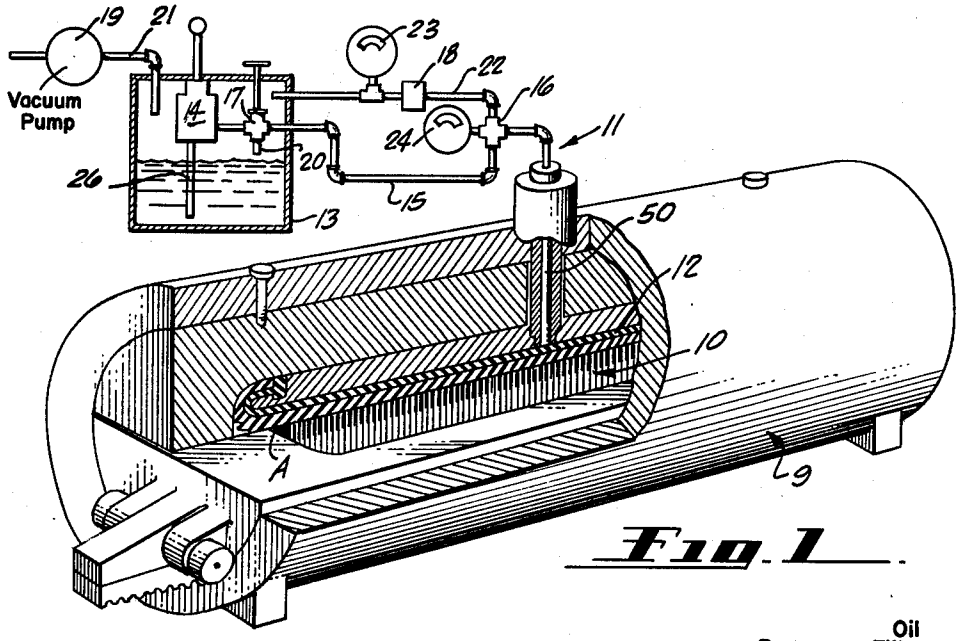

Fig. 1

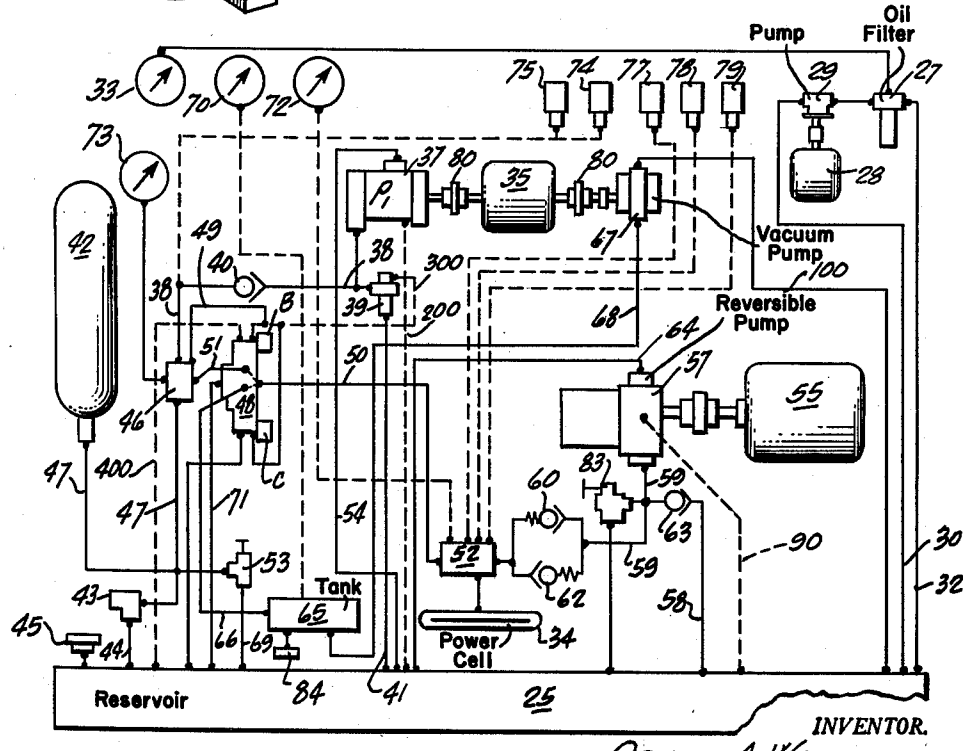

Fig. 2

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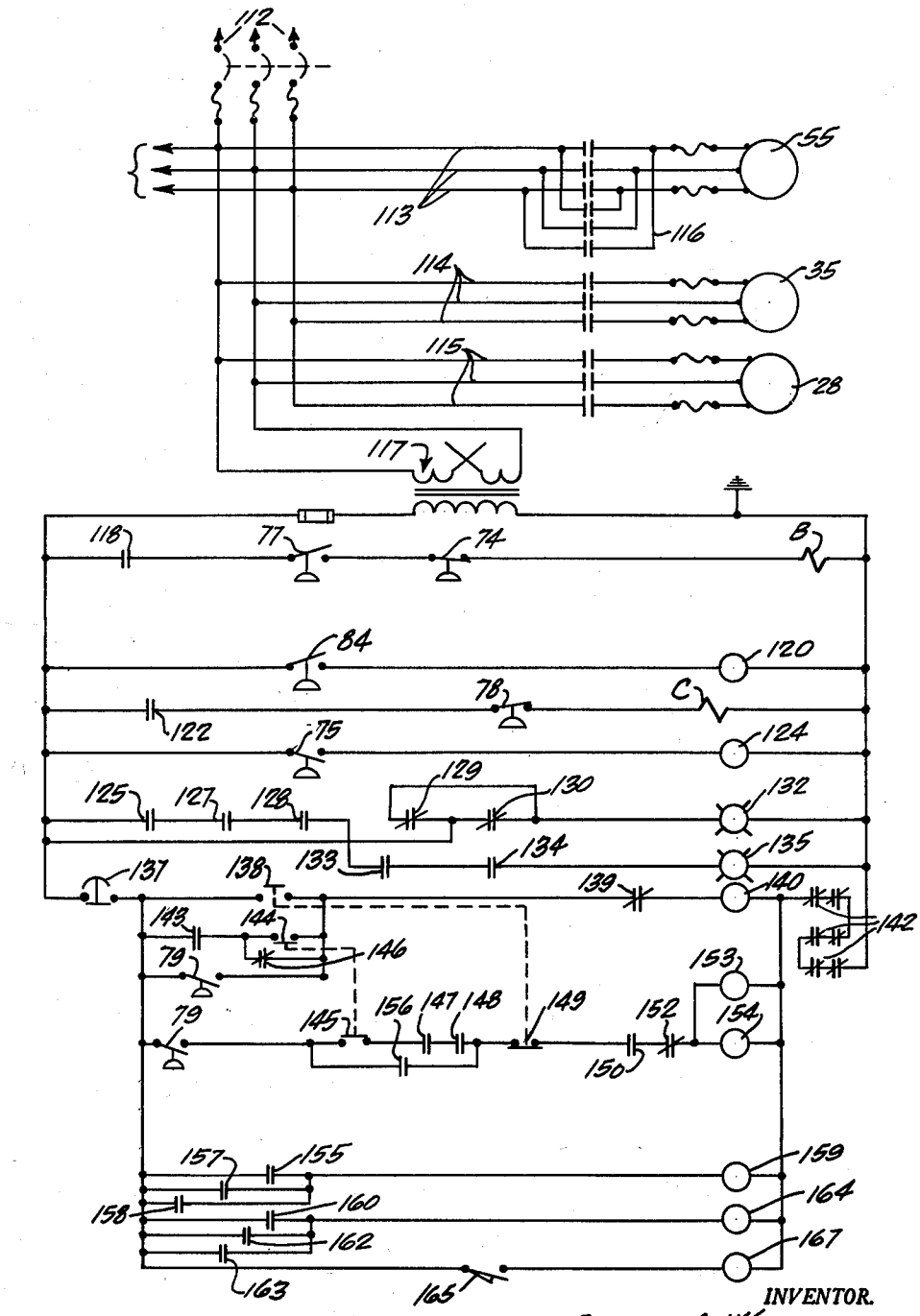

Fig. 2.

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2,923,130

HIGH SPEED HYDRAULIC PRESS SYSTEM AND METHOD

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Application September 26, 1955, Serial No. 536,384

5 Claims. (Cl. 60—51)

This invention relates to hydraulic presses of the diaphragm type.

Such presses generally include an open-ended shell enclosing a work-carrying tray slidable into and out of the shell through the open end; a material-working diaphragm mounted superadjacent to, and coextensive with, the tray, and means mounted in the shell superadjacent the diaphragm for urging it workingly against the workable material in the tray, the latter being disposed in the shell operatively subadjacent the diaphragm.

The means for powering the diaphragm usually consists of, or includes a resilient-elastic bag arranged confrontingly to the upper face of the diaphragm and adapted to be hydraulically expanded against same so as to power the diaphragm against the work.

The initial supplying of pressure fluid to this bag, for the purpose of first causing the bag and diaphragm to merely fill out to the confines of the working chamber, as well as the subsequent "powering" of the bag, are usually accomplished by a reversible-rotation pump connected to the bag, the reverse action of this pump serving, in combination with a throttle-valve, to release the powering-pressure from the bag preparatory to its evacuation at the end of the bag's cycle.

Subsequent to this release, the contents of the bag are removed by the direct, but necessarily slow, action of a vacuum pump connected directly thereto.

Among these imperfections, this mode of cycling the press falls somewhat short of the rapidity demanded of metal-working presses in the modern large-scale, highly competitive sheet metal working industries. By way of example, the most rapid cycle currently achievable by contemporary diaphragm presses is of the order of 40 secs., which, being somewhat longer than that of the conventional quick-retraction ram type press, has apparently militated against the widespread adoption, to date, of the diaphragm type press.

In contemporary diaphragm presses, further, all proposals to elevate the working pressure much above 5000 p.s.i. have come to grief on the fact, among others, that in addition to the aforementioned reversible pump, it has been deemed necessary to provide a number of other pressure-pumps in order to apply to the bag, after its volumetric filling, that incremental pressure necessary to raise its total pressure to the desired final magnitude, which may be as high as 10,000 p.s.i., thereby to cause the powered bag to force the diaphragm formingly against the work in the subadjacent tray.

A large amount of time is consumed by this initial phase of the cycle if elevated pressures are to be approached, since the initial-filling step is necessarily in such proposals, slow and gradual, and it is followed by a somewhat more rapid but still time-consuming "powering" pressure applied by the reversible pump, onto which time-period must be appended the "booster" pump's time consumption.

There are, of course, certain other, perhaps not so consequential, deficiencies in current diaphragm press

hydraulic systems, which imperfections will either become apparent, or be made manifest, hereinafter, in disclosing how they are remedied.

In ameliorating these situations, the present invention, in its most comprehensive species, accomplishes the low-pressure volumetric-filling of the bag and diaphragm to all the boundary-surfaces of the working chamber by means of the rather sudden discharge into the bag of a pre-segregated supply of properly pressurized fluid, instead of employing the gradual volumetric filling previously achieved by the reversible pump. In one mode of executing this concept, an accumulator is employed for the initial-filling portion of the fluid, and this accumulator is continually maintained filled, or, if desired, is recharged after each discharge into the bag, by means of a special accumulator filling and recharging system. At a suitable juncture in the initial phase of the bag's cycle, therefore, the accumulator automatically fills the bag with fluid at a pressure of the order of 500 p.s.i. An intensifier pump is provided and is also adapted to be connected to the bag at a suitable subsequent juncture to effect the "powering" phase of the operation of the bag, thereby to actuate the diaphragm.

By means of this sub-combination, the final operating, or powering, pressure of the bag can easily be elevated to the order of 10,000 p.s.i. in a very short time.

The length of the press' cycle is still further reduced by means for emptying the bag automatically, and with the maximum possible rapidity, at the end of the cycle. Preferably, this concept is executed by means of a pre-established vacuum maintained in a vacuum-enclosure ready to be automatically connected to the bag instantly upon the release of the working-pressure therefrom, as aforementioned. The vacuum enclosure is maintained at as near a "perfect" vacuum as is feasible by means of a substantially continuously running vacuum pump connected to this enclosure. It is also within the purview of this invention to connect the opposite "side" of the enclosure to the atmospheric reservoir for the pressure fluid.

By this system, the duration of an operating cycle of the press is reduced from the previous 40 secs. or longer, to an average of the order of 7 secs.

In a less comprehensive species of the invention, the accumulator and its charging and re-charging pump are dispensed with, as well as the "booster," or intensifier pump and the reversible-pump of the previous practice is employed to both fill-out the bag; to "power" it; and in cooperation with a throttle valve, to release the powering pressure. Hence, although the cycle is not reduced to a duration of 7 seconds, as above, it can be reduced well below that of other diaphragm presses by retention of means, as before, for automatically emptying the bag rapidly at the end of the cycle. Here, again, a pre-established vacuum is maintained in a vacuum enclosure, which is cut-in to the bag's exhaust circuit at the end of the cycle. The enclosure is retained at a fairly high vacuum, as before.

Other advances in this art achieved by subject invention will be made manifest as this disclosure proceeds.

Mainly in order to further clarify these and other objectives as well as to render the nature and accomplishments of the invention more concrete, two typical examples of the many specific modes in which the invention may be embodied are representationally depicted in the accompanying drawings and will be described in detail hereinafter in conjunction with these drawings. It is to be appreciated, however, that such drawings and said description do not specifically constitute the invention nor in any wise limit the nature and slope thereof except as required by the appended claims defining the essential

principles of the invention in terms of configurations of minimum essential components.

In these drawings,

Fig. 1 is a view of a typical form of the press, partly in perspective and partly in longitudinal fragmentary section, and also showing the simpler form of the hydraulic system diagrammatically;

Fig. 2 is a diagrammatic view of the preferred form of hydraulic system; and

Fig. 3 is a schematic showing of the electrical operating and control system for the system shown in Fig. 2.

The diaphragm-type press "plant" depicted in Fig. 1 comprises, comprehensively, a press **9** including a working chamber **10** in the upper portion of which is mounted an expansible powering fluid-cell **12**, in turn energized by a hydraulic system **11** that embodies the general concepts of this invention.

System **11** comprises a dual nature pressure fluid reservoir-and-vacuum tank **13**. For the purpose of filling out the cell, or "bag," **12** and thereby forcibly urging the diaphragm or pad A against the work in the dropped center tray therebeneath, container **13**, which is airtight, includes a hand or motor operated pump **14** mounted therein and adapted to pump the fluid content of **13** into the bag. This pump, which has a stand-pipe or supply conduit **26** extending to a point near the bottom of tank **13**, can be operated to fill the bag, in a first phase of the cycling, to a pressure of the order of 200–500 p.s.i., which is sufficient to distend the bag and diaphragm against the walls of the working chamber and to force the diaphragm lightly against the work and, in a second phase, at pressure of the order of 1000 p.s.i. or higher, to force the pad formingly against the work piece to give it a final shape.

From pump **14** a pressure-fluid conductor **15** extends, via a 4-way fitting **16**, to the bag. Conduit **15** communicates with a fluid-pressure gage **24** connected to the four-way fitting and this conduit also incorporates a two-way globe, or other, valve **17** mounted in the container with an operating wheel or handle protruding therefrom. The two-way valve **17** discharges downwardly through a conduit **20** when the handle of the valve is properly so adjusted as to bypass the output of pump **14**. Normally, valve **17** is so adjusted as to direct fluid from **14** onwardly through conduit **15** to the bag.

Subsequent to the aforestated "volumetric," or distention, filling of the bag, the pump **14** is further rapidly operated to "power" the bag against the diaphragm, at a pressure of the order of 1000 p.s.i. or higher, as required for the work being performed, in order to cause the diaphragm to forcibly form the sheet material carried in the tray, that is, in the working chamber, around or on the form blocks on which the sheet material is mounted.

Another conduit **22** leads from the four-way fitting **16** to the container and includes a relief valve **18** which is normally closed, but is adapted to spring open if the pressure worked up by the pump in line **15** exceeds a predetermined optimum. Valve **18** may hence well consist of or include a spring-loaded ball normally seated to the right in the valve casing, but overcomable to leftward under the vacuum acting on its left face and the excessive pressure on its right face.

These actions terminate the working, or pressure, phase and the evacuation phase of the press' cycle. This latter phase, by removing the pressure-fluid from the bag, enables or effectuates the withdrawal of the diaphragm and bag to the upper portion of the working chamber to permit the tray to be withdrawn, with the finished work, from the working chamber, allowing the excess pressure fluid to back-track, as it were, through conduit **22**, which includes a vacuum gage **23**.

In order to maintain that vacuum in container **13** which is necessary to effect rapid evacuation of the bag to terminate a cycle, a vacuum pump **19** and a suction conduit **21** are provided, the latter opening into container **13**. Pump **19** is driven substantially continuously by motor means, not shown, but of the conventional nature. This primer, or vacuum pump maintains a vacuum in the space above the liquid level, the vacuum not being of a great magnitude, however, but which vacuum is sufficient to effectuate rapid displacement of the contents of the bag.

When the bag has been powered to the optimum pressure, the pump, to do so, acting against the partial vacuum in chamber **13** to pressurize the bag, any excess fluid back-tracking through conduit **22**, the relief valve **18** remaining closed, container **13** now contains only a small amount of reserve fluid. The pump **14** being quiescent, the two-way valve **17** is now opened to establish a passage through pipe **20** into the now vacuumized chamber **13**. Thereupon, the contents of the bag are evacuated therefrom into chamber **13** rather rapidly, conditioning the system for initiating the next cycle.

Although the pump **14** must be operated against a partial, or low-magnitude vacuum, the standpipe **26** of the pump extends nearly to the bottom of container **13** and this pump operates on the displacement principle so that it overcomes the negative effect of the vacuum on the fluid contents of container **13**.

In Fig. 2 there is representationally shown a hydraulic system for the rapid initial-filling (low pressure, "volumetric," distention), the subsequent "powering," and the rapid evacuation, of the fluid-powering cell which rather substantially shortens the operating cycle of high-pressure hydraulic diaphragm presses from a time-period heretofore of the order of 40 seconds to a time period not greater than of the order of 7 seconds. That is, from the time the initial pressure is applied in the system to the time when the cell is empty, a period of about 7 seconds elapses.

To these and other ends, this system includes an atmospheric reservoir **25** for filtered pressure-fluid, the filtering being continually accomplished by means such as a conventional oil filter **27** through which an electromotor **28** and pump **29** force oil drawn from **25**, via a conduit **30**, the filtered oil being returned to the reservoir by a return conduit **32**. The filter is connected, by a conduit as shown, to a filter pressure gage **33** provided for surveillance of the filter's operation.

Here, as in the foregoing species, a diaphragm press of the type shown in Fig. 1 is contemplated as being operated by a novel hydraulic system, and it includes, in its working chamber, a resilient-elastic, fluid expansible "powering cell," **34**, as before. This cell is "loaded" by the pressure fluid in two stages of operation, a first, or volumetric, filling out of the bag to make it occupy the working chamber of the press and contact all walls thereof and to make the diaphragm contact with the tray and its contents; and a second, "powering" or working action. The first action is rapidly accomplished by rapid unloading of a pressure fluid accumulator system (later described) into the bag at a relatively low pressure of the order of not over 500 p.s.i., and the second action is achieved by the direct pumping into the distended bag of additional pressure fluid at a pressure as high as 10,000 p.s.i., if desired, although 5200 p.s.i. is usually sufficient.

The accumulator is provided with a pressure gage **73** and is charged and re-charged by means of an electromotor **35** driving a pressure pump **37**, the intake of which is connected by conduit **54** to the reservoir **25** and discharging toward the accumulator through a conduit **38**, an unloader valve **39** being connected in parallel to line **38** and connected to reservoir **25** by a conduit **41** in order to prevent overpressurization of accumulator **42**. Valve **39** operates when and if the pressure output of pump **37** exceeds a predetermined value, say, 500 p.s.i., and in order to relieve pump **37** and valve **39** of back

pressure or surges from the accumulator, a check valve 40 is provided in line 38 as shown.

The accumulator 42 is maintained charged with fluid at 300–500 p.s.i. and to maintain these limits, a relief valve 43 is shunted in the accumulator conduitry and is connected to reservoir 25 by a conduit 44.

Reservoir 25 is maintained at atmospheric pressure by means of an air-filtering air inlet unit 45.

A dual-function fill-and-discharge line 47 is connected to the accumulator and includes a T-fitting 46, from which one conduit 49 leads to a three-way, three-position, twin-solenoid pilot operated valve 48 and thence toward bag 34. Valve 48 is one of the well-known, conventional Oilgear Company's 3-way, 3-position, double solenoid pilot operated valves in which when solenoid B is energized, line 50 is connected to line 66 and line 51 is blocked. When solenoid C is energized, line 50 is connected to line 51 and line 66 is blocked.

Line 38 leads through T 46 to line 47 and the accumulator. The third conduit associated with T 46 leads to an accumulator pressure gage 73. A conduit 50 leads pressure fluid from the three-way valve 48 to the bag in order to suddenly accomplish the rapid volumetric filling thereof from the charged accumulator, initiating a cycle of press-operation. This release is triggered by a limit-switch and suitable electric conductors, not shown but of conventional nature, when the in-going tray strikes this switch at a pre-determined point in its inward travel.

A charge suddenly released from accumulator 42 passes by way of conduit 47 through conduit 50 to a simple header 52 which also serves, in another phase of the cycle, as a manifold. In order to drain this conduitry and associated receptacles, if necessary, a globe valve 53 is shunted thereto and is connected by a conduit 69 to reservoir 25.

The powering-actuation of the bag to force the diaphragm formingly against the sheet-material on the form-blocks in the tray is accomplished by means including an electro-motor 55 and a reversible pump 57 driven thereby, the pump, to power the bag, withdrawing fluid from reservoir 25 through a conduit 64. A conduit 59 serves, on powering the bag, to lead fluid at about 5200–10,000 p.s.i. toward the bag. Conduit 59 bifurcates as shown, and each fork includes a check valve, one valve 62 being set at about 500 p.s.i. to isolate the motor-pump unit 57 from the accumulator pressure system during the filling of the bag, thus preventing accumulator surge through 59, for when solenoid B is actuated, line 50, connected to the bag is also opened and this vents the accumulator to manifold 52 through line 50. Thus, the check valve 62 prevents any flow from the accumulator from reaching pump 57. The other valve, 60, is set at 500 p.s.i. also, so as to then open to enable the continuation of the pressurizing cycle so as to power the bag.

An operator's control pressure gage 72 is suitably connected to manifold 52 to enable the press-operator to select any desired operating pressure for the bag below the setting of relief valve 83.

In order to release the maximum, or diaphragm-powering, pressure from the bag in order to initiate the final phase of a cycle and so that the bag contents can, with safety, be suddenly evacuated, the reversible motor-pump unit 55—57 is reversed by any suitable conventional means, such as a polarity reversing switch, not shown, but actuated in the well-known mode by the needle of gage 72, this reverse-operation of pump 57 thus drawing fluid through check valve 62 and releasing the pressure in the bag down to 500 p.s.i. so that upon applying the action of the means for establishing a bag-emptying vacuum or "suction" to the bag, the latter will be at a pressure insufficient to "blast" the fluid into the vacuum tank or to tend to cause the bag itself to be sucked into the conduitry 50, 51, 47, 50 being shown in Fig. 2 as a pipe leading from the bag through header 52 to the exterior of the press.

In order to supply pressure fluid to pump 57 during its reverse operation so as to prevent cavitation during the last stages of the evacuation of the bag, a line 58 is led off to the right from line 59 and is connected to reservoir 25. In line 58 is a check valve 63 which permits flow through 58 to 57 on this occasion but prevents flow through 58 to 25 during "powering" of the bag.

A relief valve 83 is provided in a shunt pipe leading to the left from line 59, to prevent over-pressurization of the bag in the powering phase thereof. Valve 83 is connected to reservoir 25.

A two-way, or flow-and-return conduit 64 connects pump 57 to reservoir 25 and it serves both to supply fluid for discharge by the pump to the bag in the powering phase of the bag cycle and to return the fluid to the reservoir during the high-pressure release phase of the cycle.

The "quick-emptying" sub-combination of the present system for rapidly and automatically evacuating the bag comprises a vacuum tank 65 connected to a vacuum gage 70, tank 65 being adapted to draw thereinto the de-pressurized contents of the bag through conduits 50 and 66, upon release of the powering pressure therein, as above. Tank 65 is maintained at a predetermined degree of vacuum by means of a vacuum pump 67 driven in that direction of rotation that establishes extremely low pressure in the tank 65 when the one "side" of the tank 65 is connected, via conduit 66 and 3-position solenoid valve 48, as well as conduit 50, to manifold 52 and the bag.

Means are provided for emptying the filled vacuum tank of the fluid received from the bag so as to prepare the tank for subsequently receiving the next bag-load, and these means consist of vacuum pump 67, driven by motor 35 and connected to tank 65 by way of conduit 68, the pump 67 discharging by means of conduit 100 to the reservoir 25.

A plurality of switches 74, 75, 77, 78, 79, and 84 is provided for controlling and activating the accumulator, bag, and vacuum conduitry at proper junctures in the cycle of the press. These switches are all conventional Barksdale diaphragm actuated, hydraulic pressurized electrical switches, the internal construction of which therefore needs no description. They are connected on the hydraulic side by piping extending to the respective hydraulic apparatuses shown and are connected on their "electrical sides" by suitable wiring, etc., as shown in Figure 3.

First considering the accumulator, which must not attain a pressure above 500 p.s.i. or below 300 p.s.i., in order to maintain these limits there is provided an accumulator pressure switch 74, preferably one of the well-known, widely distributed Barksdale switches, which is set at 500 p.s.i.

Pressure switch 75 is so connected to the conduitry as to be cut in or automatically function if the accumulator pressure drops below 300 p.s.i., which is the lower limit at which the bag can be properly filled out.

Bag-distending, volumetric filling switch 77, connected by pipe line to the manifold 52, is also a Barksdale switch and is so set as to de-energize solenoid C in valve 48 at 350 p.s.i., thereby disconnecting conduit 51 (which leads from T 46 to the three-way valve 48) from conduit 50, which leads to the manifold 52 and the bag, to prevent the high pressure from pump 57 from reaching the accumulator.

In order to maintain the high speed bag-evacuating conduitry closed to flow therethrough until the powered bag has been reduced to a safe evacuating pressure, another Barksdale switch, 78 is provided and connected to solenoid B which it energizes when the powering pressure in the bag has been reduced to such a value that no shock will ensue upon solenoid B connecting conduit 50 to conduit 66 and tank 65 via the valve 48.

A safety pressure switch 79 is provided and connected to the proper point in the manifold 52 and is set to operate at about 5200 p.s.i. so as to then break the pump-in

circuit to the bag in the powering phase of the cycle. This switch, which is a normally inactive safety device, is also preferably a Barksdale switch, locked-in at the aforementioned value. The pressure limitation is normally taken care of by settings on the variable pressure switch on 72.

A Barksdale vacuum switch 84 is provided in association with the vacuum tank 65, and operates when tank 65 is at a vacuum of 15–20 inches of mercury to operate the vacuum relay aforementioned and 84 first, therefore, senses the presence of a full vacuum in 65 and must be closed before automatic cycling will start. When 73 and 70 indicate that the accumulator is charged and the vacuum is established, then 84 automatically shuts off motor 35.

Summarizing, switches 74 and 75 are electrically connected, as shown in Figure 3, to electromotor 35; switch 78 is electrically connected to solenoid C; switch 77 is electrically connected to solenoid B; switch 79 is electrically connected to motor 55; and switch 84 is electrically connected to motor 35 so as to control the vacuum in tank 65. When switches 74 and 84 are both "satisfied," and read off "stop" conditions, motor 35 will thereby be halted; when switches 75 and 84 read off "start" conditions, motor 35 will thereby be started.

A pressure fluid relief line 200 connects pump 37 to reservoir 25 and serves to relieve the pump of fluid if the motor 35 should happen to be rotated in the wrong direction. An unloading line 47—38 leads from the accumulator to the unloading valve 39. A pilot-operation discharge line 400 leads from valve 48 to the reservoir. A safety relief line 90 leads from pump 57 to reservoir 25.

In Figure 3 the electrical system associated with the aforedescribed hydraulic system for the purpose of automatically effecting most of the operations of the press is shown in diagrammatic detail. Although some of these electrical components have already been cursorily referred to of necessity in describing the principal subject-matter of this application—the hydraulic system—this electrical system will now be described as a complete unit.

The electrical control system for the hydraulic system of the press, as shown in Figure 3, essentially comprises, first describing the mere layout, an electric energy source 112, preferably three-phase, 440 v., 60 cycles, having a conductor path 113 leading toward motor 55, a conductor path 114 leading toward motor 35, a conductor path 115 leading toward the motor 28 which powers filter pump 29 and a control conductor path leading to a step-down transformer 117. A reversing contactor means 116 is suitably interposed in path 113 to enable reversing of motor 55.

In this control circuitry, a starter 118, such as a 3 pole reversible starter, is provided for pump motor 55, and it is in series with a normally open volumetric filling pump switch 77, with switch 74 for the accumulator and with solenoid B of valve 48, aforementioned.

In the next horizontal line is shown the normally open vacuum switch 84 in series with the vacuum switch relay 120.

A reversing switch 122 for the motor 55 is shown in series in the next horizontal line with a bag emptying switch 78, normally closed, for emptying the contents of the bag into tank 65 and with solenoid C on value 48.

The succeeding horizontal line has accumulator switch 75 is series with the relay 124 operated by switch 75.

A starter contactor 125 for sensing the direction of rotation of motor 55 is provided in the next line of the diagram in series with a relay contactor 127 which closes to assure that motor 35 operates. Then, in series therewith there is provided a relay-contactor 128 which assures that filter motor 28 operates; as well as a relay-contactor 133 for switch 84 and a relay-contactor 134 for the accumulator pressure switch, which latter relay contactor 134 closes when 35, 65, and 42 are in proper condition. When these close, a signal light 135 is energized, indicating that the entire system is "ready," or conditioned for cycling.

In the next succeeding horizontal line, a normally closed vacuum switch relay contactor 129 is in parallel with a normally closed accumulator pressure switch 130. When these are closed, a signal light 132 is illuminated, indicating that the system is not ready and the operator must wait until the final automatic adjustment has occurred before he can manually trigger the cycle, as by pushing the cycle control button.

An emergency master switch 137 is provided in the next horizontal line of the diagram and is operable to terminate all operations in case of need. This line also includes a system, or plant-starting switch 138 which, when closed, starts motor 55 in reverse and it so runs until the bag, etc., are drained of any remnants of fluid. Switch 138 is in series with a relay contactor 139 operating off pressure pump-forward relay 154, thru relay 140 the closing of which relay 140 and its associated components then causes the motor 55 to rotate in the reverse direction.

A contactor 143 is provided in the next lower horizontal line of the diagram and is connected in series with a tray-in relay 146 operated by the aforementioned tray-in limit switch to release relay 140 simultaneously with the engagement of the contacts in relay 154, to effectuate motor reversal.

A cycling initiating switch 144 is connected in series with contactor 143 and in parallel with 146 and is connected to points 145, appearing in the next full horizontal line of the diagram.

The safety switch 79 for limiting the bag-pressure is, in the next short horizontal line, connected in parallel with 143, 144 and 146 and both of these short horizontal lines are connected in series to 139, 140 and 142.

The other set of contacts of the aforementioned double, or twin, contacts safety switch 79 is provided in the next full horizontal line and in series with it are the contact points 145 for the cycling control switch, as well as the vacuum switch's relay contactor 147, the accumulator pressure switch's relay contactors 148, the points 149 of the system starting switch 138, the relay contactor 150 for the tray-in limit switch, and the relay contactor reverse switch for pump motor 55. Relay-contactors 156 for relay 154 are shown in the short horizontal line dropped below this full horizontal line. Relay 154 operates the forward switch for pump motor 55 as aforementioned. The relay 153 for vacuum switch 84 is shown in the short horizontal line above this full horizontal line.

In the next full horizontal line are shown elements 155, 158 and 157. Elements 155 and 157 are holding switches for use in starting the motor 28 of filter pump 29, and element 158 is a contactor-unit in parallel with 155 and 157, also for use in starting 28. The relay for cooperation with these elements is shown at 159.

In the succeeding horizontal line, a somewhat similar arrangement, for starting pump motor 35, is shown and comprises holding switches 160 and 162 and a contactor 163, as well as a relay 164 operated thereby.

In the lowermost horizontal line of the diagram there is shown a tray-in limit switch 165 for operating a tray-in relay 167.

With this electrical configuration, the electrical system functions essentially as follows, reading the second full, horizontal line first and proceeding thereafter in succession to the other horizontal lines. Before the "bag-fill" solenoid B on valve 48 can be opened, the aforedescribed switches and relays, etc., operate to assure that (1) there is a pressure of 300–500 p.s.i. in the accumulator; (2) motor 55 is running "forwardly"; and that the "bag-fill," or volumetric filling, switch 77 is closed and operating.

In the next horizontal line, 84 merely senses the amount of vacuum in 35. It is to be noted that in order for solenoid C on valve 48 to vent the bag to the vacuum tank 35, motor 55 and its pump must be running in reverse and that bag emptying switch 78 must have been closed.

In the line including elements 75 and 124, 75 senses, or picks up, the accumulator's pressure and relay 124 then connects this circuitry and the interlocking circuitry to the proper one of the indicating lights, relay 124 then operating element 148 as well as operating 130 and 134.

The lines including signal lights 132 and 135 are merely condition-indicating circuits and inform the attendant as to whether the various other elements are in that condition or in those positions which they must occupy before the press can be properly operated.

It is to be noted also that when the system-starting switch 138 is closed and rotates motor 55 in the bag-draining direction, this closing also causes closing of the filter pump motor's relay 159 and the relay 164 for the motor 35. Button 138's closing also effects opening of the next line of the diagram immediately below (this line including 152) which opening establishes the fact that pump motor 55 is not yet rotating "forwardly," and of course this also closes points 149 in this lower line of the diagram.

Regarding the circuits including elements 143, 144, 146 and 79, closure of any one of these circuits will effect reversal of motor 55 so as to release pressure from the bag. Any movement of the tray that is picked up by the tray limit-switches will also reverse the motor 55. Also, any pressure over 5200 p.s.i. closes 79, reversing 55.

The purpose of the circuit that includes elements 79, 145, 147, 148, 152 and 154 is to control the "forwarding" relay of the motor 55 and, to do so and pump oil to the bag, the cycle-control switch 144 must be closed, the vacuum switch 84's relay and the relay of the accumulator pressure switch must both be closed and the tray-in relay must be closed, assuming that motor 55 is already properly running "in reverse." The forward running of motor 55 can be halted by opening the bag-pressure safety switch, aforementioned.

The circuits including elements 157, 155, 158, 160, 162, 163, 165 and 167 are believed to be self-explanatory.

An operating cycle of the bag and associated hydraulic system commences with the bag substantially entirely devoid of fluid but not at a vacuum in its interior. Motor 55 is running "in reverse" to drain the bag and associated conduits, but is soon shifted to "forward" running by the interlocking circuitry aforementioned. The vacuum tank is also empty and at about 20 inches of mercury, vacuum. The accumulator is occupied by fluid at a pressure of about 350 p.s.i. to 500 p.s.i.

Solenoid B is then actated by switch 77 to connect conduits 51 and 50, whereupon the filled accumulator discharges suddenly into the bag, distending it into contact with all the walls of the working chamber of the cylindrical press, and pressing thereagainst at a pressure of the order of 300–500 p.s.i. This completes the "volumetric" phase of the cycle.

The "powering" phase of the cycle is then initiated by means of the motor 55 and high pressure pump 57, as soon as the bag filling pressure gage 72 indicates the predetermined "filled" pressure in the bag. The motor 55 runs until the gage 72 indicates about 5200 p.s.i. forming pressure in the bag, when the variable pressure switch on 72, but not shown, operates the motor reversing switch on motor 55, this switch not being shown but being standard with such motors. This motor reversing switch thus terminates the pumping in of fluid to the bag at the end of the "powering" expansion of the bag against the diaphragm that causes the latter to form the work. This also reverses pump 57 and releases the high pressure in the bag, preparatory to evacuating the latter. The released pressure fluid is discharged from pump 57 through line 64 to reservoir 25.

If the pressure in the bag is at the "shockless" evacuating pressure of less than 500 p.s.i., switch 78 then operates to energize solenoid B to connect conduits 66 and 50, so that the vacuum in tank 65 will result in the now depressurized contents of the bag rapidly transferring into tank 65. The latter, of course, in the meantime has been maintained at a vacuum, but when the vacuum reaches 20 inches of mercury, switch 84 de-energizes motor 35, the accumulator having, in the interim, been filled by pump 37, which now also is stopped.

Thus, the accumulator, bag, and vacuum tank are now again restored to the condition proper for the beginning of another cycle.

Although in describing the construction and configuration of two of the presently contemplated embodiments of the invention certain components thereof have been specifically detailed as to their exact geometrical conformations and locations, or their quantitative ratings or dimensions, it is to be understood that such specificity is employed mainly in order to render the description more concrete. The actual scope of the invention is set forth in the following claims.

I claim:

1. In combination: a reservoir for pressure fluid; a hydraulically powered expansible powering-cell; discrete means for accumulating a body of pressurized fluid therein; fluid-pressure establishing means having respective flow-paths connecting same to the reservoir and to the discrete means and operable to occasionally charge said discrete means with pressurized fluid and to expand said cell poweringly; means for triggering the charge from said discrete means into said cell in an initial, volumetric filling of the cell; second discrete means for thereafter applying other pressure fluid to the filled cell in order to forcefully expand the latter; means for releasing the powering pressure from said cell during the subsequent phase of the cell's cycle; a vacuum-enclosure adapted to be connected to said cell during the next subsequent phase of the cell's cycle; a vacuum pump operatively connected to said vacuum-enclosure for maintaining same evacuated; and means for flow-connecting said enclosure to said cell so as to rapidly transfer the contents of the cell into said enclosure in the final phase of the cell's cycle and subsequent to the release of said powering pressure; and means for then discharging said vacuum enclosure of its fluid contents so as to condition the apparatus for another cycle.

2. In combination: a reservoir for pressure fluid; a hydraulically powered, expansible powering-cell; a fluid-pressure accumulator; fluid-pressure establishing means having respective flow paths connecting same to the reservoir and to the accumulator and operable to continually charge said accumulator; means for releasing the accumulator's charge to the cell at a predetermined juncture in order to volumetrically fill said cell; means for thereafter supplying pressure fluid to said cell to poweringly expand same; a vacuum enclosure adapted to be connected to said cell to initiate the next subsequent phase of the cell's cycle; a vacuum pump operatively connected to said vacuum enclosure for maintaining same evacuated; means for connecting said enclosure to said cell for flow from the latter to the former at a predetermined juncture subsequent to the release of the powering pressure so as to rapidly transfer the contents of the cell into said enclosure; and means for transferring the contents of said enclosure to said reservoir, at a predetermined juncture previous to the filling of said accumulator, thereby to condition the system for another cycle.

3. In combination: a reservoir for pressure fluid; a hydraulically powered expansible powering-cell; fluid-pressure accumulator means; means connected to the reservoir and adapted to be connected to said accumulator means to maintain same charged with fluid at low pressure; means for connecting said accumulator means to said cell for filling the latter volumetrically; fluid-pressure establishing means having respective flow-paths connect-

ing same to the reservoir and to the cell and operable in one of the initial phases of the cell's cycle to expand said cell poweringly after same has been volumetrically filled; means for releasing the powering pressure from said cell during the subsequent phase of the cell's cycle; a vacuum enclosure adapted to be connected to said cell during the next subsequent phase of the cell's cycle; a vacuum pump operatively connected to said enclosure for maintaining same evacuated; means for connecting said enclosure to said cell at a predetermined juncture subsequent to the release of the powering pressure so as to rapidly transfer the contents of the cell into said enclosure; and means for transferring the contents of said enclosure to said reservoir before said cell is connected to said enclosure.

4. In combination: a reservoir for pressure fluid; a hydraulically powered, expansible powering-cell; a fluid-pressure accumulator; fluid-pressure establishing means having respective flow paths connecting same to the reservoir and to the accumulator and operable to continually charge said accumulator; means for releasing the accumulator's charge to the cell at a predetermined juncture in order to volumetrically fill said cell; means for thereafter supplying presure fluid to said cell to poweringly expand same; a vacuum enclosure adapted to be connected to said cell to initiate the next subsequent phase of the cell's cycle; a vacuum pump operatively connected to said vacuum enclosure for maintaining same evacuated; means for connecting said enclosure to said cell for flow from the latter to the former at a predetermined juncture subsequent to the release of the powering pressure so as to rapidly transfer the contents of the cell into said enclosure; and means for transferring the contents of said enclosure to said reservoir, at a predetermined juncture previous to the filling of said accumulator, thereby to condition the system for another cycle.

5. A hydraulic operating system for operating an elastic, expansible power-cell, comprising: a fluid reservoir; an accumulator; fluid-pressure establishing means including conductor paths connecting said pressure establishing means to the reservoir and to said cell and accumulator so as to poweringly operate the cell at a predetermined juncture in the cycle; means for releasing the powering pressure from said cell subsequent to the powered action thereof while leaving the cell volumetrically distended; a substantially evacuated enclosure adapted to be connected to the cell during the next subsequent phase of the cycling of the cell; a pump connected to said evacuated enclosure for maintaining same evacuated; and means flow-connecting said enclosure to said cell and constructed and arranged to effect rapid transfer of the contents of said cell into said evacuated enclosure in the final phase of cycling of said cell; and subsequent to the release of the powering pressure thereon; and means for emptying said evacuated enclosure of its fluid contents prior to re-cycling.

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